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INTERNATIONAL

TURKISH

GEOLOGY

SYMPOSIUM

Work in Progress on the Geology of Turkey and Its Surroundings

ABSTRACTS

24-28 September, 2001
Çukurova University
Adana-TURKEY

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ABSTRACTS OF ORAL AND POSTER PRESENTATIONS

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Organizing Committee wishes to thank the following for their generosity in supporting the Fourth International Turkish Geology Symposium.

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WELCOME

Dear Participant,

The Organizing Committee wishes to extend a warm welcome to all those attending the "**Fourth International Turkish Geology Symposium"** held on the campus of the Çukurova Univerity, Adana between 24 and 28 September, 2001. Turkey is an area uniquely placed to advance our understanding of the complexities of continental collision, accretion, volcanism, strike-slip faulting, crustal extension and seismicity and geoarcheology. It also retains considerable potential in terms of geological resources.

The Committee is encouraged by the success of first *three* meetings on this theme, held at Keele University, England in April 1992, at Cumhuriyet University, Sivas, Turkey in September 1995 and at METU, Ankara, Turkey in September 1998. Following these meetings, *several* special issues concerned with the Geology of Turkey have appeared in the *Geological Journal*, the *International Geology Review and in Special Publications of the Geological Society of London. While the* first two conferences were concerned exclusively with Turkish geology, the Organizing Committee consider it appropriate to extend the scope of Fourth Symposium to include geological topics from areas adjacent to Turkey, such as Greece, Bulgaria, Romania, Israel, Iraq, Iran, Syria and former Soviet Union states. The *p*rincipal objectives of this Symposium are;

- To present current researches focusing on the geology of Turkey and the surrounding regions
- To encourage discussions on these topics among active researchers
- To provide an overview of geological research currently being undertaken in Turkey and its environs

The Scientific Programme for this year's Symposium promises to be equally attractive and timely and there is also an extensive programme of geological and cultural excursions and social events, in addition to opportunities for exhibiting equipment, services or results.

Keynote lectures given by internationally acknowledged authorities have been scheduled as an introduction to each day's programme. The scientific programme has been built around 20 special symposia which will be held as three (four on Thursday 27th September) parallel sessions. The symposium will be attended by over 350 scientists from many parts of the world including Austria, France, Georgia, Germany, Great Britain, Hungary, Iran, Israel, Italy, Russia, Sultanate of Oman, Switzerland, The Netherlands, and U.S.A. Oral and poster presentations are scheduled every day with the exception of Wednesday. Poster presentations are scheduled between 10:00 and 18:00 and usually follow the oral presentations for a given symposia or session. Mid-congress excursions are scheduled on Wednesday.

We hope that the success of this meeting will contribute to a fuller understanding and appreciation of the Geology of Turkey and its surroundings. We also thrust that it will lead to new collaboration among those interested in the geology of this important region. We wish you a very pleasant, interesting and successful meeting

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A B S T R A C T S

KEYNOTES

Some striking Features of the Anatolian Geology

Yücel YILMAZ

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In this paper some important features of the Anatolian geology Are reviewed. Among the critical subjects included are neotectonics versus paleotectonics, timing and development of the present major morphotectonics element such as the mountains and intermountain basins, Timing–mechanism and uplifting of the metamorphic massifs, role of extention versus compression in the development of the young volcanic rocks, timing and development of the major suture zones.

Tectonic evolution of Neotethys in the Easternmost Mediterranean (an Adana perspective)

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Adana region onshore and offshore and surrounding areas provide insights into the tectonic evolution of Tethys in the Eeastern Mediterranean region. The known story begins with Pre-Cambrian basinal sediments cut by granitic rocks (Sandıklı area). This is overlain by Palaeozoic shelf sedimentation on the N Gondwana margin, punctuated by Late Ordovician glaciation. Palaeotethys was then located to the N. The nearest preserved evidence of this is an accretionary prism (Konya melange) emplaced onto the Anatolide platform in pre-Early Triassic time. Opening of the S Neotethys ocean in the easternmost Mediterranean took place in Mid-Late Triassic time, as regionally documented in the Alanya window, the Munzur-Pötürge-Biltlis massifs, Mamonia Complex (Cyprus) and Baer-Bassit (N Syria). In addition, the N Neotethys rifted, then opened by Lower Jurassic time, as recorded in the Beyşehir-Hoyran-Hadim nappes. Bahama-type carbonate platforms and margins bordered the N and S Neotethys during Jurassic-mid Cretaceous. Subduction-influenced ophiolites were created in both N and S Neotethyan ocean basins and emplaced southwards onto adjacent platforms by latest Cretaceous time, along with accretionary units (e.g. Mersin, Pozantı-Karsantı and Koçali ophiolites). Diachronous closure of the N Neotethys was completed by Late Eocene time, preceded by basin development (e.g. Tuz Gölü), localised mafic volcanism (Ulukışla basin), silicic magmatism (e.g. Kırşehir massif) and possible initiation of a precursor Ecemiş fault zone During Oligocene-Miocene, the Bolkar Mtns. and adjacent Taurides were exhumed, shedding extensive non-marine clastic sediments (e.g. Ulukışla basin). The left-lateral Ecemiş fault zone was by then active creating a linear depression. Regional uplift was completed in Plio-Quaternary time. Further south, the S Neotethys was subducted northwards in Late Cretaceous-Palaeogene time, leading to Eocene-Oligocene diachronous collision of opposing Arabian and E Tauride margins, giving rise to the Misis-Andırın melange and later, in the Miocene, to regional foreland basin development. Pliocene time saw westward tectonic escape of Anatolia along the East Anatolian and North Anatolian fault systems, whereas oblique northward subduction continued in the Eastern Mediterranean Sea to the southwest, culminating in collision of the Eratosthenes Seamount with the Cyprus active margin and uplift of the Troodos ophiolite.

Reference: Robertson, A.H.F., l998. Mesozoic-Tertiary tectonic evolution of the easternmost Mediterranean area: integration of marine and land evidence. In: Robertson, A.H.F. et al. (eds), Proc. ODP Sci. Results, Leg 160, 723-782. Avaialable from the World Wide Web http://wwwodp.tamu.edu/publications/160_SR/CHAP_54.PDF.

GPS Applications to Earthquake Mechanics and Seismic Hazard Studies: The 1999, M7.6 İzmit, Turkey Earthquake

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(Presented on behalf of TUBITAK Marmara Research Center, Turkish General Command of Mapping, Eurasia Earth Science Institute of Istanbul Technical University, Kandilli Observatory of Bogazici University, and USA Collaborators.)

The Global Positioning System (GPS) is being used for a wide range of earthquake studies in areas of active tectonic deformation. Applications include studies of interseismic, preseismic, cosesimic, and postseismic deformation. Monitoring secular (interseismic) deformation in plate boundary zones is providing quantitative information on rates of strain accumulation and fault locking depths on individual fault segments. This information is providing a physical basis for characterizing the hazards associated with specific faults and for estimating earthquake repeat times. Coseismic deformation is providing detailed information on the character of sub-surface faulting (strike, dip, rake), and the spatial distribution of slip on these faults. Such results provide constraints on the mechanics of strain release during earthquakes, and stress transfer to neighboring faults that can trigger aftershocks and “double” earthquakes. Studies of postseismic deformations provide evidence for afterslip and distributed postseismic relaxation. Understanding each of these phases of the earthquake cycle is important to seismic hazard studies.

In this presentation I will use the broad scale, regional GPS-deformation field for the eastern Mediterranean to define the tectonic setting of the Izmit/Duzce earthquake sequence. I will then use these earthquakes to illustrate the application of GPS to earthquake and seismic hazard studies. Overall, the GPS observations support an earthquake cycle model in which (1) steady interseismic deformation occurs in the upper mantle and lower crust accommodated by localized shear and distributed ductile flow, (2) aseismic faulting, which is highly accelerated following the sudden stress pulse from a large earthquake, occurs at mid- to lower-crustal levels, and (3) brittle seismic rupture occurs in the upper crust followed by afterslip along some portions of the fault. I will give special consideration to the implications of available GPS observations for current seismic hazards in the Marmara Sea region.

Miocene Paleoecology and Fossil Apes from Central Anatolia

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The Miocene is a time period that is critical for understanding the course of later hominoid (or ape) evolution in the Old World. Hominoids first appear in the late Oligocene and early Miocene of East Africa and undergo a dramatic radiation that produced numerous genera and species. At around 16 Ma primates closely related to this African radiation first appear throughout Eurasia. This early episode of faunal exchange between Eurasian and African taxa was facilitated by a major global sea-level lowstand. The earliest occurrence of hominoids in Turkey is seen at the sites of Paşalar, where the apes are relatively common, and at Çandır, where they are relatively rare. Both of these sites are dated by faunal correlation and these data suggest that they may be very similar in age. This time period appears to be unusual in that climates were very equitable and the environments were heavily forested, which together probably account for the otherwise unusual occurrence of basically tropically-adapted taxa at such high latitudes. The next occurrence of hominoids in Turkey is seen in the Sinap Formation of Central Anatolia. These sediments were intensively studied from 1989-1995 and represent alluvial fan and fluvial depositional environments. Apes are relatively rare components of the fauna and are known from a very limited temporal interval dated at slightly less than 10 Ma in age. The apes are represented by both cranial and postcranial elements and their anatomy suggests a generalized arboreal and terrestrial set of adaptations, which accords well with the results from other aspects of the fauna. After this interval of time the paleoenvironments appear to undergo a trend from somewhat closed canopy to more open habitats, and this change appears to be responsible for the local extinction of the apes. This pattern is similar to that seen for other hominoids from Greece and Pakistan and appears to be a consequence of the late Miocene global trend to greater aridity.

Oligo-Miocene Basins of South-Central Turkey: Synthesis and Appraisal

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During the middle Cenozoic progressive closure of the southern branch of Neo-Tethys was accompanied by the creation of several basins in south central Turkey. Studies of the Oligo-Miocene stratigraphy, sedimentology and structure in four such basins (Mut, Adana-Karsantı, Misis-Andırın & Maraş-Lice) reveal broadly similar patterns of basin inception, filling and structural evolution, but significantly different subsequent deformation histories. Analysis of palaeoenvironments, palaeoflow patterns and provenance demonstrates that during the Oligocene the two western basins (Mut & Adana) were sites of terrestrial and lacustrine deposition within fault-bounded, intra-montane troughs, while the eastern basins (Misis & Maraş) were marked by shallow to deep marine deposition. During the early and middle Miocene all four basins display comparable patterns of evolution, starting with a brief early Aquitanian phase of marine transgression followed by a late Aquitanian tectonic episode that is documented in the western basins by fault reactivation and local angular discordance but in the eastern basins is marked by accumulation of local chaotic (olisthostromic) units. Renewed marine transgression (mid to late Burdigalian) stimulated the generation and expansion of carbonate fringes around these basins, even during a succeeding phase of enhanced clastic supply and rapid subsidence (late Burdigalian-early Serravalian). The thick sequences of deeper water clastics generated by these mid-Miocene events show shoaling-up character but are discordantly succeeded (except in the Mut basin) by SW-prograding fluvio-deltaic sediments that denote major geotectonic reorganisation and uplift to the northeast during the late Serravalian/Tortonian interval. In the predominantly carbonate sequences of the northern Mut basin this event is reflected only in enhanced supply of coarse clastics during the later Miocene.

Tectonic subsidence plots for individual basins reveal step-wise patterns for Mut, northern Adana and Maras (with pronounced increases in subsidence at approximately 30Ma and 19-17Ma) while subsidence appears to have more continuous and uniform in the Misis and southern Adana areas. In all basins (except southern Adana) there is a marked decrease in subsidence rates during the early Late Miocene (13Ma). Similarly, the effects of significant sea-level fluctuations (probably eustatic) are manifest in the shallower late Oligocene and Miocene sequences of the northern basins, where they perturb a tectonically mediated pattern of accumulation that was ultimately responsible for creating the ‘fill-and-spill’ style of deep-water sedimentation deduced for the southern and eastern Miocene basins. In a regional context, the sedimentological and deformation history data indicate that this entire basin complex evolved from a ‘mountain-front’ extensional regime during the Oligocene into a more diversified Miocene tectonic pattern, with subduction-related ‘outboard’ basins in the south and east flanked to north and west by ‘inboard’ basins still influenced by Tauride orogenic uplift. From early Late Miocene times onwards a broadly east-to-west diachronous pattern of basin closure, deformation and block-uplift is discernible, probably reflecting full collision of the Arabian and Anatolian plates in the Bitlis zone and the inception of escape tectonics.

AEGEAN EXTENSION

Extensional Tectonics in Western Turkey and the Basins and Ranges, USA: A Review

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During the past two decades, field-oriented research in the Basins and Ranges, supplemented by laboratory geochemical analysis and radiometric age determinations, identified common structural elements of extensional tectonics and produced several testable models of continental extension.

It is now generally accepted that the initiation of the Basins and Ranges extension was caused by the formation of the San Andreas fault zone about 30 Ma ago which caused the subduction of the Mid-Oceanic ridge between the Farallon and Pacific plates. The underplated hot, oceanic lithosphere heated the overriding plate and caused localized partial melting and magmatism. Partial melting of the lower crust produced granitic melts while ductile extension continued. The isostatic rise of metamorphic core complexes started when the ductile extension began to subside about 20 Ma ago and produced more than 30 core complexes. Brittle extension in the southern Basins and Ranges was initiated about 15 Ma ago apparently because the North American plate cooled sufficiently. With the onset of extensional faulting, volcanic activity changed from calc-alkaline to bimodal.

Current geological work in the southern Basins and Ranges is concentrated on the percentage of accumulative a) extension with respect to extensional faulting; and b) displacement along the major strike-slip fault zones. Estimate of extension ranges from about 30-50% to about 400%. The estimates of displacement along the Furnace Creek fault zone ranges from about 50 km to about 100 km. Amount of slip rate along the major normal and strike-slip fault zones has now been determined by precise radiometric age dating of low temperature metamorphic minerals and continues GPS measurements.

Presently, there are three major tectonic models that were proposed for the cause of extension in Western Turkey: 1) tectonic escape and its modification the lateral extrusion; b) back-arc spreading/subduction roll back; and 3) orogenic collapse. The N- trending basins were interpreted as developed under a N-S post Paleogene compression related to the terminal closure of the northern branch of Neo-Tethys Ocean. They were filled by Early Miocene sediments, were cut by E-W trending basins of Tortonian age; and continued their development under the N-S extensional regime. A volcanic evolution model suggests a close link between the change of volcanic character and tectonism. Recently, it is suggested that the E-trending basins were formed by a process similar to the rolling hinge model of extension proposed for the Death Valley region of the Basins and Ranges.

Current geological work in Western Turkey is concentrated a) on the age and nature of the metamorphism in the Menderes massif, recently interpreted as a metamorphic core complex; and b) on the exhumation history of the metamorphic rocks along the low angle detachment surfaces. Also important is to determine that whether the Menderes massif is a large big metamorphic core complex or it is made out of small metamorphic core complexes.

Stratigraphy and structure of the major E-W trending Turkish graben system

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The Alaşehir and Büyük Menderes grabens have similar stratigraphy and contain four sedimentary packages. First two sedimentary packages were dated by using palynological data (Eskihisar association 20 -14 Ma). A recent study suggests Late Miocene age for the second sedimentary package due to the younger palynological results which are however evaluated as "typical for Eskihisar association" by Benda. Consequently, existence of Eskihisar sporomorph association in the second sedimentary package has been confirmed by additional samples and claim of reworked nature of the samples bearing this association is invalid in Alaşehir graben. Another recent statement regarding contradictory age data in the Nazilli area, Buyuk Menderes graben is also inaccurate because the palynological and micromammalian data have been obtained from different, first and third sedimentary packages respectively.

Recently completed magnetostratigraphical study demonstrates that the transition from first to second sedimentary package occurred during 15.5 Ma in Alaşehir graben and 17.2 Ma in Buyuk Menderes graben. These results securely place the initiation of E-W trending graben formation to Early Miocene. First high angle fault system controls the accumulation of first and second sedimentary packages in the Early to Late(?) Miocene. During Pliocene to Quaternary, second and third fault systems are responsible for the accumulation of third and forth sedimentary packages respectively. Each fault system causes the rotation of the previous systems and present low angle normal faults represents the first graben boundary fault. This sequential development is similar to the flexural rotation / rolling hinge model and the activity on rotated first fault system leads to exhume larger amount of rock units independently from the initial throw on the first fault system.

The Early Miocene initiation of sequential development of the graben formation and the evidences against the suggestion of a contractional phase in the Miocene-Pliocene interval show that the term of "paleo(?)/neotectonic graben formation" has no meaning in western Turkey and the use of the age data of the second and /or third sedimentary packages as a timing of graben formation is also misleading.

Evolution of the Küçük Menderes graben (Western Anatolia, Turkey)

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The Küçük Menderes graben is one of the characteristic neotectonic structures in western Anatolia that trends E-W with an area extent of 80 km length and 3-10 km width. The graben is bounded by Bozdağ horst of Gediz graben from north and Aydın horst of Büyük Menderes graben from south. The graben is situated in and overprinted on a huge E-W trending syncline where the axis of the structure runs from Beydağı in the east to Gökçen-Tire-Belevi line in the west.

The faults bounding the graben from south – extending from Beydağ to Belevi- are well defined. The manifestations of faulting are extensive and thick alluvial fans, thick talus deposits, aligned springs and fault planes. The northern margin is controlled by faults that are poorly manifested compared with the southern ones and only observed at certain areas of the margin. However, extensive and thick alluvial fans, talus deposits, uplifted-hanged streams valleys on rift shoulders and aligned springs are characteristic features observed in northern margin.

In addition to the main graben, there are various sub basins like Kiraz, Dağkızılca and Selçuk. These basins that are oriented in various trends are filled with Neogene clastics where this fill is restricted to certain parts of the main graben.

The deformational phases in the region are identified using statistically calculated results of the slip data collected at various parts of the graben. The results point out three successive deformational phases and a counter clockwise rotation in the study area for post-Neogene period. The first phase is a strike-slip regime evolved under almost N-S compression. This phase is followed by a second phase that is resulted in WSW-ENE extension with strike-slip components. Final phase is an extensional phase that causes NW-SE and NE-SW oriented extension in the region. This deformational phase is still seismically active.

Geology of the Gediz Graben and its Tectonic Significance

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Gediz graben – an approximately E-W trending structure – forms one of the most prominent features of western Anatolia. The origin, age and evolution of the graben have long been debated and the controversies still continue. Most of the studies along the graben have been concentrated on the stratigraphy of the so-called basin fill but the structural problems, particularly the relationship between presently low-angle normal fault (so-called detachment) and high-angle normal faults, have not yet been addressed. We have studied the structural aspects of the graben in the hope that they will shed light on the existing controversies.

The basin fill is made up of folded and/or southward tilted Miocene sediments and unconformably overlying almost horizontal Pliocene and younger fluvial sediments. Two sets of structures shape the present-day outline of the Gediz graben: presently low-angle normal fault and high-angle normal faults. The former forms the boundary between the Miocene sediments in the hanging wall and the metamorphic rocks of the Menderes Massif in the footwall. It trends approximately E-W and dips 08°-24°N. Similarly, the Miocene sediments in the hanging wall dip southwards at an angle of up to 40° or even more. The footwall is marked by greenschist facies mylonites and structurally overlying cataclasites, formed during the exhumation of the Menderes Massif. The fault plane is almost horizontal at topographically higher locations and there the Miocene sediments crop out as isolated patches above the fault plane. Occasionally, the slip surfaces of the presently low-angle normal fault offer an opportunity for a structural investigation and we have studied polished slip surfaces with numerous occurrences of striae, grooves and gutters. One of the most diagnostic features of the slip-surface is the presence of very large corrugations. On the other hand, the high-angle normal faults juxtapose different facies of the Miocene sediments and the Pliocene and younger sediments with the older rock units. They dip at an average angle of 50° N and form a well-developed basin-ward step-like morphology. The presently low-angle fault and the structurally overlying Miocene red clastics occur at different topographic levels within this step-like morphology. In this work, we will, for the first time, provide field evidence that the high-angle faults are younger structures that cut and displaced the presently low-angle normal fault.

In conclusion, our observations are consistent with the two-stage graben model and suggest that the first phase was associated with the presently low-angle normal faulting, exhumation of metamorphics in the footwall and the sedimentation of Miocene in the hanging wall while the second phase was the manifestation of neotectonic period commenced by the Pliocene normal faulting and formation of the E-W trending modern Gediz graben.

Stratigraphy and volcanic evolution of the Aliağa-Foça Region (Western Turkey)

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In the Aliağa-Foça region, three main rock associations crop out in the Neogene succession. These are, **1.** The Yuntdağ volcanics, **2.** The Foça volcanic complex and **3.** Aliağa limestone. The Yuntdağ volcanics form the oldest unit in the area and consist of a thick and widespread andesitic-trachyandesitic lava sequence and accompanying coarse grained volcaniclastic rocks. In the Yuntdağ volcanics red to gray andesitic lava facies dominate the whole succession. Upward these porphyritic lavas pass gradually into the black, aphanitic andesite lava facies. The subvolcanic stocks and dykes of the same andesitic volcanism form the third distinct facies in the Yuntdağ volcanics and are found mainly in the central parts of the main vents. All this coherent volcnic facies are interlayered by the coarse grained block and ash flow deposits of the andesitic Yuntdağ volcanism.

The Yuntdağ volcanics are overlain by the subaqueous to subaerial rhyolitic Foça volcanic complex. In this sequence, three different subunits are distinguished which are **1.** The Foça rhyolites, **2.** The Foça volcaniclastics and **3.** Foça alkaline volcanics. The Foça rhyolites are made up of the massive rhyolite lava flows and domes. The Foça rhyolites are surrounded by the Foça volcaniclastic sequece in which two main volcanic facies are distinguished which are pyroclastic flow deposits and hyaloclastic breccias. Close to the domes, coarse grained hyaloclastites and perlites cover the massive rhyolites and pass laterally into the fine grained, strongly to slightly welded ignimbrites. In the upper parts of this volcaniclastic sequence, the alkaline lava flows interdigitate the Foça volcaniclastics. The Foça volcanic complex laterally and vertically pass into the Neogene Aliağa limestone consisting of white to yellow, gastropoda bearing limestones and clayey limestones.

Stratigraphic relations between the underlying calc-alkaline Yuntdağ volcanics, rhyolitic parts of the Foça volcanic complex and the Foça alkaline volcanics and geochemical features of these units show that they were formed proggressively and there is no prominent gap in the evolution of the volcanic succession.

Neogene and Quaternary Geology and Tectonic development of the Denizli Region

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The Kale-Tavas basin fill extending in northeasterly direction, occupies eastern part of the Denizli region. The basin was formed as a piggy-back basin on the southerly transported Lycian nappes. During this period the present Menderes dome was not yet elevated. The Early Miocene continental basin, lying to the north of the Kale-Tavas basin aligned approximately in N-S trend, may be viewed as a cross graben. These basins were lost their structural identities to the end of the Middle Miocene. During the Late Miocene a tree-armed extensional basin began to form under regional N-S extension. The junction of the radially-developed branches corresponds approximately to the Honaz area. From this the Denizli-Sarayköy branch and the Baklan branch trends NW and NE respectively and the Acıpayam-Çameli branch trends N-S. The Menderes dome began to rise during this period, and acted as source of supply of materials, forming lateral fan deposits consisting of red clastics. During the same period the N-S trending and southerly extending branch of these extensional basins (the Acıpayam-Çameli branch) was filled with thick fluvial conglomerates. Later these depressions were morphologically smoothened, and gave way to a lake basin, in which white marl-siltstone and then limestones were deposited extensively. These sediments covered the entire region to the end of Late Miocene. This phase was followed by the elevation of the fault-bound Babadağ high. This high delimited the Denizli lake basin from the south, and began to localize the present E-W trending structural depression.

The Baklan depression (the easterly located branch) was also began to shape up during this phase forming the present obtuse V-shaped structural depressions. These broad basins have then became narrower to form the present structural depressions, during Quaternary period. During this phase the N-S trending Acıpayam-Çameli branch has also been reactivated but its axis shifted to the west. The present major morphological elements of the region have been formed during this later phase of the graben development.

Low-angle Normal Fault Along the Southern Margin of Niğde Massif (Central Anatolia) and Its Tectonic Significance

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Along the southern margin of the Niğde Massif (central Anatolia) a low-angle normal fault separates the sedimentary cover in the hanging wall from the underlying marbles and quartzites in the footwall. The hanging-wall is made of uppermost Cretaceous- Palaeocene sediments, which has also enjoyed brecciation along the interface with the fault. We have studied the geometry and kinematics of this fault at nine sites. At these localities, the slip surfaces are polished and strongly corrugated on a scale of 10 to 100 metres and are dominated by alternating culminations (anticlines) and depressions along their lengths. The surfaces are also characterized by the occurrences of numerous corrugation-parallel striae, grooves, gutters and tool tracks. Fault breccia is evident in the footwall. The fault strikes in (140°-100°, mean 125°) and dips at an average angle of 35° (20°–50°) and shows normal faulting with minor components of strike-slip component. We have also estimated the stress field orientations, using the observed slip vector orientations and the calculated σ_1 trend for the first movement is 070° and plunges gently at 85°, whereas σ_2 and axes σ_3 axes trend in 292° and 202º and plunge at 04° and 03°, respectively.

Along most of its length, the fault bounds the uppermost Cretaceous-Palaeocene unit to the south and the units start with a basal conglomerate with fragments derived from the underlying high-grade marbles and quartzites. Locally, the fault juxtaposes Mio-Pliocene detritics and lacustrine deposits with the metamorphics. The fault is also buried beneath the Plio-Quaternary semi-consolidated to loose sediments made up of large gabbro fragments within a reddish sandy-clayey matrix. The field relation suggests that the metamorphics were already at the surface when the fault developed and the faulting must have occurred sometime during the Miocene.

We have also compared general trend of the structural elements of the high-grade metamorphics in the footwall (the NE-SW to ENE-WSW general trend of the stretching lineation) and the features intrinsic to the fault plane (N-S to NW-SE trending corrugations, grooves, gutters and striae). This suggests that there is no genetic link between normal faulting and the ductile deformation of the high-grade metamorphics. Similarly, the kinematic indicators in the metamorphic rocks indicate a top-to-the NE shearing during the high-grade ductile deformation and this is not compatible with the normal faulting.

We therefore argue that this fault did not accommodate any significant exhumation of the metamorphic rocks and that this fault is a late normal fault cross-cutting, or sliping along, an older nonconformity.

The Quaternary evolution of the Gulf of Corinth, central Greece: coupling between surface processes and flow in the lower continental crust

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The Gulf of Corinth in central Greece is an active normal fault zone with particularly clear evidence of isostatic footwall uplift, constrained by Quaternary marine terraces, and hanging-wall subsidence and sedimentation. It is bounded to the south by a Pliocene to Early Pleistocene sedimentary basin which is now eroding into the Gulf. Previous work has suggested that the relief across this region has increased dramatically since the Early Pleistocene, due to the isostatic response to increased rates of footwall erosion and hanging-wall sedimentation. It is indeed assumed here that incision accompanying the draw-down of global sea-level at ~0.9 Ma, during the first major Pleistocene glaciation, initiated the erosion of the basin south of the Gulf of Corinth and so abruptly increased the sedimentation rate in the Gulf. The resulting transient thermal and isostatic response to these changes is modelled, with the subsiding depocentre and eroding sediment source coupled by flow in the lower continental crust. The subsequent enhancement of relief, involving an increase in bathymetry from near zero to ~900 m and ~500 m of uplift of the eroding land surface in the sediment source, is shown to be a direct consequence of this change. The model is sensitive to the effective viscosity of the lower crust, and can thus resolve this parameter by matching observations. A value of ~$5X10^{19}$ Pa s is indicated, suggesting a viscosity in the lower crust at the Moho no greater than ~10^{18} Pa s. Other apparent examples of similar transient topographic effects caused by increased rates of sedimentation and erosion are also identified in the Aegean region, suggesting that this coupling process involving flow in the weak lower crust may be of major geological and geomorphological importance.

Manisa Fault (western Anatolia) and Its Kinematic Significance

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Western Anatolia is one of the most seismically active and rapidly extending regions of the World and is currently experiencing an approximately N-S continental extension. The region is dominated by approximately E-W trending active normal faulting and there is also evidence for active NW- and NE-trending normal faulting. Although the existence of active faults is reported from the region, not much said about their geometry and kinematics. This is because of the scarcity of fresh slip surfaces. Where fault planes expose, the details on the surfaces are either weathered or the surfaces are completely dragged.

In this work, we aim to report spectacular new exposures of the active Manisa fault – a NE-ward arched structure that trends in NW direction for some distance in the south and then bends into an approximately E-W direction around Manisa to the north. The rocks of the Bornova complex – composed of massive, highly strained, huge limestone blocks within a flyschoidal matrix – and the Mio-Pliocene sediments, exposed on Sipil Dağı – a prominent hill rising up to 1500 m above the sea level – form the footwall, while the Quaternary colluvium deposits, mainly of limestone scree, occupy the hanging wall.

As the limestones are resistant to erosion, the normal fault slip surfaces occur at the base of limestone escarpments. The immediate footwall is composed of a fault breccia, containing limestone clasts cemented mainly by clay, sand and calcite. Similar brecciation is also evident in the immediate limestone scree. Quarrying of the limestone scree in the immediate hanging wall has revealed remarkably continuous pristine slips surfaces, up to 50 m high (along the direction of slip), over a length of a few hundreds of metres along strike. These surfaces offer great opportunity for a structural investigation. We have studied two distinct sites along the NW-trending section of the Manisa fault. There, the fault strikes in 140°-100° (mean 125°) and dips southeast-wards at an average angle of 52° (43°–58°). It is a typical normal fault with minor strike-slip component.

The slip surfaces are polished and strongly corrugated on a scale of a few centimetres to hundred's of metres and are dominated by alternating culminations (anticlines) and depressions along their lengths. The surfaces are also ornamented by the occurrences of numerous slip-parallel striae, grooves, tool tracks and gutters. In addition, slip surfaces are characterized by the numerous open tension cracks and fissures, oriented almost perpendicular or sub-perpendicular to the slip direction. The tension fractures (comb fractures) occur mainly along the rising humps (anticlines) and their traces on the slip surface make crescenting shape with their horns pointing the normal movement nature of the faulting.

We have estimated the stress field orientations, using the observed slip vector orientations and calculated principal stress axes directions. The evidence available suggests that three possible mechanisms are responsible for the generation of corrugations at different scales: (1) lateral curved propagation and linkage of faults, (2) formation of new connecting faults that breach the relay ramps and (3) upward propagation of slip planes through heteregenous bodies.

Low-angle normal faulting in Bulgaria: an alternative view

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Claims have been made that tens of kilometres of Neogene extension has occurred on low-angle normal faults in Bulgaria, forming "metamorphic core complexes". In May 2001 I visited these localities, guided by a supporter of this idea and another senior Bulgarian scientist who considers that some interpretations of this region misinterpret the field evidence so fundamentally that they indicate scientific fraud. I found no evidence of low-angle normal faulting, but witnessed:

- steep normal faults where low-angle dips had been reported, based on measuring the slope of weathered surfaces rather than the true dip of the fault plane.
- gently-dipping unconformities between basement and Neogene sediments, previously mapped as low-angle normal fault planes
- alluvial fan deposits containing plant remains, previously interpreted as cataclastic breccia formed at depth by low-angle normal faulting
- sites where previous studies had claimed that no adjacent source rock exists for clasts in conglomerates, requiring low-angle slip to move the site tens of kilometres away from the sediment source: whereas adjacent source areas are obvious in the field
- sites where sedimentation has been used to argue that extension was active, where the absence of steep normal faults has been taken as implying low-angle ones: when the sediment could have been deposited for reasons unrelated to active faulting, such as rivers transporting material into pre-existing topographic lows.
- the argument that before extension the region was an elevated plateau, like Tibet, which experienced "extensional collapse", and since low-angle normal faults are reported in and around Tibet, they are expected here also: when much of the region is covered by Oligocene marine sediment and so was at sea level then
- ancient thrust faults reinterpreted as Neogene low-angle normal faults, without any kinematic indicators in the required sense
- sites with thermochronologic ages, previously interpreted as due to tectonic denudation by low-angle normal faulting: where the lack of age progression favours cooling by erosion instead
- brittle microstructures previously interpreted as ductile fabrics formed by tectonic denudation of footwalls by low-angle slip.
- mylonitic fabrics previously attributed to Neogene ductile deformation in low-angle normal fault footwalls: when the same fabrics occur throughout metamorphic rock units of probable Precambrian age, and could have formed during any of the many deformation phases affecting these ancient, polydeformed rocks.
- granites previously interpreted as intruding synkinematically to low-angle normal faulting: yielding isotopic ages much older than the Neogene.

These observations have a bearing on claims concerning Neogene low-angle normal faulting in Turkey: similarities are evident with data-sets available for the Niğde and Menderes Massifs.

Stratigraphical evidence about the depression of the northern edge of the Menderes-Taurid Block during Late Cretaceous

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The Menderes-Tauride Block form the southern edge of the inner Tauride ocean which opened during Triassic. Pelagic basin fills on which red colour Globotruncana bearing biomicrites deposited, was formed on the platform carbonates lying between the central and eastern Taurid area during the Late Cretaceous time. The pelagic sediments of the basin were investigated around Aydıncık and Mersin within the central Taurides and around Munzur mountains in the eastern Taurides. Cenomanian age reef carbonates, which contain Orbitolina and Hippurites, form the uppermost part of the Liassic-Cenomanian platform carbonates in Munzur mountains. Presence of all broken hippurites fragments demonstrate continuous breaking and transportation to the area from a close field at the same time. Reddish-dark gray colour, thin bedded Turonian-Campanian age limestone containing Globotruncana fossils and chert nodules rest on the reef limestone. Late Campanian age fore reef bio-clastic limestone including rudist fragments and reddish-gray colour clayey limestone and marls as pelagic sediments rest unconformably on Liassic-Aptian age platform carbonates around Aydıncık village (İçel). The Menderes-Tauride block was formed as an isolated platform type to the south of inner Tauride ocean during Liassic-Cenomanian. During late Cretaceous time period, Menderes-Tauride block, which descended in relation with the closure of the inner Tauride ocean that caused progradational ophiolitic napp emplacement, was shifted to drowned platform type then followed by the pelagic sedimentation developed afterward within the following formed basin.

Sedimentological evidence for the existence of an Early Miocene E-W trending Alaşehir (Gördes) half-graben in the W Turkey

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The Neogene-Recent tectonic/sedimentary evolution of the W Turkish graben system remains subject to debate. In one school of thought the Menderes Metamorphic Massif underwent a phase of extensional exhumation (c. 20 Ma), associated with initiation of E-W trending graben. These basins were infilled with lacustine and red alluvial clastics of Early Miocene age. In this model, N-S basins ("cross graben") could reflect large-scale undulations in the footwall of a N-S regional extensional detachment system that unroofed the Menderes Metamorphic Massif. In this case, extension was continuous until Recent, or occurred in discrete Early-Mid Miocene and Late Miocene/Plio-Quaternary phases. In a second, competing, interpretation the Menderes Metamorphic Massif was unroofed mainly by simple erosion well prior to 20 Ma. Localised granitic intrusions in the uppermost Menderes metamorphics related to E-W extension, which also created N-S trending "Tibetan" grabens in which the Early Miocene lacustrine carbonates and red alluvial clastics accumulated. E-W graben began only in Late Miocene to Plio-Quaternary time following a poorly dated Late Miocene-Early Pliocene regional hiatus.

Resolution of the two models hinges on facies patters within the Early-Middle Miocene lacustrine/alluvial clastics. These are well exposed along the south margin of the Alasehir graben, above a presently low-angle, regionally significant extensional detachment fault. Mapping of the 3-D geometry of alluvial fans over ca. 5 km along strike (E-W), coupled with palaeocurrent analysis (e.g. clast imbrication, cross bedding) shows that a least five separate overlapping fan lobes existed. Each of these prograded *northwards* through breaks in the E-W footwall detachment system. Palaeocurrent data provide no support for possible E-W (or vice versa) sediment outbuilding from regional scale N-S faults related to "Tibetan" grabens. Instead, sedimentation was controlled by a major E-W trending active extensional fault system. The Early Miocene alluvial sediments were later overlain by westward-flowing, axial-fluvial deposits of Mid-Miocene age, reflecting a probable connection with the Mediterranean Sea. These sediments are, in turn, unconformably overlain, and locally interfinger, with a poorly dated second phase of coarse alluvial fan conglomerates of Late Miocene/ Pliocene age.

We, therefore, infer a significant role for E-W extensional unroofing of the Menderes Metamorphic Massif in the Early Miocene history of western Turkey.

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Geology and Development of the Denizli Basin

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The Denizli Neogene basin displays a multi phase development. These phases correspond to partly discreet, partly transitional periods of deformation. The basin began to developed above the Menderes Massif in the north and the Lycian nappes in the south. In the southeastern part of the region crops out the Oligo-Miocene marine sequence formed within the northeasterly trending Kale-Tavas basin. These sediments covered the eastern part of the region, but did not extend further west then the Denizli city. This marine environment ended after Burdigalian. The region turned into a continental high during much of the Middle Miocene. With the beginning of the Late Miocene, the Menderes dome began to elevate to form the Buldan horst. This elevation supplied, quickly-accumulated, red-colored lateral fan deposits into the surrounding low-lands. They pass laterally into an extensive lake basin, in which white limestones were deposited. They blanketed the entire region to the end of late Miocene. The Buldan horst subsided to some extent during this period as indicated by progressive onlap of the lacustrine limestones onto this previously elevated high. The lake was not far above the sea level as suggested by the presence of brakish water carbonate-marl sequence around the Sarayköy and Babadağ areas. Immediately after this phase the Babadağ high bounded by listric normal faults, dipping to the north, began to elevate probably during the Pleistocene. The high delimited the basin form the south and acted as a major source of supply of fluvial clastics into the depressions. In the central part of the depression a remnant lake was possibly survived during this phase. The Denizli depression became much narrower during the Quaternary, with the development of E-W normal faults, and the present axial depression; the Büyük Menderes River valley has been developed during this late phase of extensional deformation.

Geology of the Neogene Basins of the Buldan-Sarıcaova region and their importance within the Neo-tectonics of the Western Anatolia

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In this study, stratigraphic position and depositional conditions of the Neogene aged three distinct rock units outcropping from the Buldan and Sarayköy areas of the junction of Büyük Menderes-Gediz graben, to the north of Kuyucak-Pamukören have been investigated. The lower sequence exposes on the Aydın mountains located between Büyük Menderes and Alaşehir depressions. It has been deposited in a Lower- Middle Miocene aged basin developed under control of NNE-SSE trending faults and later preserved from the erosion within in the post depositional E-W faults. This sequence rests unconformable on the metamorphic basement rocks. They consist of three distinct lithostratigraphic formations. The thickness of these deposits outcropping in the south of Buldan is approximately 1200 m. The middle sequence consists of lacustrine deposits including fluvial fans intercalated with gypsum and brackish-water fossils. The deposits surrounded the entire eastern plunge of the Buldan horst and extends far beyond. Both of these sequences having distinct geometries are unconformable with one other and were deposited in two distinct basins. While the first sequence was developed along the N-S margin of the basin, the second one was deposited in accordance with margin geometry of the massif depending on rising of Menderes massif during Late Miocene-Lower Pliocene. Detritic terrestrial, fluvial and talus deposits formed in response to E-W trending gravity faults make up of the third sequence of the region. These are observed along the margin faults of Büyük Menderes and Gediz Grabens.

Neogene stratigraphy and molluscan fauna of Domaniç-Tunçbilek region (Kütahya-Western Anatolia)

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In this study, paleontology and stratigraphy of Neogene units of Western Anatolia exposed around Domaniç-Tunçbilek (Kütahya) have been examined using Molluscan fauna.

Eleven genus, twelve species of the Molluscan fauna have been described in seven measured stratigraphic sections of three different formations belonging to Domaniç-Tunçbilek (Kütahya) region. Based on these fauna, the Tunçbilek formation age assigned to Pontian era. Çokköy formation age, found as Dacian era. Also, Emet formation age is given Romanian era as stage level.

According to the stratigraphic-paleogeographic distribution, and paleoecology of the fauna, in Pontian, the region was contained Central Paratethys fauna. Marshy and coaly levels have been occured due to level of the lake has been changed by tectonism. In Dacian, which is indicated around Domaniç-Tunçbilek, the lake was feeding by rivers and also materials from the volcanic activity of the region. In Romanian, feeding by rivers has been continued.

Supra-allochthon sedimentary successions in Western Anatolia: New Stratigraphic data and tectonic results

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The study has carried out in four reference areas. In the İnceler (Denizli) area, shallow marine sediments rest unconformably on the Lycian peridotite. The İnceler succession consists of carbonate cemented basal conglomerate, cream-colored limestone with abundant benthic foraminifera and corals, gray-cream colored fossiliferous sandstone and mudstone with limestones intercalations. These sediments contain well-preserved fauna; *Nummulites perforatus, Nummulites aturicus, Nummulites beaumonti, Alveolina fusiformis, Alveolina elongata, Eorupertia magna, Asterigerina rotula, Linderina brugesi, Sphaerogypsina globula, Silvestriella tedraedra, Chapmanina gassinensis, Operculina* sp., *Aktinocyclina* sp., *Discocyclina* sp., *Textularia* sp., *Stomatorbina* sp., *Heterostegina* sp., *Rotalia* sp., *Gypsina* sp., *Amphistegina* sp., *Globorotalia* sp., Hauerinidae, Algae, Rotaliidae. The above fauna dates the İnceler succession as Bartonian (Middle Eocene).

In the area of Beşparmak Mountain (Baklan), 30 km north of the İnceler area, the Mesozoic metaclastics and metacarbonates of the Lycian nappes has an angular unconformity with the overlying Eocene succession. The latter commences with the basal conglomerate and grades up into fossiliferous sandstone, sandy limestone and foraminiferal limestone. The fauna in these sediments are *Asterigerina rotula, Nummulites perforatus, Nummulites beaumonti, Fabiania cassis, Eorupertia magna, Chapmanina gassinensis, Halkyardia minima, Silvestriella tedraedra, Rotalia* sp., *Globigerina* sp., *Operculina* sp., *Heterostegina* sp., *Assilina* sp., *Gypsina* sp., *Planorbulina* sp., *Textularia* sp., *Discocyclina* sp., Hauerinidae, Rotaliidae, Algae which they yield the Bartonian age for the succession. Both the İnceler and the Baklan successions have quite similar fauna which are determined for the first time.

Similar non-metamorphic successions of Late Palaeocene to Middle Eocene age are also known from Başlamış (Manisa) and Dereköy (Denizli) areas.

These four successions should be formed in connected depressions during the Palaeocene-Eocene. The late Eocene phase of thrust-sheet translation, resulted in the closure of the supra-allochthon basin and overthrusted of the ophiolitic nappes onto the basin sediments. During the extensional collapse of the Lycian orogen, the successions may be gone away from each other by gravitational spreading of the thrust piles to their present position.

Tertiary Geology of the Yeşilyuva and Kocabaş Region (Denizli, SW Turkey) and its Geotectonic Significance

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The investigation area includes various geological units of volcanic, ophiolitic and sedimentary rocks. Based on their stratigraphical succession and lithological characteristics, they comprise three lithostratigraphic units as follows: the lower group; the basement (Pre-Oligocene), the middle group (Upper Oligocene – Lower Miocene) and the upper group (Upper Miocene – Pliocene). The boundaries between these groups are unconformity surfaces. The basement of the region is known as the Lycian Nappes consisting of the ophiolitic melange and the Taurus Mesozoic carbonate succession. The middle group comprises two formations formed within the Kale-Tavas basin. Overlying upper group, from bottom to top includes three units. These are red continental conglomerates, lacustrine sandstone, mudstone and marl alternation and lacustrine limestone. They are laterally and vertically transitional. The volcanics are made mainly of Upper Miocene-Pliocene? basalt lavas and trachytes. The major faults in the investigation area, formed during the pre-neotectonic and syn-neotectonic periods. The pre-tectonic trend are NW-SE, NE-SW or N-S. The faults of Neotectonic period mainly trend E-W. The sediments which were deposited into these subsequent basins formed in different periods and directions. The older basin is known as the Kale-Tavas basin, which trend NE-SW. The younger basin is the Yeşilyuva-Kocabaş basin, which trend N-S. The lavas formed partly co-evally with the younger basin are alkaline in character and were poured out along N-S trending extensional openings.

ORE DEPOSITS

A geostatistical approach to geochemical characterization of productive versus non-productive skarn granitoids in Central Turkey

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The study of the relationships between productive and sterile plutonic rocks in the CACC region of central Turkey suggests a direct genetic connection between the composition of plutons, and their associated ore deposits. In order to discriminate between productive and sterile granitoids, two Fe-skarn granitoids (Çelebi and Karamadazı), and a series of sterile plutons within central Anatolia were examined. The Karamadazı and Çelebi granitoids are geochemically different from other sterile/non-productive plutons in Central Anatolia. The parameters governing the productivity of these granitoids were determined by principal component analysis (factor analysis) method. Based on this method, the factors controlling the geochemical characteristics of the Karamadazı Granite are TiO_2+MnO+Zr/SiO_2 and CaO+Na_2O+Sr/Rb+Ba+K_2O ratios, and for the Çelebi Granitoids the ($FeO_{(T)}$+CaO+MgO+Y)/(K_2O+Rb) and (Na_2O+Ba+Al_2O_3)/(SiO_2) ratios. These two granitoids are clearly distinguished from the sterile/non-productive Central Anatolian Granitoids (CAG) on Harker diagrams based on these controlling factors (parameters). Sterile CAG plutons are different from the productive Çelebi Granitoids in their higher silica content and generally higher total alkali values. This study suggests that fertile (iron producing) plutons are less differentiated and have very little contribution from continental crust compared to the sterile (non-productive) plutons. Higher apatite and zircon abundances in the Çelebi Granitoid suggest that the Çelebi Granitoid has more I-type characteristics compared to sterile plutons of CAG. The Karamadazı Granite is the most striking example for the granitoids in CAG having the least contribution from the continental crust, evidenced by the lowest mean Rb, Ba, Th, the highest mean Sc, V, and mean Zr, Y, Ni contents. Based on the factor analysis, it is proposed that the Karamadazı Granite displays geochemical characteristics similar to the Terlemez and Ağaçören granitoids of CAG.

$^{34}S/^{32}S$ Isotope Ratios of Güneş-Soğucak Sulfide+Calcite+Quartz Vein at Divriği in Sivas Province, East-Central Turkey

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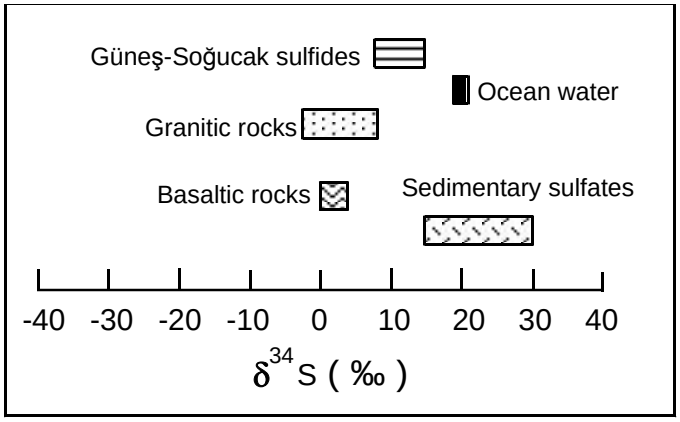
Güneş-Soğucak sulfide mineralization is located between villages of Güneş and Soğucak at Divriği in Sivas province. Sulfide mineralization occurs as a vein and disseminated type in upper Cretaceous partly serpentinized ultramafic rocks. The vein type sulfide mineralization is elongated in a NW-SE direction and its thickness is ranges from 10 cm to 2 m. The sulfide vein occurs in the fracture zones of the pyroxenite, peridotite and gabbro associated with a number of acidic and basic dyke complex. The sulfide vein is outcropping in Ağpınar, Karapınar, Soğucak and Almalı creeks from a NW to SE direction respectively.

Güneş-Soğucak sulfide vein contains various sulfide minerals with calcite and quartz. Paragenetic sequences of ore minerals reveal that the sulfide vein started to form at high temperature (>500 ^{o}C) and continued towards lower temperature (<100 ^{o}C). It is concluded that the Güneş-Soğucak sulfide vein formed in a wide range of temperature in a hydrothermal system.



Ten sulfides (mostly pyrite) from Gunes-Karapınar creek, Soğucak-central and Soğucak-Almalı creek were analyzed for their sulfur isotope ratios. δ^{34} $S_{\Sigma S}$ values range from 7.9 to 14.6 ‰, with most values at the higher end of this range. The figure shows ranges of $\delta^{34}S$ values for these sulfides along with ranges for common rock types. Most igneous sources of sulfur have values near 0 ‰; sedimentary sulfides have a wide range, but generally are less than 0 ‰; and sedimentary sulfates range upwards from approximately 15 ‰ (i.e. near or above present-day ocean sulfate). Given the range of sulfur isotope values for our data, it is evident that there must have been a component of sedimentary sulfate present in the hydrothermal fluids. However, because the mineralization is in an area where there are abundant igneous rocks, it would be expected that there was some sulfur contributed from the igneous rocks as well. Indeed, these data do not preclude significant contributions from either sedimentary or igneous sulfide sulfur sources. Further work is required to assess the relative contribution of these sulfur reservoirs to the overall S budget of the hydrothermal fluids.

*Supported by TUBİTAK, Project No. YDABÇAG-100Y007, and by MTA Project No. 2000-13B4.

A geostatistical reserve estimation case study and comparison of the methods: Kalburçayırı (Kangal, Turkey) coal deposit

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This study includes the reserve evaluation of Kalburçayırı (Kangal, Sivas) lignite bed. In the study, block kriging method for geostatistical techniques, polygon and triangular method for classical reserve calculation methods were used.

To compare the methods with each other and to calculate the error variance of these three methods, the variogram function was determined and it was spherically modelled with the parameters of C_0 = 6.0, C = 12.0 and a = 1100 m. Using the model, the error variance of thickness was calculated as 10.01 for polygon method, 9.80 for triangle method and 2.33 for block kriging method.

The calculated reserve was considered as improved reserve because in the reserve calculations, drilling values which take place in improved reserve boundary which is obtained from the previous data were used. Global reserve amount was calculated for each method, compared to each other and interpreted. The smallest error variance was found in block kriging method. The reserve amount of the coal deposit was found as 56.490.410 ± 2.340.244 tons and this amount have the minimum error variance compared with the others, therefore for feasibility calculations of the lignite bed, obtained result is suggested. In the block kriging method, for confidence levels of 95 %, confidence interval is 4.14 % of reserve amount and this value is less than 20 % which is accepted in improved reserve term.

Listwaenite and Birbirite with gold mineralization from Anarac Ophiolite Complex, Central Iran

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Serpentinites in upper proterozoic ophiolitic terrains of Anarac area north of Naiien are subjected to hydrothermal alteration. Fluid bearing CO2 caused carbonatization processes, then Quartz-Carbonate rocks or Listwaenites are formed. These carbonatized serpentinites are well developed along shear zones, fractures and tectonic contacts of serpentinites. Not only serpentinites, in places, metamorphic sourrounding rocks are also undergone carbonatization.

Birbirites are the ultimate production of hydrothermal alteration. These rocks are highly silicified Listwaenites or serpentinites.

Quartz, chalcedony, Magnesite, dolomite, goethites, chlorite, minor pyrite and jarosite are the main constituents.

On the base of SEM observations gold mineralization are established in Listwaenites and birbirites of Patyar area. Visible gold grains occurred in two different settings:

1- as inclusions in pyrite, in association with ferroan dolomitic veins that Latter developed in Listwaenites and 2- in Iron Oxide veinlets that occurred in birbirites.

A geostatistical grade and tonnage estimation study of Ilıcadere (İzmir, Turkey) Pb-Zn mineralisation

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This paper includes grade and tonnage estimation of Ilıcadere (Bayındır, İzmir) Pb-Zn mineralisation. The data which were coming from 74 vertical drillholes transferred into computer system and statistical parameters were determined for each variable (Pb, Zn and Cu). By compositing data, three dimensional assessment of the mineralization were done using some special geostatistical techniques. In order to calculate the improved reserve amount of the mineralisation, the variogram functions were determined for the vertical and horizontal directions, anisotropy of deposit was investigated and the mineralisation was spherically modelled by the parameters for Pb; C_0=20, C=200, a=75 m., for Zn; C_0=4, C=14, a=75 m., for Cu; C_0=0.002, C=0.005, a=75 m. The validity of model parameters to mineralization was tested using the back-kriging technique and the parameters were used for estimation of the average grade of the 10x10x10 m. blocks by geostatistical block kriging technique.

Cu was only modelled and no further study was applied to Cu values because of the lack of data and unreliable Cu values. For Pb, 213 blocks with 26.95 % Pb mean grade and 33.94 estimating error variance; for Zn, 581 blocks with 7.07 % Zn mean grade and 2.58 estimating error variance were estimated. Grade-tonnage distributions were calculated for Pb and Zn resulting of estimation. Using the distributions, the reserve amount and average tonnage were determined for different cut-off values. According to the assessments, the results are suggesting to use for feasibility calculations of Ilıcadere (Bayındır, İzmir) Pb-Zn mineralisation. The kriged estimates can be used in mine planning. For example, in this study, they were used in producing grade-tonnage curves. In mining industry, the grade distribution of each block is very important as well as the average block value. Fluctuations in the grades within the Ilıcadere mineralisation for different time periods may be studied using conditional simulation. Using the variogram and actual data, the model of the deposit can be made that simulates the grade of each selective mining unit.

Ca rich Schorl-Feruvite From The Eşme (Uşak) Gold Deposit

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Tourmaline is a common gangue mineral in gold bearing quartz veins and hydrothermal breccia in Eşme(Uşak) gold deposit. The fine grained tourmaline crystals form rosettes or radial aggregates in quartz veins. Tourmaline also exist in open-space filling stage as cementing the clast rich breccia formations. The chemical composition of the tourmaline for this prospect tend toward feruvite composition. The most extreme composition of feruvite is analyzed is $(Ca_{0,49}\ Na_{0,45}\ K_{0,01})\ (Fe_{1,16}\ Mg_{1,8}\ Ti_{0,23}\ Mn_{0,01})\ (Al_{4,97}Fe_{1,03})(BO_3)_3\ (Si_{5,94}\ Al_{0,06})O_{18}(OH,F)$. While the X site is occupied by equal proportions of Na and Ca without significant vacancy, Fe is a significant component at the Y and Z sites marked by Fe-Al exchange due to its uncommon enrichment. The main substitution mechanism for Eşme tourmaline involve Ca Fe Na_{-1} Al_{-1} exchange vector. This trend of the substitution which is typical for the oxyferruginous tourmalines of hydrothermal origin reflects the role of the host rock chemical composition and oxygen fugacity of magmatic liguidus during crystallisation proccess on the chemical nature and structure of tourmalines.

Development of weakly mineralized (Au/Cu) Mid-Tertiary Lithocaps, Kuşçayırı Prospect/Bayramiç – As a guide to concealed porphyry Cu-Au/Au mineralizations in NW Turkey

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The Kuşçayırı Au/Cu prospect is located in West Anatolian Extensional province and is one of a few **High Sulphidation** epithermal systems to be described from this area of Turkey. The region is underlain by the Paleozoic metamorphic rocks, which are cut by medium to high level Mesozoic granodiorite intrusions. These are unconformably overlain by andesitic to dacitic lava dome complex facies and shallow-seated quartz-feldspar porphyries of Oligocene age. Middle to Late Miocene extensional phase has been responsible for the formation of NNE-SSW- and NE-SW-trending grabens with associated movement of EW- and NW-SE –oriented faults, having variable degree of sinistral strike-slip motion. It may be these faults that appear critical in controlling the development of EW- and NW-SE -trending silica- quartz structures or veins in NW Turkey.

Au/Cu mineralizatio is localized along EW –trending linear silica-quartz structures or pods within the altered Oligocene volcanics in the area. The mineralization is represented by disseminated or fracture pyrite (up to 12 %), variable amounts of silicification, hematite-pyrite matrix breccias up to 4 m wide and 30m long produced by intense fracturing of siliceous rocks and moderate to weak saccharoidal to crystalline quartz stringer stockwork veining in small breccia pipes.

The alteration assemblages, progressively changing from an intensely leached pyrophyllitic-alunitic-silicic core to peripheral illite-kaolinite-smectite and then into propylitic zone with epidote-chlorite minerals, are strongly aligned in EW-strike in the Kuşçayırı prospect. The mineralization in the area is associated with an alteration phase represented by advanced argillic assemblage of quartz-pyrophyllite-alunite forming central leach zone. The highest gold content, returning 78m at 0.4 ppm, is restricted to high-temperature portion of the alteration zone characterized by stockwork or replacement quartz with pyrite-pyrophyllite-alunite salvages. Minor gold and associated metallic minerals such as magnetite, calcite, arsenopyrite, realgar, pyrite and specular hematite along with minor chalcopyrite also occur within the intermediate argillic alteration assemblage including smectite-kaolinite-illite-chlorite. The mineralizing event involves temperatures ranging from 284 C to 325 C in fluid inclusion, coincident with the formation temperature of pyrophyllite and illite

Terrains of widespread subaerial to subaqueous arc volcanism developed in Western Turkey, where occurrences of numerous **High/Low Sulphidation** epithermal systems associated with major NW-SW extensional deformation and consequently formed NE-SW-trending grabens have been long recognized, appear to be highly favorable host environment for the formation of porphyry-related copper-gold mineralizations. The Kuşçayırı lithocap with **Au/Cu** might be one of several others yet to be discovered in Northwest Turkey.

Sodium sulphate deposits of Neogene age: the Kırmir Formation, Beypazarı Basin, Turkey

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The Evaporite Member of the Kırmir Formation, which is composed of secondary gypsum in outcrop, accumulated in shallow lacustrine environments during the upper Miocene. This member can be subdivided into a bedded lower unit and a massive upper unit, being irregular the boundary between these units. In the lower unit, most of the gypsum throughout the basin is identified as coming from the transformation of glauberite. In the glauberite layers of the Çayırhan mine, some glauberite textures suggest a primary, subaqueous precipitation on a depositional floor. More common, however, are the glauberite textures indicating an interstitial growth within a clayey-magnesitic matrix. In the thenardite layers, some disruption structures can be assigned to synsedimentary dissolution. These structures, together with the thenardite textures, suggest that the original sodium sulphate was mirabilite, being thenardite a secondary product formed during early to moderate burial diagenesis. The massive upper unit, in which evidence of sodium-bearing minerals is missing, is characterized by laminated to banded gypsum in the marginal areas of the evaporitic basin, whereas thick matrix-poor, clast-supported gypsum breccias prevail in the northern, deeper part of the basin. The precursor facies of these breccias was mainly laminated (primary) gypsum, which changed to anhydrite during moderate burial. The brecciation of these calcium sulphate layers occurred as a result of synsedimentary, gravitative slumping under tectonic control. Although the sulphur isotopic values ($\delta^{34}S$) of the sulphates of the Kirmir Formation suggest a marine-derived brine supply, the oxygen isotopic values ($\delta^{18}O$) and the strontium ratios ($^{87}Sr/^{86}Sr$) do not support such a supply. In the Kırmir Formation, a non-marine origin (presumably linked to volcanic rocks and associated hydrotermal fluids) is interpreted for the sulphate anion, despite the marine-derived suply suggested by the $\delta^{34}S$ values.

The mineralogy and chemistry of the chromite deposits of Pozantı-Karsantı Ophiolite

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The Mesozoic aged Pozantı-Karsantı ophiolite is located 60 km north of Adana. The ophiolite extends in a northeasterly direction for more than 100 km. with an average width 20 km. between the towns of Pozantı and Faraşa.

The autochthonous Mesozoic platform carbonates, belonging to the "Tauric limestone axis" have a tectonic contact with the Pozantı-Karsantı ophiolite. The ophiolite sequence consists of tectonites and cumulates. The harzburgite is affected by asthenospheric plastic flow during spreading. Non-deformed layered cumulates are represented by dunite, clinopyroxenite, layered gabbros and quartz diorites.

The Pozantı-Karsantı ophiolites have about 1000 individual chromite deposits throughout the ophiolite; the geographically the of chromite pods are clustered in two locations: a) The Karsantı district to the north east b) The Gerdibi-Cataltepe district in the south west. The chromite ore bodies occur in both harzburgite and cumulate parts of the ophiolite. The podiform chromite deposits are variable in size and shape, and show plastic and tectonic deformation. Coarse grained, banded and disseminated textures can be attributed to slow cooling and crystal settling from a saturated magma. Rapid variations of chromite texture, crystal size and nodular texture reveal quick changing of deposition conditions.

Electron microprobe analyses have been carried out on chromites from the Pozantı-Karsantı areas. The plot for the Pozantı-Karsantı shows that most of the data lie in two main fields depending on Cr# (between 77-81 and 72-75 wt.%). The compositional variations between single pods are mainly in Mg# rather than Cr#, which can be explained by increases of fO_2 and temperature, resulting in an increase of Mg# in chromite.

In the plots of Mg# vs Fe^{+3}#, the Fe^{3+}# indicates very limited variation and data are placed within the podiform range .The ternary plot of Al - Fe^{3+} - Cr also shows the variability of Cr/Al ratio. The data from the Karsantı and Pozantı areas remain in the podiform field and areas do not show any distinct chemical trend. The stratiform deposits of Kizilyuksek show the same pattern as podiform deposits.

The Pozantı and Karsantı chromite analyses have low TiO_2 contents (0.21 wt.%) which is a characteristic for podiform chromite. Chromites from the study areas are clustered mainly within the Troodos field.

It is reported that the ophiolites in the Pozantı-Karsantı areas is suprasubduction (SSZ) origin. During the formation of chromites, the following factors are involved in SSZ ophiolites. a) The degree of partial melting, b) Hydrous nature of the SSZ magma c) Magma mixing changes in P and their affect on the partial pressures.

Presence of subduction-derived water (hydrous nature) in the melt could expand the olivine and spinel phase volume and so lead to extensive crystallisation of olivine and chromite during the formation of the ophiolite.

Lead-Zinc ore deposits in the east and northeast part of Pozantı (Adana)

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Number of Pb-Zn ore mineralization is located within the Permian (Karıncadağ) and Mesozoic (Akdağ) limestone blocks of the Tauride carbonate platform along the both sides of the sinistral Ecemiş fault zone in southern Turkey. The Karıncadağ contains marble, recrystallized limestone, dolomitic marble, dolomite, calcschist, foliated Bolkardağ marbles intercallated with micaschist. Whereas the Akdağ is characterized by micritic limestones, sandy-silty limestones and rarely dolomitic limestones of Demirkazik formation.

Considerable mineralizations of lead-zinc beds in fractures, fissures and karstic cavities of the carbonate rocks are exposed both in the eastern (Akdağ) and in the western (Karıncadağ) blocks. The lead-zinc mineralizations exhibit rather complex structure in this area where number of private company is operating currently. The mineralization does not follow a stratigraphic horizon. Primary and secondary mineralization, that are sometimes observed together, fill in pockets, fracture, dissolution spacing and capilary veins. The primary mineralization is dominated by galenite, sphalerite. and also sulphur minerals namely pyrite, calcopyrite are seen in this paragenesis. The secondary mineralization is smithsonite, cerussite, anglesite, limonite and small amount of malachite-azurite.

Microprobe analyses were performed on sphalerite, galenite, pyrite, smithsonite. Co/Ni ratio in pyrite, Cd and Cu concentrations in sphalerite and SrO concentrations in smithsonite suggest that the mineralizations had been formed as hydrothermal source under relatively high temperature (~ 300°C). Zn-Pb concertrations of the host-rock in the study area indicate that the main mineralization source has no relation with hostrocks. All the evidences suggest that the primary source for the main Zn-Pb ore mineralization is an epigenetic-hydrothermal (200-300°C) formation process due to acidic magmatism of Horozdağ pluton.

Preliminary results of the study on the origin of chromite minerals in the beach sands of the Mersin Bay

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Chromite abundance in the beach sands of the Mersin bay is considered to be a part of the regional pollution problem. In order to determine the possible chromite sources, we have started a detailed geological–geochemical study. Extensive ophiolitic rock outcrops containing chromite deposits and showings occur in the Central Taurides. Chromite and associated minerals may be transported by drainage system to the coastal plain and incorporated into the beach sands. Another source of the chromite in the beach sand may be the local industry, using chromite. In this study, distributions of chromite and chromium are studied in beach sands and alluvial sediments, and the origin(s) of the chromite in the beach sands is discussed in the light of the geological and geochemical data.

Geology, Mineralogy, and Geochemistry of Carbonate-Hosted Karagöl Zn-Pb Vein Deposit (Niğde-Turkey)

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The Karagöl district (Niğde) is located in the central Toros mountains. The Toros mountains are highly faulted, folded and napped as a result of tectonic history. Nappes observed include Yahyalı (Devonian-Silurian-Trias), Black Aladağ (Upper Devonian-Cretaceous), Çataloturan (Carboniferous-Permian), Minaretepeler (Upper Trias), and White Aladağ nappes (Upper Trias-Cretaceous). Zn-Pb ore mineralizations, mainly of vein-type, occur within the fault zones and the karstic structures hosted by carbonates of Devonian-lower Cretaceous age.

Primary ore minerals include sphalerite, galena and trace pyrite, chalcopyrite, and freibergite. Secondary minerals observed are cerusite, anglesite, smitsonite, goethite, malachite, azurite, hemimorphite, and lepidochrocite. Calcite, dolomite, and quartz account for gangue phases. Sphalerite contained 6-12 wt % Fe, 1241 ppm Cd, and 75-200 ppm Mn. Galena comprised 25-34 ppm Ag and 52 ppm Bi. Pyrite/marcasite had 49 ppm Co and 84 ppm Ni (Co/Ni=0.59). Field observations in conjuction with mineralogical and chemical investigations suggest that the primary sulfide deposition took place hydrothermally and oxide-carbonate ore minerals deposited later as a result of karstification and terrestrial weathering.

Geological, Mineralogical and Geochemical Characteristics of Kolsuz (Niğde) Clay Deposit

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Kolsuz clay deposit is located 40 km in the south of Niğde. The study area is occupied by marine sediments of Late Paleocene-Lower Eocene age, lacustrine deposits of Late Miocene age, and volcanic rocks of Pliocene age. The Kolsuz clay deposit is hosted by the Kızılbayır Formation of Late Miocene age. This formation is comprised by, from bottom to top, conglomerates, red-green clay stuffed with gravel shale-mudstone sequence, and gravel lenses. The Kolsuz clay deposit is 20-150 cm in thickness and occurs as intercalated with mudstone-shale succession. This sequence overlies the gravel horizon forming the base of Kızılbayır Formation.

Samples collected from the deposit were analyzed using optical microscopy and x-ray diffractometry for their minerological and petrographic characteristics. Scanning electron microscopy with energy dispersive spectrometry was used for elemental analyses. Major minerals determined include montmorillonite, albite, quartz, calcite, hematite, and halloysite. The Kolsuz clay deposit is highly enriched in montmorillonite. According to the chemical analyses, the samples are composed of 48.71 % SiO_2, 12.87 % Al_2O_3, 6.05 % Fe_2O_3, 8.71 % CaO, 3.41 % MgO, 0.51 % SO_3, 2.14 % K_2O, 2.89 % Na_2O and 12.62 % LOI. Low Al_2O_3 content could be an indication of high sand content of the clay deposit. Fe_2O_3 content (6.05 %) is also high which is in cement industry due to its undesired effect on coloring, refractoriness,and cookability. Based on the field observations and geological and mineralogical investigations, this study suggest that the Kolsuz clay deposit is formed by montmorillonite, which sould be transported from a neighboring site where hydrothermal alteration was pervasive.

Maden Adası (Ayvalık-Balıkesir) Polymetallic Mineralization: An Example of a Zoned Metasomatic-Hydrothermal System

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In Maden Adası calc-silicate paragenesis is occured as veins and impregnation in metamorphosed volcanosedimentary units where it is characterized by axinite, epidote, amphibole, garnet, pyroxene bearing calc-silicate bands. Scheelite and chalcopyrite occur as irregular concentrations in these units. The large interval of the paragenesis of the calc-silicate bands reflect the different mineralogical compositions of the protholith. Although the large compositional range from ferroaxinites to manganaxinites, ferro-axinite is the dominant end-member in this region. Further from the skarn zone of Maden Adası two base metal veins with different paragenesis reflecting the distance from the heat source were emplaced in volcanic rocks. Lateral metal zoning from the skarn to hydrothermal veins is as follows: tungsten is enriched as scheelite at the skarn zone; copper is enriched outward from the skarn in Maden Adası Vein as bornite, cuprite, native copper, chalcopyrite with pyrite, arsenopyrite, barite and less amounts of galena and sphalerite; in Alibey Vein galena is the main sulphid mineral with sphalerite, pyrite, chalcopyrite, rutile, bizmut sulphosalts.

The mineralogical and enrichment studies on talc occurrences in Kepsut–Örenli (Balıkesir) area

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The study area is situated in the vicinity of Örenli Village of Kepsut Town located east of Balıkesir, in Northwest Anatolia.

The rock units of the investigated area are Paleozoic aged Fazlıkonağı Formation, Mesozoic aged marbles and Paleocene aged Çataldağ granodiorite. Fazlıkonağı Formation comprises glaucophan-epidote schist, glaucophan-chlorite schist originated bazic magmatic rocks and quartz-albite –chlorite schist, quartz-albite –muscovite schist, quartzite originated pelitic sedimentary rocks and locally marble, serpentinite.

Talc deposits mined in Örenli Village occur at Paleozoic aged schists related to Chlorite Subfacies of Green Schist Facies. These talc occurrences are considered to be one of the most important talc ore in Turkey.

It is thought that the initial carbonate rocks changed to talc minerals due to low-grade metamorphism. Talc mineralization contains a little carbonate minerals, chlorite minerals and opaque minerals.

Opaque minerals (pyrite, hematite, limonite) bearing talc samples were applied grind-flotation-enrichment processes. According to the data, it has been assigned that the most favourable grain measurement and the lightest coloured (whitish) talc concentration can be gained at – 63 micron fraction.

Talc is mainly used in ceramic, dye, paper, cosmetics-medicine and agriculture industries. After founding enrichment laboratories and applying the processes, talc beds in the study field, some 3 million tone reserve, would importantly contribute to Turkish economy.

Mineral Chemistry and Geothermobarometry of Some Silica Oversaturated Alkaline Plutons from the Post-Collisional Alkaline Plutonism in Central Anatolia, Turkey

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Post-collisional alkaline plutonism in Central Anatolia are subdivided into two subgroups such as silica oversaturated alkaline (ALKOS) and silica undersaturated alkaline (ALKUS) plutons on the basis of field, mineralogical-petrographical and wholerock geocehimstry data. The Baranadağ Quartz Monzonite and Hamit Quartz Syenite, constituting the most representative members of the ALKOS subgroup, are exposed to be emplaced within the medium- to high-grade metasediments of the Central Anatolian Crystalline Complex. The rocks of these plutons show medium- to corase-grained texture. The major and accessory constituents are composed of plagioclase + orthoclase + pyroxene (augite) + amphibole (hornblende, hastingsite) + biotite + quartz, and apatite + sphene + zircone + allanite minerals, respectively. Both of these plutons contain large K-feldspar megacrysts which, however, are commonly and typically observed in Hamit Quartz Syenite. Geological setting, mineralogical composition and wholerock geochemistry data reveal that both the Baranadağ Quartz Monzonite and Hamit Quartz Syenite have been derived from a single magma source which represents post-collisional, within-plate, A-type, and silica oversaturated alkaline characteristics.

The pyroxene, amphibole, biotite, plagioclase and orthoclase minerals of some rock samples from the Baranadağ Quartz Monzonite and Hamit Quartz Syenite have been analysed by the electron microprobe analyses (EMA)method for the mineral chemistry studies. The mineral chemistry data have been mainly used for the chemical nomenclatures/structural formulae calculations and the geothermobarometry studies among which the latter one particularly aims to approach the cooling depths of the plutons. The geothermometry studies include Ti content of amphiboles, amphibole-plagioclase geothermometry, amphibole-clinopyroxene geothermometry, feldspar pair (K-feldspar-plagioclase) geothermometry. As for the geobarometry study, it has been solely based on Al content of amphiboles. All these studies have concluded that a magmatic melt has been separated from main magma source to yield the Baranadağ Quartz Monzonite in a depth of approximately 15 km (or more) during the diapiric rising up within the crust in a post-collison geological context. The solidification of amphibole minerals in this magmatic melt from which the Baranadağ Quartz Monzonite has been derived has commenced to solidify at the conditions ranging from pressures of 5.0 kbars P (corresponding to cc 15 km) and temmperatures of 680 ^{o}C to 2.0 kbars P (cc 7 km) and 600 ^{o}C. The crystallisation of amphibole minerals in the magmatic melt of Hamit Quartz Syenite have occurred relatively shallow depths ranging from pressures of 4.0 kbars P (cc 13 km) and temperatures of 680 ^{o}C to 3.4 kbars (cc 11 km) and 600 ^{o}C.

Alteration and Mineralization in Darreh Zerreshk Porphyry copper deposit, Iran

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The Darreh Zerreshk porphyry copper deposit is located in central Iran (Yazd province). this area located between central Iran block in north east and the folded belt of zagros in the southwest.

The Darreh zerreshk porphyry copper deposit is one of the most important copper deposits in Yazd province. Proven reserves are estimated more than 30 million tonnes of disseminated sulfide ore grading 0.68% cu and less than <0.01% Mo. (Published data, COFI MINES company).

This deposit is hosted with in diorite - feldespar porphyry granodiorite rocks with age of Eocene which intruded to cretaceous carbonate rocks copper mineralization is associated mainly with potassic alteration and to lesser extent with phyllic alteration. mineral assemblage in this deposit consist of pyrite ,chalcopyrite, molybdenite , magnetite, bornite, sphalerite, chalcosite, malachite and azurite.

The purpose of this study is to evaluated detail charactristics of the hydrothermal alteration associated with this deposit and to identify the physical conditions and factors of cu mineralization and other ore minerlas.

In this manner we have done the following studies: (1) identification the alteration and vein mineral paragensis by combination of field observation, core logging and microscopic examination of polished thin sections, (2) fluid Inclusion study , (3) analyzation of rocks by NAA and AA, (4) isotope study of selected minerals.

Field observation petrographic studies and drill holes data demonstrate that Darreh zerreshk prophyry deposit have a irrigular alteration zone. hydrothermal alteration produced a potassic assemblage orthoclase + biotite ± chalcopyrite in central part of the main stock which is surrounded by phyllic alteration with Quartz +siricite + pyrite minerals. Phyllic alteration with aboundant veinlet mineralization is well developed. Argillic alteration with kaolinite + gypsium ± siricite surrounded by phyllic zone and propylitic alteration in external alteration zones.fluid inclusion studies indicalte that early hydrothermal fluids are contain both high and low salinity and high temperature fluids. These fluids are interpreted to present orthomagmatic fluid that maked alteration zone in Dareh zerreshk porphyry copper deposit.

GEOARCHAEOLOGY
and
GEOCHRONOLOGY

Origin of the building stones in the monuments of the ancient Troia

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Troia VIII (shortly before 700 BC – 85 BC): The Greek Period, Ilion

At the time, when Homer lived, the mostly abandoned site, like Troia was re-settled by Greeks from Asia Minor. Especially from the beginning of the 3rd Century BC, there was deliberate veneration of the "Holy City of Ilion", with the building of a sanctuary dedicated to Cybele outside to the Southwest, and of a temple to Athena inside the citadel. In 85 BC the site was thoroughly destroyed by the Romans.

Troia IX (85 BC – c. AD 500): Roman Period, Ilion-Ilium.

The temple of Athena was rebuilt, especially under the emperor Augustus. These are the remaining ruins of the monument: long sections of the massiv foundations supporting the porticoes and surrounding walls of the 9500 sq.m rectangular sacred precinct; altars and an assambly-hall, also a small covered theatre from the period of Augustus but rebuilt under Hadrian (the Odeion); not far from these a possible sports-and-baths complex with mosaic floors; and a large theatre set in a natural hollow to the Northeast of the temple mount. Ilion or Ilium receives generous patronage from Rome until the 3rd Century AD.

The building stones from the monuments have been studied in order to determine their origin. These monuments in Troia were mostly made from marble. To answer the question, where the marble comes from we present a systematic sampling and investigation of marble occurrences from the Biga peninsula and other Anatolian occurrences. In addition to the fieldwork studies, mineralogical, petrological, geochemical, isotopgeochemical and cathodoluminescence analyses have been applied. Comparative observations of the building stones with ancient quarries of the Biga peninsula provide evidence of the origin of the main building stones, but some stones are coming from greek marble occurences.

Thoughts on Tin and Taxes in Bronze Age Anatolia

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One of the enduring mysteries of the Bronze Age is the question of the source of tin for bronze production (see papers in Franklin et al., 1978*). While many bronze artifacts have been found during archeological excavations in Anatolia, there have been no discoveries of ancient tin mines that are convincing from the standpoints of geology and mining. The Göltepe complex near Çamardı (Niğde) was undoubtedly an important processing center (Yener and Vandiver, 1993) but, from a geological perspective, the nearby Kestel (Celaller) mine is far from representing a significant tin source, in that the highest grades encountered in hard-rock samples are only on the order of 0.5-0.6%; most reported grades are much lower (Çağatay and Pehlivan, 1988; Yener et al., 1989; Willies, 1990); how would the ancients have discovered such a low-grade tin source (Muhly et al., 1990; Hall and Steadman, 1991; Muhly, 1993; Sharp and Mittwede, 1994)? While some alluvial material from the Kuruçay streambed below the Kestel mine may have yielded cassiterite that could have contributed to bronze production, that is speculation.

As has been discussed by Muhly (1985), a certain amount of confusion has surrounded the Assyrian term AN·NA. Nevertheless, Assyriologists usually and most accurately translate this term as “tin”. Large Assyrian trading centers, known as “karum”s, were established around the city-states of Anatolia, and a major one of these was at Kültepe (or Kaneš, 20 km NE of Kayseri). Tablets found at Kültepe and other trading centers shed light on the types of goods that were brought into (textiles, ornamental objects and Sn [AN·NA]) and taken out of (Ag and Au) these trading centers and, more significantly, indicate rates of taxation on imported goods. In return for goods they brought into the trading centers, merchants were required to pay taxes, which varied according to the types of goods, to the ruler of the trading centers. Interestingly, the lowest tax rates were exacted on Sn (2.5-3% on Sn, and 5-6% on ornamental objects and woven goods), presumably 1) as an incentive to bring Sn for trading and, ultimately, for bronze production, and 2) because little Sn was known from Anatolia. According to Kültepe tablets, the “nishatum” tax was paid at a rate of 5% on textiles and wool, 5/120 on Ag, and 2/65 on Sn; furthermore, the “išratum” (tithe) tax was collected on cloth and other goods at a rate of 10%, but was not collected on Sn (Bayram, 1993).

Thus, the geologically unconvincing evidence reported by Yener and colleagues from the Kestel mine, combined with the evidence from Kültepe tablets, suggest that an important Anatolian source of Sn for bronze production remains an open question. While Anatolia may indeed host/have hosted Sn ores that were important for bronze production, the source of those ores is yet unknown.

[[1] Full references of works cited herein are available upon request from SKM]

The dune of Elaiussa Sebaste (Southern Turkey), Genesis and Archaeological Implications

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The ruins of a roman city, Elaiussa Sebaste, are located along the south-eastern coast of the Turkey, north of Cyprus, between the modern cities of Silifke and Mersin. Part ot these ruins lies on a promontory nowadays covered with dune sand and bordered by two coves both characterized by a pocket beach.

Collaborating with an archaeologic group excavating the ruins, different researches have been carried out with the aim of: i) locating the port area of the old city; ii) defining the place of origin of mortars and building materials; iii) understanding the origin of the dune, the source of the sand and the reason of the harbour infilling.

This note is about the studies carried out on the dune, which lies on a Miocene carbonate substratum. A detailed topographic survey of the deposit and of the its perimeter has been carried out with a differential GPS. The accuracy of the relief is about 10 cm. The collected data have been mapped with a contouring program. Compareing the data of the topographic survey of the dune to the results of several gravity prospectings, a map of the base of the dune and a map of the dune thickness variability have been obtained. Moreover the total volume of the dune sand has been calculated.

Afterwards a morpho-vegetationa survey of the dune area was carried and the analysis of the forms allowed: i) to define the directions sand travel which is mainly from NW towards SE, ii) to correlate the distribution of the vegetation with the dynamics of the sand and with the presence of manufacts or ruins below the surface of the dune.

17 samples of the dune have been collectd: 11 at the surface and 6 at about 30 cm below; other 12 samples are from the two pocket beaches: 9 from the northern beach and 3 samples from the southern one. Then, by means of drillings, the infilling of the old harbour in the back of the promontory has been sampled. Finally samples along the beaches and at the river mouths north and south the dune area have been collected.

The grainsize analysis of all the samples indicates that: i) the dune sediment is a well sorted medium-fine sand; ii) the sand of the pocket beaches is quite similar to the dune sand; iii) the grainsize of the sand from others beache increases north- and south-wards.

X-ray powder diffraction has been carried out on samples from the neighbouring beaches and from the dune. A further sample from the river Goksu has been also analysed. The diffraction patterns indicate that, despite the grainsize differences, the composition of the dune and beach sands is remarkably similar as the sand are prevalently constituted by calcite with some 15% weigth of quartz. Minor constituents are feldspar, pyroxene, amphibole, and serpentine. On the contrary some 10% weight of dolomite has been found into the sand from Goksu river. From the evaluation of the cell parameters of the various phases we are currently attempting to derive the provenance of the minerals constituting the sand.

The combined results suggest that in the Elaiussa area the wind has blown and elaborated sediments already selected by sea currents.

Radio-Geochronologic studies of the Tutkhun Group of the granitoid intrusions

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In the valley of the upper flow of Tutkhun river in the core of the Kazykhanlychai anticline the intrusion of the same name with apohyses. Among them one can identify the largest Agzybir in the South-East and the Mozchai in the North-East. The Kazykhanlychai intrusive brakes the dislocated in the NE direction terrigenous layers of the Albian-Senomanian, limestones of the Senomanian, nummulite limestones and effusive-pyroclastic rocks of the middle Eocene as well as the olistostromal and effusive-radiolarite benches of the ophiolite complex and makes a contact influence on them. The above mentioned intrusions are represented by the gabbroid and granitoid types of rocks with transitions into rocks with increased amounts of alkalines and subalkaline facies which are divided into I gabbroid and II granitoid phases. All these rocks are dissected by the postmagmatic steeply-occurring tectonic dislocations of the near-latitudinal, near-meridional and north-east strikes and they created a complex structure. Some of these dislocations are filled with dykes of the vein fauna of intrusions and later quartz veins with gold-sulphide mineralization which create the ore field of the Tutkhun field with its eight areas.

There exist no common opinion about the age of the enclosing rocks. They may be of the late Eocene-Oligocene, late Eocene, Paleocene-early Eocene (R.K. Gasanov et al., 1985), Oligocene (Z.M. Atakishiyev et al., 1987) age of intrusions of the Tutkhun group. To solve this problem we conducted radiochronologic studies by K-Ar method. We selected samples from the Mozchai and Kazykhanlychai intrusions. 10 samples were good for the radiochronologic purposes including 4 samples with weak features of the secondary changes and one sample of biotized metamorphized rock from the thrust of NW strike and SE part of the Kazykhanlychai intrusion.

The age of the Mozchai intrusion was determined 45 my and of the Kazykhanlychai intrusion - 45 my. Results of the studies allow to date time of the intrusion of the Tutkhun group and the associated gold-sulphide mineralization as late Eocene.

Archaeological Search of Northern Kocaeli

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The subject of this project is the geophysical investigation of the roman period found in Kocaeli. This surface investigation has been made within the framework of a 2 year project. The study has still been carried out. In the archaeological search, both magnetic and electrical methods have been employed. First of all magnetic measurements have been on tumulous in the region of Kocaeli. Modelling and power spectrum techniques have been applied on magnetic measurements, in the second step of the survey, structural parameters have been obtained by evaluating electrical measurements. Wenner electrode system was used for geoelectrical measurements. The resistivity data were shown on a map. After the mapping, the regions containing high magnetic properties were determined on the maps. After the low-pass filter was applied to the magnetic anomaly map for obtaining the shallow anomalies, the inversion method is applied to the selected profiles from the filtered map for determining the archaeological materials. The excavation boundaries were determined in the research area according to data obtained from both magnetic and resistivity methods. Thus this techniques are very helpful for archaeologists in the stage of planning an excavation. However, it could not possible to compare the geophysical results with possible structures since no excavations being carried out at this site yet.

Gravity prospecting at Elaiussa Sebaste (Southern Turkey)

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The roman city of Elaiussa Sebaste is located along the south-eastern coast of the Turkey, north of Cyprus, between Silifke and Mersin. The ancient city is located on a promontory that lean forward on the sea and at the present is between two sandy baies.

In ancient times the monumental complex was surrounded by the sea, and the promontory seemed an island connected to land by means of narrow isthmus. In fact, the literary sources, particularly Strabone, mention Elaiussa Sebaste site as an island.

To better understand the Elaiussa history, is determining to know the geological and morphological features that have conditioned its evolution in the times: at first Hellenistic city, then city and port during the period of the Imperial Rome and under Byzanthium, until the total abandonment during the Middle Ages.

To confirm hystorical data about the existence of the Elaiussa Sebaste port and to outline the morphology of a possible port basin, a gravity prospecting has been carried out.

Because between the insland and land is present a plane filled with sediments having low density and, on the contrary, along the slopes outcrop limestones with hight density, it is possible determine the thickness of filling deposits by means of a gravity prospecting, and then drawn the morphology of the port basin.

The gravity prospecting has been carried out on an area of about 30 ha with 420 gravity stations, and at the end, a interpretative model of the development of the ancient city has been realized.

OPEN SESSION

The role of 1D, 2D and 3D basin modelling in prospect identification and justification in petroleum exploration within exclusive models and medhods; A comprehensive basin modelling study from an Anatolian basin

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Basin modelling can be viewed as the testing of scientific hypotheses regarding geological, chemical, physical and geophysical processes and conditions occurring during the formation and evolution of a sedimentary basin. The objective of the paper is to present and discuss a detailed comprehensive 1D, 2D and 3D basin modelling study within all aspects from a petroleum exploration point of view aiming at the prospect identification, justification and risk assessment. A prospect from an Anatolian basin is evaluated using the most up to date methods and models applied in thermal history, maturity, pressure, compaction, generation and expulsion modelling consisting of the kinetic model Easy%Ro (Sweeney & Burnham, 1990) integrated with coupled fluid flow compaction, various subsidence (Steckler & Watts, 1978), permeability (modified Kozeny & Carman), porosity reduction (Sclater & Christie 1980; Falvey & Middleton, 1981; Baldwin & Butler, 1985), thermal (transient and basement heat flow), matrix and fluid conductivity (Deming & Chapman, 1989) models and calculations. Various basin parameters are simulated against time and are presented using movie sequences showing the 1D (wells), 2D (sections) and 3D (maps) model results together within a time window counting from past to the present day. Also, some of the significant parameters controlling geological and thermal history of the basin and petroleum system are evaluated and presented within a multidimensional framework combining virtual demonstration of the 1D and 2D or 1D and 3D model outputs with respect to the time. In consequence, generated and expelled hydrocarbons and potential oil accumulation amounts and volumes are gathered from the model results and presented using tables, graphs and movie sequences.

A Method for Assessing the Resolution, Sensitivity and Uncertainity of the Deterministic Models in Basin Modelling: Resolution Limits of the Easy%Ro Model

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One of the major contributors to uncertainties in basin modeling arises from the determination of the parameters necessary to reconstruct the thermal history which in turn is related to the importance of the thermal maturity in evaluating the petroleum potential of a sedimentary basin. Thermal maturity modeling is widely used in basin modeling for assessing the exploration risk. Of the available models, the chemical kinetic model Easy%Ro (Sweeney & Burnham, 1990) has gained acceptance in vitrinite reflectance modeling. In this study, thermal gradient is calibrated against vitrinite reflectance using the Easy%Ro model coupled with an inverse scheme in order to perform sensitivity analysis and assess the uncertainty. As a quantitative measure of mismatch between the modeled and measured reflectance values, the mean squared residual (MSR) is used. A 90 % confidence interval is constructed for the determined mean of the squared residuals to assess the uncertainty for the given level of confidence. The sensitivity of the Easy%Ro model to variations in the thermal gradient is investigated using the uncertainty associated with scatter in the calibration data. The best thermal gradient (minimum MSR) is obtained from the MSR curve for each well. In this paper, I intend to show how the resolution of thermal gradient is related to the control data and the applied model, Easy%Ro. The single parameter inverse scheme can be applied to investigate the quality of the calibration data and provides a quick assessment of the uncertainty and sensitivity of any parameter in a forward deterministic model.

Geochemistry of beach sediments from the southwestern Black Sea

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This study forms part of the project "Late Quaternary of the southwestern Black Sea shelf" which is supported by the Turkish Scientific and Technical Research Council-TÜBİTAK (Project YDABÇAG 198Y083). The main objective of this study was to collect and to interpret data to understand whether or not there are economically important mineral occurrences along the southwestern Black Sea coasts. With this in mind, a total of 127 sediment samples were collected from 16 beaches located between İğneada (near the Bulgarian border in the NW) and Kilyos (near the İstanbul Strait in the SE). Although the collected sediment samples represented foreshore, backshore and dune environments, the preliminary results discussed here were obtained from backshore areas. Compared to average composition of crustal rocks, sediments in this study are generally low in contents of Al (0.13-3.69%), Fe (0.33-4.92%), Mg (0.04-1.34%), K (0.64-1.43%), Ba (47-348 ppm), Th (1-7 ppm), Cu (1-25 ppm), Zn (5-40 ppm), Ni (1-37 ppm), V (1-91 ppm), La (3-29 ppm), Ce (5-53 ppm), Y (2-21 ppm), Li (3-12 ppm), Zr (1-28 ppm), Rb (11-42 ppm) and Hf (<1-3 ppm). Higher levels of elements were observed at some locations for Fe (5.8-12.8%), Mn (1473-2918 ppm), Co (28-53 ppm), Cr (101-595 ppm) and Ti (0.07-0.66%). Based on these results, it seems that Ti, Fe, Cr might be somewhat economically important in future although elemental concentrations measured here are far too small compared to the well-known marine placers in other coastal parts of the world. Studies are still going on.

Inorganic geochemistry of deep-sea sediments from the Çınarcık Basin (Eastern Marmara Sea), Turkey

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Late Quaternary inorganic geochemistry of deep-sea sediments was investigated in 3 gravity cores, from the Çınarcık Basin of the eastern Marmara Sea. Sediment cores were taken at 1248 m (327 cm), 1249 m (367 cm) and 1201 m (354 cm in length) water depths using the R/V MTA Sismik 1 in August 2000. The main objective was to understand the extent of which lithology, seismotectonics, anthropogenesis and depositional environment control the sediment chemistry. A total of 60 sediment samples were selected and analyzed for grain size, total carbonate content and 41 elements. Sediments were composed mostly of fine-grained mud and showed typically greenish gray to grayish green colors. The occurences of small scale, parallel laminated/layered coarse silt and fine sand units probably represent turbidite divisions. Total carbonate contents of sediments are usually low (5-15%) but slightly higher values up to 30% were also determined in core 14, from the western part of the study area. Compared to average composition of sedimentary rocks (i.e., shales, sandstones, carbonates), the sediments of the Çınarcık Basin contained higher Mn (up to 7019 ppm) whereas most of the other elements (Mo,Cu,Co,Fe,As,U,Th,Sr, V,Ca,P, La,Mg, Ba,Ti, Al,Na,K,Zr,Ce, Sn,Y,Nb,Be,Sc,Li,Rb and Hf) appeared to be at similar levels. The nearly uniform distribution of lithophile elements Al and Li in the cores suggest no major downcore changes in the lithologies. The overall high Mn contents of sediments could be related to diagenetic effects in the sediment column. On the other hand, Pb,Zn,Ni and Cr contents were found to be comparably higher in the uppermost core sections which probably indicate, at least in part, human-induced influences from the Greater İstanbul Metropolitan area. Studies are still going on.

GT Model: A model of taxonomic mapmaking Assessing the quality both before and after making the map

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Spatial data are displayed as maps on paper or on screen of GIS. *Taxonomic maps*, such as geologic maps, represents the spatial distribution of a given classification scheme. A map, of course, is only a mean for providing information to make important decisions. Therefore, the quality of map information or map-accuracy is a vital issue, since it affects the quality of the decision that will be made.

Obviously, map making is an important decision by itself, therefore having some knowledge about the quality of *future maps* that will be made by a known mapmaker is very important. *Before initiating a map making project*, the decision-maker likes to have some reasonable answer for relevant questions. For instance, will the map be worth of its cost? Will the map provide the information with desired quality?

The accuracy of maps made by remote sensing is determined by making a *ground truth* (GT) study. GT data is used to form a cross-classification table of the field reality *vs.* the map outcome, namely a *confusion matrix*(CM). This *observed* CM of the map provide the information for accuracy determination of the *finished* maps. Unfortunately, such evaluation cannot answer the question of future accuracy.

Often, the accuracy of the maps are mistaken as a measure of the mapmaker's performance, and as a measure of his future success. However, the *accuracy* of the map and *diagnostic capability* of mapmaker (or classifier) are not the same. Some correct classifications could be result of good luck, and <u>not</u> due to positive identification by the classifier. Hence, accuracy of the maps made previously by a certain mapmaker is an <u>inflated</u> measure for the mapmaker's diagnostic ability. Over two decades ago, GT-Index (Türk, 1979) created as a measure of diagnostic ability of mapmaker for a given class.

To answer the relevant questions of decision maker, a model of map making has been developed as an extension of GT-Index. This model facilitates calculation of CM by means of three sets of parameters: (i) GT-Index values of the mapmaker for a certain classification scheme, (ii) relative abundance values of each map category within the region to be map and (iii) the relative areas of each map-unit within the map. By means of this model (i) the interrelationship among the factors that affects map quality can be investigated, (ii) CM of a taxonomic map can be formed without making a special ground truth study, (iii) the quality and utility of taxonomic maps can be estimated before making the maps. This paper presents this model.

The Modeling of Primary Occurrences, Migration and Trap of Dadaş Formation to the North of Diyarbakır

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Dadaş Formation, which comprises marine shales, is a source rock. The petroleum initiated in Dadaş source rock within the subsurface were migrated from lower topographical levels up to high topographical levels. The petroleum dismissed from the source rock migrated within the overlying Hazro sandstones and underlying units of Bedinan formation as reservoir rocks. The primary migration of petroleum, presenting 20-23 API gravity within the Dadaş Formation, which uses Hazro sandstones as reservoir rock, were trapped in the fault controlled topographical high levels formed due to Cretaceous tectonism in the region. This is followed by the formation of "Hazro structure" which formed in response to Miocene tectonism. Also, within this time interval, formation of petroleum maintain from Dadaş source rock. Meanwhile, as the burial increases in response to continuing sedimentation, the formation of a higher gravity petroleum occurs. It has trapped in the Hazro structure formed as a result of Miocene tectonism, passing below the structure comprising the petroleum with 30-35 API gravity that has migrated from Hazro sandstones.

Organic geochemical characteristics of the Eocene units in southeast Suluova, Amasya, Turkey

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The aim of this study is to indicate the organic geochemical characteristics of the Eocene units in the southeast of Suluova (Amasya), Turkey. Eocene units consist of conglomerate, sandstone, siltstone, marl, mudstone, bituminous shale and coal.

Total organic carbon values were measured on 30 samples. The data obtained show that the total organic carbon values lie between 0.01 – 7.98 %. Generally, total organic carbon contents are higher in the shale facies than in other sediments. Rock-Eval analyses were made on 8 selected samples that have the highest total organic carbon contents. The hydrogen index (HI) ranges from 203 to 846 mgHC/gTOC, oxygen index (OI) ranges from 28 to 64 $mgCO_2$/gTOC in the samples. The organic matter can be classified as Type 1 and Type 2 kerogen on a Van Krevelen diagram. T_{max} values vary between 428° and 440^oC with an average 436^oC. These values indicate the catagenesis stage. According to the microscopic studies, organic matter is composed of predominantly of autochtonous algal and amorphous material, with contribution of terrestrial material.

When all the data are evaluated together, the Eocene units can be regarded as a source rock for hydrocarbons at some levels.

Organofacies characteristics of the Eocene units in the northern Çorum, Turkey

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The purpose of this research is the investigation of the organic facies characters for Eocene Armutlu formation, located to the north and northeast Çorum. There is Permo – Triassic Kalecikkaya formation at the base in the investigated area. This unit is cover by Jurassic Ağılönü formation. Armutlu formation was deposited with sandstone, siltstone, mudstone, marl and limestone alternation. Narlı volcanics consist of andesitic basalts and tuffs. This units overlain by the Oligo – Miocene Kızılırmak and Bozkır formation. All these units overlie by Pliocene – Pleistocene Kamışlı formation and Quaternary alluvial sediments.

The total organic carbon content of Eocene Armutlu formation is poor. Samples are formed terrestrial and reworked organic matter. Vitrinite reflectance values are between % 0,27 – 0,43 with an average % 0,34. According to this values, Armutlu formation is on the zone of diagenesis stage. On the contrary, Tmax value is between 435oC with an average 433 – 436oC. Hydrogen index value is between 33 mgHC/gTOC. According to datas, Armutlu formation hasn't a source rock of oil but may rarely product the gas. Organic geochemical and microscopic datas show CD and C organic facies.

Biogeochemical studies at the Musalı and Silifke-Anamur area in Mersin, Turkey

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Soil and plant samples were collected from 64 sites in Musalı and Silifke-Anamur area in Mersin, Turkey. The amount of Mn and Cu were determinated in all the plant species and their organs such as leaves, twigs and cones. It show that the Mn was highly concentrated in the twigs of Pinus brutia. Although Cu has not been reflection in this plant species. Morever, the content Mn in this plants were found linear relationship with these elements content of the soils and correlation coefficients (r) for Mn is 0.8830 (n: 48). Therefore, it is good indicators of the Mn concentrations in the soil and this species could be successfully used for biogeochemical prospecting. This species is typical and common species of the Mediterranean climate.

Geological geophysical prognosis of oil and gas potential of Mesozoic volcanites in the Kurin depression

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The growth of reserves of hydrocarbonation deposits in Kurin depression is connected whit a density decrease by fracture volcanogenous reservoirs of Mesozoic. The search for the way of prognosis of such reservoirs in a cross-section as well as localization therein of oil-potential zones in central part of Kurin depression in Azerbaijan was carried out with making use of geological-geophysical and gas-geochemical data. Determination of depth and outlining dimensional orientation of uplifts of Mesozoic volcanites is based on correlation of gravity and magnetic field anomalies with the results of seismic and electro-prospecting procedures. There exist a justified complex of gas-geocemical data for the areas of distribution in cross-section of Mesozoic disconsolidated volcanogenous rocks. The presence of contrasting high values of anomalies of heavy and light hydrocarbons above the volcanogenous reservoirs may serve as an indication of oil-potential in some areas. Combination of basement uplifts with the velocity inversion of longitudinal elastic waves in cross-section as well as of gravitational magnetic fields of anomalies allows to determine the relationship conditions of Mesozoic volumes distribution and the relevant types of oil and gas traps.

Application of the seismic method on determination of Petroleum-bearing zones in Azerabaijan

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The facts on gas release from Earth depths as a result of tectonic, seismic and volcanic activity allow to suppose that a great amount of natural gas accumulated in the Earth subsurface may be the source for hydrocarbons. The development of horizons occurring in great depths for growth of oil and gas results reserves demands at present scientific solving of a number of important problems. From this point of view the research for correlation of distribution of hydrocarbon seepage, oil and gas accumulations and zones of seismic activity with deep faults and their active lines is of spot interest. In the present work the association of deep fault systems with the characteristics of gas anomalies in Azerbaijan is considered. As original information for the correlation were used, on one hand, the map of deep fault systems made up by the procedure for joint use of geophysical field anomalies in complex with the geological data which reflect likely block model of the Earth crust and quantitative parameters of faults and, on the other hand, the maps of regional distribution of hydrocarbon gas field in petroleum-bearing areas complete on the base of gas survey data. The map of background and anomalies methane content appear at to be most effective and interesting in terms of interrelation that with the deep faults. Considerably high correlation is apparent between crossing knots of deep faults of different strike and characteristics of anomalous zones of light hydrocarbons. The dependence of increase of characteristics of light hydrocarbons anomalous zones on amplitude value of displacement of the deep faults along the consolidated basement and their level of occurrence is noted. Some of such anomalous zones and crossing knots for deep faults corresponds in the position of known oil and gas fields. High values for light hydrocarbons are observed in Gobustan region over the mud volcanoes occurrence zones, which are situated on or around major fault lines and their crossing knots. The general increase in elevated background in this region is recorded as one approaches the Shemakha crossing knot of large deep faults of the Caucasian submeridional and other strikes. The established relations between gas anomaly characteristics and the crossing knots of deep faults, which are to provide the better access to deep strata may areque for the hydrocarbon formation in deep strata.

TETHYS

Subsidence and Sedimentary History of the Eastern Black Sea Basin

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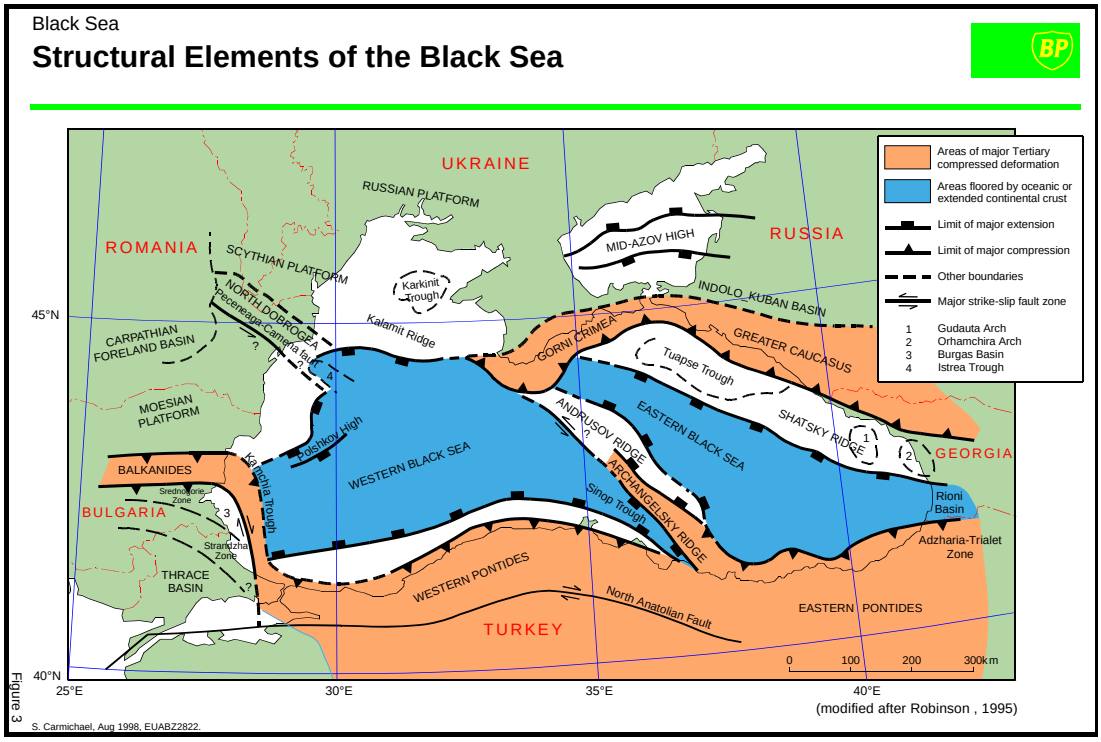
Oil and gas exploration activity within the eastern Black Sea (EBS) area has resulted in a significant volume of 2D seismic data being acquired. These data have formed the basis of ongoing studies into the tectonostratigraphic evolution of the EBS. The intent of this paper is to present an overview of the observed linkage between the regional tectonics and the subsidence and sedimentary evolution of the eastern Black Sea basin.

The EBS basin is one of two sub-basins, which comprise the present day Black Sea. It is considered to have formed during the latest Cretaceous to Palaeocene in response to clockwise rotation of the mid Black Sea high away from the Shatsky Ridge. This structural rotation caused sinistral strike slip displacement along the western margin of the Andrusov Ridge with the adjacent western Black Sea basin, which had its origins during the earliest Cretaceous. The margins of the basin are deformed as a consequence of Tertiary compression and uplift associated with the final closure of the Tethys Ocean. Basin subsidence and much of the post-rift sedimentary fill was contemporaneous with this compressional deformation. Foreland basin development occurred along the basin margins, locally modifying subsidence and exerting control on sediment depositional patterns. Post rift subsidence in the central part of the EBS resulted in some 12 km of sediment deposition. This appears to be at odds with the observed extensional fault controlled subsidence, which is relatively minor in comparison. The EBS has experienced significant changes in bathymetry, sediment supply and fluctuations from marine to lacustrine environments throughout its history, reflecting in a small scale the intense geological activity experienced by this part of the world.



Palaeozoic Additions to Central Europe: The identity and origins of crustal blocks accreted to Baltica along the Trans-European suture zone.

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Multidisciplinary studies of geotransects across the North European Plain and Southern North Sea, analysis of borehole data and reassessment of the timing of deformation belts across North-Central Europe have recently been undertaken. They permit a new model to be stablished for the sequence and timing of crustal block accretion to Baltica along the Trans-European Suture Zone (TESZ) during the Palaeozoic.

In south-central Poland, fossil, geochronological and sediment provenance data indicate that the Lysogory, Malopolska and Bruno-Silesian blocks, associated with the Moravian microcontinent, were attached to Baltica by the Late Cambrian in a first accretionary stage. This microcontinent was proximal to both the Uralide margin of Baltica and the Amazonian craton in Gondwana during the Early Cambrian.

Avalonia, underlying Central England, also has links with Amazonia. East of the Anglo-Brabant Deformation Zone, apparently similar basement extends to NW Poland. Borehole fossil and sediment provenance evidence indicates that this Avalonian basement docked with Baltica, in the second stage of Palaeozoic accretion, during the Ashgill, after rifting from Gondwana during the Llanvirn. Thus the Moravian microcontinent had already docked with Baltica while Avalonia was still attached to Gondwana. Beneath the North European Plain and Southern North Sea, deep seismic profiles suggest that Avalonian basement overrides thin ?proterozoic sediments overlying Baltican crust for up to 100 km, so the suture dips at a shallow angle to the SW.

The third stage of Palaeozoic accretion records the arrival of the Armorican Terrane Assemblage (ATA), comprising crustal blocks which migrated from Gondwana separately as an archipelago. The main collision with the S margin of Avalonia and Baltica occurred during the Carboniferous, accompanied by N-S compression and dextral transpression in the east where collision between the ATA, reconstituted into a single block during the Devonian with the closure of the Saxothuringian Seaway, and the west margin of the Bruno-Silesian block was particularly oblique. The latter junction, traceable north beneath the Polish Trough as the Moravian Line, is revealed by changes of Middle crustal structure and discontinuities of geophysical features recorded in the POLONAISE 1 and TTZ seismic profiles.

Triassic Blueschists and Eclogites from Northwest Turkey: Vestiges of Paleo-Tethyan Subduction

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Triassic eclogite and blueschist facies rocks occur as a thrust sheet, 25 km by 7 km, in an Eocene fold-and-thrust belt in northwest Turkey south of the Sakarya river along the İzmir-Ankara suture. They consist mainly of metabasites with minor marble, phyllite and metachert, and rare lenses of metaserpentinite. The common blueschist facies mineral assemblage in the metabasites is sodic amphibole + epidote + albite + chlorite + phengite ± garnet. Sodic amphibole commonly shows replacement by barroisite, and there is continuous petrographic transition from blueschist- to barroisite-metabasites. Eclogite with the mineral assemblage of garnet + sodic pyroxene + sodic-calcic amphibole + epidote is found only in one locality. P-T conditions of the epidote-blueschist facies metamorphism are estimated as 450 ± 50°C and 11 ± 2 kbar. The blueschist formation was followed by a decrease in pressure and increase in temperature leading to the recrystallisation of barroisite-amphibolites. Phengite and sodic amphibole Ar-Ar ages from three metabasites fall between 215 and 205 Ma, and indicate Late Triassic high-pressure metamorphism. The Triassic blueschists are tectonically over- and underlain by lithologically similar metabasite-rich units but showing only greenschist facies metamorphism.

The Triassic blueschists in northwest Turkey constitute part of a much larger allochthonous tectonic unit of Triassic mafic volcanic rocks, called as the Nilüfer unit. The Nilüfer unit probably represent the upper layers of a Triassic oceanic plateau, which was accreted to the Laurasian margin during the latest Triassic closure of the Paleo-Tethys. The close spatial association of the Triassic and Cretaceous blueschists along the İzmir-Ankara suture suggests that the suture represents a long-lived plate boundary of at least Late Paleozoic to early Tertiary age.

Geodynamics of the Tethyan Conveyer-Belt System

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In contrast to present-day oceans, Tethys had a stable asymmetric structure with the active Eurasian and passive Gondwanian margin. From the Late Paleozoic to Present lithosperic plates were moving towards the Eurasian margin i.e. towards the 3500 km wide subduction belt, within which the individual subduction zones were slowly migrating or jumping over long distances (Kazmin, 1999). A controversy exists about the forces that caused several stages of rifting on the Gondwana margin. In some cases this rifting resulted in continental breakup and formation of a new spreading axis. It was suggested that rifting occured either in a backarc setting (Sengor,1990), or was caused by the superplume activity (Segev, 2000). As work on reconstructions demonstrated, (e.g. the "Paleogeographic atlas of Northern Eurasia", 1998) rifting of the passive margin most probably coincided with periods when the active and passive margins were not separated by a divergent plate boundary (Kazmin, 2000). It was possible in two cases: 1) when a mid-oceanic ridge was subducted (end of the Paleozoic, end of the Middle Jurassic). 2) when a subduction zone jumped to a position close to the passive margin (end of the Early Cretaceous). In both situations the slab-pull of the subducting plate was transferred directly to the passive margin causing rapture along the pre-existing "weak zones", mainly the Late Precambrian sutures. One can speculate that the large-scale plate convergence after a head-along collision (e.g. India-Eurasia) is also driven by the slab-pull. According to Lobkovsky (1988), the lithospheric mantle can be decoupled from the crust and subducted for a long time in the course of collision, while the crust is being "scrapped", piled up or expelled laterally.

Causes and effects of Gondwana break-up and implications for the evolution of Neo-Tethys

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The break-up of Gondwana started during the Late Triassic-Early Jurassic as the Pangean supercontinent underwent rifting and dismantling in the central Atlantic region. Extensional tectonic events leading to continental breakup in the history of Pangea and Gondwana developed in the aftermath of global plate reorganizations and major collisional events (Caledonian-Appalachian, Alleghanian, Variscan-Hercynian-Uralian, Cimmerian), which obliterated several ocean basins and their seaways. Significant crustal shortening that accompanied these mountain building episodes resulted in the formation of a thick orogenic crust and a pre-conditioned, heterogeneous mantle. Rifting along the northern edge of Gondwana might have initially started as a result of extensional tectonic collapse of the Variscan-Alleghanian-Hercynian orogenic belt and evolved within a large megashear zone between Afro-Arabia and Eurasia that provided access to a nonuniform and historically contingent mantle source. Advanced rifting and continental break-up produced non-volcanic conjugate passive margins and “continental margin ophiolites” north of Afro-Arabia. Rift volcanism ensued through distinct pulses in Mid- to Late Triassic, Late Jurassic, and Early Cretaceous times and produced basaltic lava series with N-MORB, T-MORB, and OIB affinities. Diachronous, latitudinal opening of the Neo-Tethyan ocean tracts was facilitated by slow-spreading in transtensional and/or small marginal basins in the Alpine-Apennine, Dinaride-Hellenide, and Anatolide-Tauride orogenic domains, whereas by relatively fast-spreading in the Oman region to the east. Slow-spreading in a “cold” environment produced tectonically thinned, dismantled oceanic crust with extensive hydrothermal alteration and ore mineralization. Fast-spreading in a “hot” environment developed thick and complete oceanic crust with a layer-cake pseudostratigraphy and static hydrothermal alteration driven by crack propagation and conductive heat flow.

Continental rifting and dispersal within Gondwana to the south involved igneous activities associated with large-scale mantle plumes producing voluminous flood basalts (i.e. Paraná, Deccan, Karoo) and volcanic rifted margins. Increased plume activity and widespread emplacement of plateau basalt provinces and dike swarms in the late Mesozoic were nearly coeval with major episodes of seafloor spreading and oceanic crust formation. Robust magmatism that was spatially and temporally associated with rifting and continental separation in southern Gondwana followed times of enhanced supply of lithospheric slabs to mantle during previous episodes of subduction and continental convergence during the assembly of Pangea. The differences in the mode and nature of continental rifting from north to south within Gondwana were a result of different mantle response to the prior history of lithospheric plate activities.

Western Tethys Jurassic gaps as windows on the land. Interaction between hot-spots and gaps.

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Excellent outcrops with good fossils for timing and environmental reconstruction have been found in Apennines, Dinarids, Albanids, Taurids and Pontids, evidencing, in Jurassic stratigraphical sequences, the presence of the Mid to Late Jurassic discontinuity with a long gap and other hiatuses in Early Jurassic. Besides fossils, Sr-isotope analyses were made to have major information of ages, especially where good fossils were scarce. Limitedly to these eastern Mediterranean regions it has long been recognized that after Early Jurassic, the more active rifting phase is associated with drowning of some portions of carbonate platforms being the final setting of them drastically a reduction of the rimmed platforms. The sedimentary facies became pelagic, going the sea floor near the diphotic zone. The extensional faulting system caused the formation of wide ramps surrounding rimmed platforms, e.g. Barla Dag in Western Taurus, Umbria-Marche in Central Apennines, showing a strong influence of the open sea in shallow water.

But the surprising, unexpected event occurring during drowning was the general subaerial exposure, as enormous windows on the land, acting by opposite push contrasting the drowning. The longest Mid to Late Jurassic emergence is responsible of the sedimentary "main gap" widespread in Apennines, Dinarids, Albanids, Taurids and also Pontids. In the geological literature, the sequences of these regions were considered continuous, and no gaps were recorded. Therefore in palaeogeographical reconstructions, condensed sedimentation in deep basins was supposed.

By new data on the contrary, the carbonate platform-ramp systems went in subaerial exposure, reaching the land environment for average 25 Ma during the "main gap", from Early Bajocian to Kimmeridgian/Tithonian. This uplift event is related to the strength responsible of break-up of Pangea and ascribed to the hot-spot presence.

Within the term "hot-spots" there are included many types of phenomena, among them the lithopheric extension, not only the narrow deep plume tails extending to the core and the plume heads becoming responsible of the up-doming and more or less volcanic activity. Therefore the plume heads are the main aspect interesting gaps in the sedimentary evolution of margins of the diverging or converging plates, being involved in the uplift.

In Eastern Mediterranean regions, by facies analysis and the new detailed integrated stratigraphy, the reading of the Jurassic sedimentary history and consequently the palaeoenvironmental reconstructions are changing.

Role of the Misis-Andırın lineament in closure and suturing of the Southern Neotethys ocean in the Eastern Mediterranean region

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The Misis-Andırın lineament is widely interpreted to record the Late Cretaceous-Early Tertiary closure of the south Neotethys in the eastern Mediterranean region. However, widely different models are currently proposed: 1. Suturing occurred in the latest Cretaceous accompanying southward ophiolite emplacement onto the Arabian platform; 2, Suturing occurred in the Eocene-Oligocene coeval with inversion of the Syria Arc to the S; 3, Collision was delayed until the Late Miocene, followed by left-lateral "tectonic escape". In one alternative, collision occurred in pre-Miocene time, followed by transtensional basin formation, then a Late Miocene compressional phase.

We re-investigated the Misis-Andırın lineament during l999-2000 to test alternative models. Our provisional conclusions are: 1. Ophiolites were emplaced onto both the northern and southern margins of the S Neotethys in latest Cretaceous time; 2. Passive margin conditions resumed in the Palaeogene; 3, The S Neotethys sutured in Eocene-Oligocene time (diachronously), accompanied by dramatic mass-wasting to produce the Misis-Andırın melange (an “olistostrome”). In the Misis area, Upper Cretaceous ophiolitic extrusives were accreted to the over-riding plate during collision; 4. Miocene turbidites represent a flexural foreland basin (Adana-Karamaranmaras–Lice basin) related to on-going Africa-Arabia plate convergence. This basin was over-ridden by its hinterland in Late Miocene time, coupled with further mass wasting in the Misis area. Westward tectonic escape began in Early Pliocene time transecting the area with widely distributed left-lateral strike-slip faults. In the Misis Mountains the present topography of narrow linear ranges separated by Quaternary basins may relate to localised transpression. Finally, the evolution of the Misis-Andırın Range was kinematically linked with the Kyrenia Range (Cyprus) to the West and the Munzur Mountains to the E throughout the entire Neotethyan rift, drift closure history.

The Beyşehir-Hoyran-Hadim (B-H-H) Nappes: Mesozoic marginal and oceanic units of the Northern Neotethys in Southern Turkey

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The Beyşehir-Hoyran-Hadim (B-H-H) Nappes (Özgül, l997) occur in four main outcrop areas, over ca. 300 km, laterally: Karaman (in the E), Bozkır, Beyşehir and Hoyran (in the W). Regional units in upward tectonic order are: 1. Authochthonous Tauride carbonate plaform (Cambrian-M. Eocene); 2. Allochthonous Hadim Nappe-Devonian-Late Cretaceous); 3. Ophiolite-related units (e.g. harzburgitic thrust sheets and U. Cretaceous mélange); 4. Allochthonous Bozkır Nappes (Triassic-Late Cretaceous). However, the Hadim Nappe is absent from the Hoyran area (W). Our work focuses on the Bozkır Nappes, the uppermost regional unit. In the type (central) area the nappes begin with a thrust sheet (ca. 400m thick) of mainly redeposited carbonates, quartzose sandstones and mudstones of Mid-Late Triassic age (Korulan Fm.), interpreted as a proximal slope/base-of-slope succession. Tectonically above is an intact succession (ca. 1 km) of Mid-Late Triassic alkaline volcanics and volcaniclastics (Huglu/Dedemli unit), interbedded with minor pelagic carbonates, viewed as rift-related volcanism. This is depositionally overlain by a thin (<100m) succession of Upper Triassic-Upper Cretaceous pelagic carbonate and radiolarian chert. Above, the uppermost unit comprises sheared thrust sheets, broken formation and mélange, including Jurassic shallow-water carbonates, radiolarian chert and Upper Cretaceous pelagic limestone. Similar units are seen elsewhere in the B-H-H Nappes, but the stacking order varies (e.g. Beyşehir). Zones of tectono-sedimentary mélange ("wildflysch") commonly separate higher units (e.g. Beyşehir area). The B-H-H Nappes document Triassic rifting and later-Mesozoic seafloor spreading within the northerly Neotethys. The harzbugitic ophiolite (e.g. Dipsiz Göl ophiolite) probably formed above a subduction zone. The ophiolite was emplaced southwards onto the N margin of the Tauride platform in latest Cretaceous (area of the future Hadim Nappe). Suturing was delayed until the Late Eocene when the Hadim, plus Bozkır, nappes were thrust southwards. Assuming in-sequence thrusting, the Bozkır Nappes restore to a location north of a Neotethyan spreading axis. Alternatively, they originated near the northern margin of the Tauride microcontinent, but reached their final position by Eocene out-of-sequence (re)thrusting.

Origin of the Çetmi melange (N-W Turkey)

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The poorly known Çetmi Melange is located in the west of the Kasdag Group in the Biga Peninsula (N-W Turkey). It represents a former accretionary complex and was considered as the western continuation of the Intra-Pontide suture (Okay et al, 1991, 1996), defined as the southern boundary of the Strandja and the Istanbul zone (Sengör, 1981).
The different lithologies observed as blocks in the Çetmi melange are:

- Different types of limestones of various ages (Anisian red hallstatoid blocks, Norian-Rhaetian white large neritic and pelagic blocks, and Late Cretaceous red micritic blocks).
- Red or green radiolarites (Late Jurassic).
- Magmatic rocks of andesitic type, serpentinites and some detritic sediments.
- Two large tectonic slices of garnet-micaschist and eclogite also occur, whose HP metamorphism has been dated at 100 Ma (Okay and Satır, 2000).

We consider that this melange represents a former mixed accretionary complex with different origins for its components (see Beccaletto and Stampfli, 2000) : based on lithological similitudes and paleogeographic reconstructions, we allocate the Anisian and Norian-Rhaetian limestones to a Meliata-Küre oceanic passive margin domains, whereas the Late Jurassic radiolarites and Late Cretaceous limestones could be part of a Vardar-Izmir/Ankara oceanic domain. The andesitic rocks could record the magmatic activity linked to the subduction of the Meliata ocean and/or Vardar ocean.

Therefore we prefer to propose a duplication of the Izmir/Ankara suture (outcropping and defined farther south of the studied area) rather than the existence of a narrow new oceanic domain (the Intra-Pontide ocean), as on explanation for the present day location of the melange.

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Petrogenesis and tectonic setting of the Saraykent silicic volcanics, Yozgat, Turkey

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Early Upper Cretaceous-Paleocene volcanic rocks of the Saraykent district range in composition from calc-alkaline basaltic andesites to dominant rhyolites.

The basal lavas range from calcalkaline basaltic andesites to dominant rhyolites. Based on trace element correlations three main geochemical groups were identified: the Akçakışla rhyolites (present as domes), Akçakışla rhyodacites-dacites (lava flows), and Ozan-Saraykent rhyolites (lava flows). LIL elements have been mobile in all the groups, but mainly in the Akçakışla rhyolites. REE patterns show the marked similarity between the Ozan and Saraykent basal lavas. The Akçakışla dome rhyolites are more fractionated with lower La_N/Yb_N ratios (~ 10), whereas the Akçakışla basal lavas have much higher ratios (La_N/Yb_N ~30) . The chemical coherence and petrographic similarities between the Saraykent and Ozan lavas suggest a single suit related via fractionation.

Three geochemical groups were also established for the ignimbrites: Saraykent ignimbrite, Bağlıca ignimbrite-Toklu-Kızıldağ Crystal Tuffs, and Keklikpınar ignimbrite. The ignimbrites, like the basal lavas, display a pronounced depletion in Ba on ORG-normalized plots. Relative to the basal lavas, chondrite-normalized patterns for the ignimbrites are different in displaying negative Eu anomalies that indicate feldspar fractionation. TiO_2 and P_2O_5 contents of the Keklikpınar ignimbrite are found to be typical for a high-silica rhyolite, whereas those of other ignimbrites are typical for low-silica rhyolites. The lack of geochemical overlap or coherence between any of the lava and ignimbrite groups suggests they represent distinct eruptive events and are not related in any simple volcanic development and cogenetic sense.

Two geochemical features are common to all the volcanic rock groups: 1) the presence of a Nb-Ta anomaly, which is generally accepted as a crustal signature, and 2) the relatively low Y abundances which appear characteristic for the region as a whole. These fundamental features of the local silicic volcanism largely reflect source composition and effects.

Petrology of Late Berriasian-Late Hauterivian and Conomanian oceanic basalts within the Central Sakarya ophiolitic complex, NW Turkey: Constraints for the evolution of the İzmir-Ankara oceanic branch of Neotethys

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Within the Late Cretaceous İzmir-Ankara Suture Complex (IASC) in central Sakarya area, two adjacent tectonic slivers of basaltic pillow lavas with red chert-mudstone alternations have been studied in detail.

The radiolarian assemblage of the first slice is characterized by the following taxa: *Angulobracchia* (?) *portmanni*, *Godia nodocentrum*, *Pantanellium squinaboli*, *Thanarla brouweri*, *Pseudoeucyrtis tenuis*, *Svinitzium mizutanii*, *Mirifusus dianae*, *Tethysetta boesii* indicating a late Berriasian-late Hauterivian age. The radiolaria fauna from the second slice yielded: *Thanarla pulchra*, *Novixitus mclaughlini*, *Pseudodictyomitra pseudomacrocephala*, *Pseudodictyomitra tiara*, *Stichomitra communis* that reveals a Cenomanian age.

The stable incompatible elements of the late Berriasian-late Hauterivian and Cenomanian basaltic samples demonstrate the relative evolution of two different petrochemical groups. In terms of magma type, the late Berriasian-late Hauterivian Ti-augite phyric pillow basalts and breccias are chemically classified as alkaline and display a considerable compositional overlap with the WPAB field similar to those found in oceanic islands (OIB). The MORB-normalized multi-element diagrams of them are characteristically enriched in most incompatible trace elements with typical (OIB-like) humped pattern showing peaks around Rb, Ba, Nb and then decrease in an irregular fashion. The depletion of the highly incompatible elements (relative to K) indicates that alkali basalts have been derived from an OIB mantle source and could represent intra-plate seamounts. The Cenomanian pillow basalts are subalkaline in composition and plot within the N-MORB field. Moreover, they display geochemical affinities more akin to N-MORB with a flat pattern close to unity and represent the formation basalts in the ridge segment of an oceanic crust during Cenomanian.

The first finding confirms the formation of hot spot-related oceanic seamounts within the IA oceanic crust during the Early Cretaceous, whereas the early Late Cretaceous age from the MORB-type basalts is the youngest spreading age so far obtained.

Tholeiitic and alkali basaltic magmatism in the Kılıçlar area (Elmadağ-Ankara): dismembered Cretaceous ocean floor and ocean island edifices from the Ankara Melange

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A geochemical study was undertaken of a structurally continuous suite of Cretaceous basalts subjected to low-grade metamorphism in the Kiliclar area, 60 km SE of Ankara. While these rocks form part of the tectonically-disrupted Ankara melange in the Anatolian Nappe, field observations show the existence of continuous non-disrupted sequences several hundreds of metres thick. All the basaltic rocks, including high-level sills, analysed from the sections west of the river valley, N of Kiliclar, are tholeiites of MORB affinity. Their association with radiolarian cherts is typical of an oceanic setting. By contrast, basaltic rocks collected on the east side of the valley (Floyd 1993) which appear to overlie the Kiliclar tholeiites with no recorded intervening disruption, exclusively comprise alkali basalts, of probable ocean island basalt (OIB) affinity. The proximity of these two basaltic suites and their contrasting chemistry suggests that in the Kiliclar area there is preserved within the Ankara melange an original relationship between Cretaceous ocean floor and a seamount edifice.

Konya HP Belt Metabasites: Aspects of Petrology and Geochemistry

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The Konya HP belt consists of a segment of the Kocyaka Metamorphic Complex situated on the southwestern margin of the Central Anatolian Crystalline Complex (Kirsehir Block). The local tectonostratigraphic succession consists of Upper Cretaceous calc-schist metasediments overlain respectively by the Altinekin & Akcasar melanges containing various blocks of ophiolitic character, now exhibiting HP glaucophanitic assemblages. The Altinekin melange is dominated by a calc-schist matrix containing meta-basaltic blocks (often phyric pillow lavas), whereas the Akcasar melange has a sparse serpentinitic matrix with abundant blocks of metabasalt, amphibolite, serpentinite and metachert. The whole sequence is interpreted as an inverted, mechanically fragmented segment of oceanic lithosphere that was disrupted and metamorphosed to high grade in a subduction zone adjacent to the Sakarya microcontinent.

The calc-schists and the matrix to the Altinekin melange form a chemically coherent group with compositions ranging from pelagic to calcareous sediments, They are interpreted as mechanical mixtures of typical oceanic sediments that cap ocean floor or ophiolitic sequences, with the addition of a minor volcaniclastic input. The majority of the metabasaltic blocks in both melanges are chemically related and form a single comagmatic group of meta-tholeiitic basalts. Meta-alkalic basalts are also present, but rare. The tholeiitic basalts exhibt a range of compositions that suggest they have undergone olivine and plagioclase fractionation; the latter phase can still be recognised as a relict within the HP assemblage matirx. The meta-tholeiitic basalts generally have depleted incompatible element patterns that resemble N-MORB in character, but display a wider range.

Compared with the SSZ stratiform ophiolites of the Central Anatolian Crystalline Complex (CACC), they do not have island arc tholeiite compositions, but instead resemble basalts typical of back-arc basins. It is suggested that the arc basalts of the CACC and the back-arc basalts of the Konya belt may have formed an arc-back arc pair during the Upper Cretaceous. This conclusion removes the need for a separate Inner Tauride ocean unconnected to the northern Neotethyan oceanic strands.

Structure and Formation of Loki Solient of Transcaucasian Basement

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The structure of Loki salient as well as the other ones of Transcaucasian basement seems to be more complicated than considered earlier. The most part of the salient is composed with Hercynian granitoids, although, metamorphic rocks formed under different paleogeographic environment and geodynamic regimes in the very beginning are also met. Among them it should be noted magmatic complexes of such structures as island arcs and intraplate volcanic islands (metabasites), as well as series of passive continental margins. Metabasites and metapelites are intermingled with each other as result of repeated tectonic clustering in the form of sheets and scales. Evidently, Loki salient was being formed during Late Proterozoic and whole Phanerozoic eras. Apparently, metabasites represent Prototetis fragments, obducted on the southern end of East-European continent during Early -Middle Paleozoic era. Metamorphytes along with gneissic-migmatite complex of Transcaucasian massifs bear resemblance with immature continental crust of Nubian-Arabian schield and are obducted on the southern edge of East-European continent within the confines of which mature continental crust of Caucasian part of active margin was formed. Tectonics and overthrust directed northward of Transcaucasian basement (including Loki massif) took place within Late Paleozic and Early Mesozoic eras. As for modern anticlinal structure of Loki salient, it was formed as a result of Alpine phases of tectogenesis.

The M - Type Siah Kuh granite batholith SE of Kerman/Iran: Evidence for initiation of Neotethys subduction in Triassic Time

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The upper Triassic granite batholith of Siah Kuh, which lies in the Sanandaj-Sirjan metamorphic belt, is intruded into upper Devonian-lower Carboniferous metamorphic complex mainly of greenschist facies. Their contact is marked by recrystallized amphibole. The granitic rocks show low LIL and HFS element abundances, low Rb/Zr ratio which reflects to the non involvement of crustal contamination. Geochemical data, multielement and various trace element dicriminant diagrams, the presence of K-feldsapr interstitial micrographic texture along with lower Ta, Nb, Hf, Y abundances indicate that the Siah Kuh granitic rocks have characterisitics of tholeiitic , metaluminous, M-type granites of primitive island arc settings. These rocks are probably formed in pre-plate collision by the onset of subduction of Neotethys oceanic crust beneath Central Iran in Triassic time and from a parental magma which derived directly from the partial melting of mantle or subduction oceanic crust beneath the island arc.

Collision-driven mantle flow and crustal response in the Eastern Mediterranean region during the late Cenozoic

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The neotectonic evolution of the eastern Mediterranean region is driven by the collision of the Arabian and African plates with Eurasia. Since 17 Ma the collision of Arabia has contributed to the westward translation of the Anatolian microplate, which has been undergoing crustal shortening and uplift in the east and strike-slip tectonics, crustal extension and subsidence, and widespread magmatism in the west. The westward tectonic escape of Anatolia has also been facilitated by the rapid rollback of the Hellenic slab that is responsible for radial extension in the Aegean province in the upper plate. We propose that the westward translation and the internal deformation of the Anatolian microplate, the slab rollback at the Hellenic Trench, and the opening of the Aegean proto 'marginal basin' are all manifestations of the supra- and sub-slab flow fields in the mantle within the broad field of continental collision in the eastern Mediterranean region throughout the late Cenozoic.

Shear wave splitting measurements of sub-slab mantle anisotropy beneath the Hellenic Arc and of mantle anisotropy beneath Anatolia reveal that the mantle flow field in this region is strongly controlled by the relative motions of the deeply-rooted cratons of Africa, Arabia, and Eurasia surrounding the westward extruding Anatolia. The flow field beneath the oceanic lithosphere of the African plate subducting northwards at the Hellenic Trench is best characterized as W or WNW flow parallel to the slab face; beneath Anatolia, the sub-slab flow field generally trends N-NE. We interpret the latter flow field to represent a predominantly sub-slab flow since source-side S-wave splitting, which samples below slab strictly, and a single surface measurement at GSN station ANTO are similar in fast-shear wave trend and delay time. Thus the mantle flow field beneath Anatolia reflects channelized flow in a down-dip direction at the slab edge, where flow parallel to the slab is redirected to the east by thick (300 km) Arabian cratonic lithosphere south of the collision zone. Shallow mantle asthenosphere, formerly lying between the thick lithosphere of Arabia and Eurasia, has extruded westwards beneath Anatolia and flowed into the supra-slab region of the Aegean province, forcing back or increasing the rollback velocity of the subducting Hellenic slab. The crustal deformation and landscape evolution in the eastern Mediterranean region are thus an artifact of a lateral mass transfer at shallow mantle levels beneath Anatolia as the eastern Mediterranean basin closes.

CENTRAL ANATOLIAN GEOLOGY

Tectonic units and geological evolution of the Çankırı Basin

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Six tectonostratigraphic units have been differentiated in and around the Çankırı Basin, Central Anatolia. The Kırşehir unit to the south, formed from high-grade metamorphic rocks of controversial origin and age. The Karakaya unit forming the basement of the Sakarya continent consists of metamophic, sedimentary and volcanic rocks which are products of Karakaya marginal basin. Both the Karakaya and the Kırşehir units remained as continental basement along the Neo-Tethyan evolution of the region.

The Sakarya unit representing a passive margin sedimentary prism facing to the Neo-Tethys ocean to the south of the Sakarya continent, consists of Lias to Upper Cretaceous sediments. During the Late Cretaceous an extensive magmatism developed on these passive margin sediments indicating that this passive margin turned into an active margin due to nortward subduction of Neo-Tethys. This ocean consumed along two subduction zones, one beneath to the Sakarya continent and other beneath to its floor. The Kalecik unit consists of accretionary prisms, ensimatic arc magmatics and overlying regresive clastics.

At the end of the Maastrichtian the Neo-Tethys closed, these oceanic and continental entities amalgamated into each other, and they formed an orogenic mosaic. The Çankırı basin started to open during the Late Palaeocene(?)-Early Eocene, it reached its deepest position during the Middle Eocene and gained an intramontane basin nature since Late Eocene. The İskilip unit represents the Eocene sedimentary fill of the Çankırı basin. The Miocene Çankırı unit consisting of clastics and evaporites deposited in this intra montane basin.

Surface and Subsurface Characteristics of the Çankırı Basin (Central Anatolia, Turkey)

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The geology of the Çankırı Basin has been studied using multi-source data including satellite images, aerial photos, gravimetric data and seismic sections, which are subsequently used to generate maps and a 3D model of that part of the basin that is covered by the seismic sections. A geological and a lineament map of the basin were obtained using remotely sensed data together with published data and fieldwork results. The subsurface geology of the basin was interpreted from seismic sections. The lateral continuity of the units and the structures have been compiled into a 3D GIS, which was used to construct fence diagrams. In the seismic sections, buried thrust belts are recognized, one in the northern part of the Çankırı Basin and the other on the eastern margin of the Çankırı Basin. From the compilation, three different phases of deformation are recognized. The earliest phase is characterized by thrusting and took place in the Early Tertiary. The second deformation phase is characterized by extensional deformation associated with normal faulting in the latest-Early Miocene to Middle Miocene. The latest phase is characterized by compressional deformation that inverted some of the normal faults that had been developed in deformation phase 2, and has been active from the Late Miocene to Recent. It was also observed in the seismic sections and in the constructed fence diagrams that the Early Tertiary units have a wedge like geometry being thicker in the north and the east and becoming thinner towards the basement. This relationship together with regressive character of the basin in-fill, as observed in the field, is attributed to contemporaneous thrusting and sedimentation in the Early Tertiary. Growth faults have been recognized in the latest-Early Miocene to Middle Miocene units and are attributed to an extensional tectonic regime in the Middle Miocene. Some growth faults were inverted and this is interpreted to be an indication of a new compressional deformation regime after the Middle Miocene.

A neotectonic pinched crustal wedge in the west of Çankırı Basin accommodating the internal deformation of Anatolian Plate

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Intracontinental convergence related to the closure of Neo-Tethyan ocean in NW central Anatolia has been suggested to continue until Late Pliocene (Ankara Orogenic Phase). However, the continuation of intracontinental convergence until the Late Pliocene has been questioned because the south-vergent thrust relationship between Neogene succession and Neo-Tethyan suture zone is not confirmed around Yuva village in the NW of Ankara. Instead, an extensional regime has been suggested during the Miocene due the orogenic collapse by using mainly geochemical evolution of Galatian volcanics. In the Pliocene a transpressional/ tensional regime has been proposed as a result of strike slip movement on the North Anatolian fault. The geological setting of Oyaca-Kedikayasi dacites and their isotopic ages lead researchers to admit the cessation of the intracontinental convergence by Early Miocene. Moreover, recent kinematic and structural study also proposed an extensional regime during Middle Miocene due to the gravitational collapse in NW central Anatolia.

The Neo-Tethyan suture exposed along a NNE trending topographic high between Ankara and Çankırı that act as pinched crustal wedge thrusting eastward onto different stratigraphical levels of the Neogene successions of Çankırı basin; however its western side shows a normal fault relationship. The field studies demonstrate that this pinched crustal wedge was inactive during the accumulation of the Miocene - Lower Pliocene sedimentary units and was created by the movement of the North Anatolian Fault Zone and its splay after the Late Pliocene that produces NW-SE contraction, NE-SW extension between Ankara and Çankırı. Recent 6.6.2000 Orta earthquake focal mechanism solutions support this contention and seismic activity between Ankara and Çankırı suggest that this wedge can accommodate the internal deformation of Anatolian plate.

Although recent kinematic and structural work suggests similar regional stress pattern following Late Miocene, the Neo-Tethyan suture has been evaluated as (a) double vergent thrusted wedge towards east and west (b) east vergent imbricate zone in which Neogene units thrust over Neo-Tethyan suture zone (c) sinistral strike-slip fault zone. This interpretation is completely different not only in a structural point of view but also by its role on the Neogene basin formation than the pinched crustal wedge model.

Rotations of fault-bounded continental blocks around the Çankırı Basin, North Central Anatolia

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Çankırı basin, one of the biggest Tertiary sedimentary basins of Central Anatolia, is located between Sakarya and Kırşehir Continents which are separated by an Ankara-Erzincan ophiolitic suture. The Çankırı basin started to open during Late Palaeocene(?)-Early Eocene reached its deeper position during Middle Eocene, then shallowed since Late Eocene. Volcanic rocks associated to the later stages of the deposition. The basin was affected by extensional and following strike-slip tectonic regimes during Middle and Late Miocene, respectively. During this period terrestrial clastics and evaporites deposited within the basin.

North Anatolian Transform Fault and its southward splaying branches cut and divide both the eastern margin of the Çankırı basin, Tokat massif, and the basin infill into fault-delimited blocks. Palaeomagnetic studies indicate that these fault-bounded blocks have been affected by vertical block rotations. They rotated clockwise and anticlockwise according to the geometry and type of the faults delimiting them.

In this study we describe palaeomagnetic data from the Eocene magmatic rocks of the Çankırı basin and surroundings and propose a model for their different movements.

Geochemical characteristics of collision-related Eocene volcanism around the Çankırı Basin, North Central Turkey

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This study presents initial geochemical findings of our projects on the collision-related Eocene volcanic units exposed around the Çankırı basin, North Central Anatolia. The volcanic units under consideration are interfingered with sedimentary units of the Çankırı basin which postdates the collision. Previous studies to date have shown that Çankırı basin had a complex evolutionary history being initiated as a fore-arc basin during Upper Cretaceous, and gradually changing into a post-collisional sedimentary basin after the collision of Sakarya and Kırşehir micro-continents along Ankara-Erzincan suture. Volcanism started in the Middle to Upper Eocene coeval with the thickening of the crust at the base of the basin by south-vergent thrusts.

On the basis of their petrography, the lavas may be divided into two volcanic series: (1) hydrous (PAm) and, (2) anhydrous (POAM). Anhydrous series is further divided into plg+olv-phyric and plg+cpx-phyric lavas while hydrous series is represented by plg+amp-phyric and plg+biotite+amp-phyric lavas. Anhydrous lavas span a compositional range from basalts to andesites with only a few samples classifying as andesite. Hydrous lavas, on the other hand, cover a broader compositional range from basaltic-andesites to rhyolites. The PAm – POAM division is also apparent in trace element fractionation trends: in hydrous series MREEs (and also Y) show negative gradients with increasing silica in contrast to positive gradients displayed by anhydrous series. Variation diagrams involving highly compatible and incompatible element pairs indicate that magma replenishment and mixing were important processes in the magma chamber evolution of these lavas.

Lavas of both hydrous and anhydrous series are calc-alkaline in character with a subset of samples exhibiting shoshonitic signature and only a few samples displaying alkaline affinity. All lavas exhibit a selective enrichment in LILEs and LREEs over HFSEs relative to MORB. Compared to younger (11-2 Ma) collision related lavas of the Erzurum-Kars Plateau in the east, these lavas display a more profound depletion in HFSEs. This can be regarded as indicative of a depleted lithospheric mantle source enriched by a distinct subduction component. We believe that this subduction component was inherited from a previous subduction event, which imprinted its signature on this part of the lithospheric mantle.

Geology and tectonics of the Ankara suture and its bearing on the development of the Central Anatolian (Haymana and Tuzgölü) basins

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The study area, which is located to the south of Ankara province, is a tectonic mosaic consisting of different continental fragments and ophiolitic suture. The suture represents a zone of collision along which the easterly located Kırşehir massif collided with the westerly located Sakarya Continent. The Continents have completely different metamorphic basement associations overlain by different rock sequences. The sequence in the Sakarya continent displays development of a passive continental margin during much of Mesozoic. On top of this an active continental margin sequence and volcanics began to develop during the late Cretaceous. Later a back-stop (The Samsam high) was formed from accreted melange at the edge of the continent. This high led to the development of two separate basins; the westerly-located basin formed above the Sakarya continent was a fore-arc basin (the Haymana basin). The easterly-located basin underlain by an ophiolitic melange and an ophiolitic substratum, and represent a deeper basin (the Tuzgolu basin) formed at the end of the Late Cretaceous. The accreted melange back-thrusted onto the Sakarya continent. The Remnant oceanic basin began to be progressively filled with clastic materials during the Late Cretaceous-Early Eocene period, and then was completely terminated. Due to the continuation of collision in the Late Eocene period, the sedimentary association of the Haymana basin together with the Samsam ophiolitic association thrusted over the sedimentary association of the Tuzgolu basin sequence. While uplift and rapid erosion around Haymana region occurred, around Tuzgolu region continental clastic and evaporite deposition in a basin severed from open sea took place during Late Eocene-Middle Miocene period. In the late Miocene-Pliocene period, the erosion of Haymana province formed a peneplain and the whole study area was covered later by a widespread lake environment.

The "Sivas Fold and Thrust System" in the Central Anatolian Thrust Belt of Turkey-timing, kinematics, magnetic fabrics and displacement

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The Central Anatolian Thrust Belt corresponds to intra orogenic basins, with nearly complete Neogene continental deposits, showing a contrasted tectonic complexity and loosely termed the Central Anatolian Basins. The so-called "Sivas basin" is the main representative of that belt occurring at a specific location along the junction between the Taurides and Pontides.

An area around Sivas, crossing the "Sivas fold and thrust system" will be examined in some details.

The geometry of this anticlinorium can be reduced to the superposition of three distinct structures from north to south: the Ishani anticline, the Sahbey duplex and the Doganca anticline. The tectono-stratigraphic evolution displays two stages of folding at least (preTortonian and Mid Pliocene). The kinematics have been derived mainly from joints and microfaults analysis, no real schistosity exists and the strain is extremely low. To get a better assessment of the kinematics, the coupling of the fault kinematics with the "fabric" of the Anisotropy of the Magnetic Susceptibility (AMS) has been considered. The AMS is demonstrated to be an efficient tool to record subtle internal deformation resulting from compaction effects, layer parallel shortening at a pre-buckling stage and reconstruction of the "magnetic foliation" during folding.

The coupling is validated and verify the homogeneity of the regional direction of the kinematic axis: NW-SE for the principal plane of movement and NE-SW for the "secondary" plane. No clear evidence of a major change in the kinematic directions related to the two steps development of the whole structure has been recorded, though a N-S direction is observed locally.

The computation of the displacement implied by the geometry and kinematics of the thrust related folds of the section is not straightforward. A strict geometric balancing is not pertinent in such a situation where décollement folds are the prevalent structures. The geometrical features are more efficiently assessed by experimental results obtained in modelings of Coulomb thrust wedges including soft and hard materials as analogues of the gypsum and sandstone of the stratigraphic section.

Geotraverses across Central and Eastern Anatolia: Tectonics and Paleogeography

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Some representative crustal sections based on precise surface geology have been constructed across the Central Turkey as the initial step of any tentative paleogeographic reconstructions. From NW to SE the geotraverse encompasses three main continental domains: the southern margin of the Eurasian plate delineated by the Pontide belt s.l., the "ghost" Anatolian micro-continent and the northern margin of the Arabian plate.

The Taurus belt describes a pop-up wedge in between the "Pamphyllian" suture and the Inner Tauride suture -The Sariz-Gürün unit which occurs in the structural core of the Taurus belt, presents the single known instance of no record of the ophiolitic obduction in its Late Cretaceous deposits - The wedge changes its geometry along strike and "dies" along the trend of a "paleo-Malatya" fault. A section across central eastern Turkey shows a drastic change of the tectonic style from a vertical stacking in the west to an emergent imbricate in the east.

The implications for the structures at depth will be discussed, but the Taurus belt can not be continued eastward along a W-E trend as usually shown on maps.

The Pontides/northern Neotethyan ophiolites/Kirsehir basement define an other wedge beneath which the Tavsanli zone/Inner Tauride suture disappear, and in front of which, the Taurus wedge is thrust northward.

Inside the northern "Pontic" wedge a definition of the location of the northern Neotethyan suture zone (Upper cretaceous) among the successive fronts (Eocene-Miocene-Pliocene) of the emergent thrusts involving ophiolites will be discussed in conjunction with the status of the Tokat and Kirsehir basements.

In conclusion schematic pre and post collision palaeographic maps will be presented.

A platform to basin transition model: the middle Cretaceous of the Amasya region (North-Central Anatolia)

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By detailed sedimentological and facies analysis in the Amasya region, a depositional model was developed for platform and basin during Early Cretaceous to Late Cretaceous. The middle Cretaceous sedimentary rocks of the Amasya region (north-central Anatolia) represent a platform to slope/basin transition, whose general organization correspond to the anatomy of a carbonate margin. Benthic foraminiferal packstones/grainstones (platform), limestone breccias, turbidites (slope/apron), pelagic foraminiferal wackestones/packstones and radiolarites (basin) correspond, respectively, to platform and basin environments. Paleostructural patterns in platform to talus relationship and sedimentologic characteristics of the slope deposits suggest that the platform to talus transition was controlled by tectonic movements. In this paper, the relations of the carbonate platform, redeposited sediments (slope deposits; limestone breccias, calciturbidites), pelagic carbonates, radiolarites and environmental model during the middle Cretaceous in the Amasya region are described. These redeposited and pelagic sediments of the Amasya region were deposited in an asymmetric basin, formed by block faulting during the middle Cretaceous rifting phase.

Fluvial, lacustrine, coastal and shallow marine sedimentation in Sivas Lower Miocene Basin, Central Anatolia, Turkey

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The Sivas basin is known as an important basin in central Anatolia. It was formed during the closure of the northern branch of Neotethys in Tertiary times as others (Haymana-Polatlı, Çankırı-Çorum and Tuzgölü basins). The basin is elongated in the NE-SW direction and bordered by Pontides in the north, Torides in the south, and Kırşehir massif in the west. Paleocene and Eocene time intervals are represented by marine deposits. However, Late Eocene-Early Miocene period has various lithological and environmental features.

Lower Miocene deposits of the Sivas basin, which is the subject to this study consist of various lithological units, such as siliciclastics, carbonates and evaporites. They were predominantly formed in terrestrial (lacustrine and fluvial) and shallow marine environments. Each lithological unit might be deposited as a major facies in the certain part of the basin or locally make vertical and lateral intercalations with each other. Fluvial, coastal plain, delta/or barrier island, which are essentially characterized by siliciclastics exhibit typical relationships in the field scale. Carbonates are mostly reefal limestones. They were precipitated in the coastal belt being devoid of siliciclastic influx, showing fairly good lateral extention. Bioherm or patch reefs were deposited in lagoons, eustaries or on the top sets of deltas influenced by the periodical siliciclastic influx. Evaporites show typical features of coastal sabkha or inner lagoon in which the sandstone, siltstone-marl and limestone intercalations are commonly observed.

Sediments of this complex depositional system indicate a shallow water environment with several different hydrodynamic conditions during early Miocene in the Sivas basin. Development of non-uniform facies types were formed by the repetition of the overlapping marine and terrestrial sequences. Shallow marine environments induced by periodic siliciclastic influx have been characterized by active depositional realms, such as barrier island and delta, local carbonate shorelines or platform carbonates in association with the cyclic deposition of evaporites. The irregular configurations of shoreline, synsedimentary faulting and climatic changes are most likely to be the main causes in the development of these complex depositional systems of the Sivas Basin during early Miocene.

PONTIDES GEOLOGY

Geology of the Cretaceous Sedimentary basins of the Western Pontides

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The southern passive margin of the Western Black Sea Basin consists of two tectonic units, the İstanbul Zone and the Central Pontides. These units are delimited by north-south Araç-Daday shear zone juxtaposing totally unlike basement rock groups and covering later Mesozoic sedimentary rocks. This zone is probably eastern continuation of the Intra-Pontide suture zone. To the west of this zone the İstanbul Zone is covered by a sedimentary succession deposited in a southerly-deepening continental margin basin. This basin was bisected lengthwise during the Maastrichtian forming the Zonguldak in the northwest and the Ulus basins in the southwest. Both of these basins were deformed in the Early Cainozoic. To the east of the Araç-Daday shear zone, the northerly-deepening basin, the Sinop Basin, dominates the architecture of the Pontides in the north. It began forming by extension in the Barremian and was destroyed by a single phase north-south compression in the Late Eocene-Oligocene. After the juxtaposition of the Central Pontides and the İstanbul Zone, an E-W trending extensional magmatic arc has been established on these sedimentary basins in response to northward subducting Neo-Tethys to the south. This magmatic arc which started during the Turonian, gave rise the Western Black Sea oceanic back-arc basin.

Structural geology of the Southeastern part of the Ulus Basin and its significance for the evolution of the western Pontides

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The Ulus Basin is filled with Lower to Upper Cretaceous turbidite. It is interpreted as an extensional basin resting atop of the Paleozoic to Triassic basement and Jurassic sedimentary cover of the Western Pontide. Gradual stratigraphic transition from the Late Jurassic shallow-marine Inaltı limestones to Cretaceous turbidite has been established in central, northern and partly southern parts of the basin. Studies in the region bounded by Azdavay in the west and the fault boundary with the Central Pontides in the east have revealed "abnormal" features of the Ulus Basin. There, the Cretaceous turbidites are characterized by polyphased deformation. The earliest phase created imbricate stack of thrust sheets. Within individual sheets, red radiolaria-bearing siliceous shales of hemipelagic origin underlie the turbidites. The only age determination of the radiolarians gives the Late Jurassic age. Taken together with the imbricate structure of turbidite this allows an inference about accretionary wedge nature of the southeastern part of the Ulus Basin. Right-lateral shearing was important component during the formation of this accretionary wedge. However, this shearing played more prominent role during subsequent phases of deformation. Numerous bedding parallel shear zones (S_2) have been formed during the second phase. The most prominent one, the Sabuncular-Koçağız shear zone, is located between Ulus turbidites in the north and a sliver of the Jurassic volcanic and sedimentary rocks of island arc origin (Sada volcanics) in the south. This zone indicates at least 30 km of displacement of Central Pontides in front of the Ulus accretionary wedge. Right-lateral shear zones represent boundaries of large inclusions of Paleozoic and Triassic rocks within the Cretaceous turbidites. Large asymmetric folds with steep plunging hinges (F_3) that are conjugated with northeast-striking right-lateral strike-slip faults (S_3) formed later. En-echelon pattern of the accretionary complexes and magmatic arcs in the Central Pontides may be also interpreted as a result of Cretaceous right-lateral shearing, which was parallel to the general strike of the Pontide orogen.

High Resolution Cyclostratigraphy and Sequence Stratigraphy of Shallow Marine Siliciclastic–Carbonate Successions (Barremian–Aptian) of the Zonguldak Region (Western Pontides, NW Turkey).

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The study area, Zonguldak, is located at the NW of Turkey, in the western black sea region. 3 stratigraphic sections have been measured in detail in the Zonguldak city, Kozlu village, and around the Cengellidere town respectively. Stratigraphic sections cover Barremian–Aptian stages and totally composed of meter scale cycles. Cyclicity is constructed by vertical facies associatios and are consisting of repetetive stacking of calcareous sandstones/sandy limestones and limestones. Thin calcareous sandstones and sandy limestones are set at the bottom representing flooding and limestones composed of wackestones and packestones are set at the top representing highstand of the each cycle. In all sections, cycles are not generally capped by subaerial exposure structures, however few cycles have dissolution vugs and lime mudstone including charophyta at the top, the presence of lag clasts at the bottom of overlying cycles show that cycles are actually in shallowing - upward character. In this study, they are termed as submerged cycles.

In Zonguldak and Kozlu sections, a prominent charophyta rich level is recorded within the cyclic successions. This level is totally composed of charophyta packestones and interpreted as a sequence boundary. In the Cengellidere section, within the similar cyclic successions a more siliciclastic invasion takes place, and the base of pulsing conglomerates and thick cross-bedded sandstones is interpreted as a sequence boundary. Systems tracts are constructed by using changes in thicknesses of cycles and dominancy of certain types of cycles at certain positions within the sequence packages.

Sequence boundaries in the Zonguldak region are correlated with the global sea level curve and the number of cycles is counted within the sequence packages. Dominant shallowing - upward cycles correspond to the Milankovitch cycles (Eccentricity band, E-2 signal) and are termed as 4th order cycles in this study. However, higher frequency smaller scale cycles are also recorded within the 4th order cycles. The alternation of two genetically related facies without disturbing the shallowing upward structure within the 4th order cycles is interpreted as smaller scale cycles and hiearchycally ranked as 5th order. Generally one 4th order cycle contains 2 to 5 5th order cycles. Even some individual beds within 5th order cycles exhibit fining – upward structures and are interpreted as 6th order cycles. However they are rarely observed compared to 5th and 4th order cycles.

It can be concluded that Barremian–Aptian platform deposits in the western Pontides is woven by the records of superimposed short-and long-term sea level fluctuations and prominent third-order sea level falls were totally recorded on this platform.

Pre-Cambrian ophiolites in the basement of İstanbul-Zonguldak unit (NW Turkey) and its tectonic significance

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Sünnice–Almacık–Armutlu metamorphic basements of the İstanbul–Zonguldak Unit, NW Turkey, are supracrustal lithotectonic assemblages consisting of ultramafic to subalkaline mafic–intermediate–felsic volcanic arc sequences, intruded by arc granitoids together with a continental crustal fragment of Pre-Cambrian age. These three isolated metamorphic massifs, which crop out under the İstanbul–Zonguldak Paleozoic sequence ranging from early Ordovician to Carboniferous age underwent greenschist to amphibolite facies metamorphism.

Field relations, structural characteristics, and geochemical data obtained from representative lithologies of the Sünnice, Almacık, and Armutlu massifs suggest that all the three metamorphic basement rocks represent almost a complete suprasubduction ophiolitic suite, composed mainly of an ordered ophiolitic foundation (Çele metaophiolite), and an ensimatic island arc association (Yellice metavolcanic association) constructed on top of the ophiolite. This island arc complex was tectonically juxtaposed with a continental crust prior to deposition of early Ordovician sedimentary sequence.

Continental margin arc versus volcanic rifted margin: Geochemical evidence for tectonic setting of Late Cretaceous volcanogenic sequence, İstanbul, NW Turkey

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The Upper Cretaceous volcano-sedimentary belt, extending along the southern cost of the Black Sea from Srednogoria in Bulgaria in the west through the Central Pontides in northern Turkey, is one of the main tectonic elements of the Mediterranean Tethysides. This belt was interpreted as a magmatic arc sequence developed above a northward-dipping subduction zone of Tethys or a rift-associated volcanic margin sequence, developed during the opening of the W Black Sea Basin. In order to test these models, we have mapped out the belt in the north of Istanbul and we have studied geochemistry of the volcanics by XRF, ICP-MS and microprobe. The Upper Cretaceous volcano-sedimentary sequence, termed the Kavaklar Group, is divided into three formations, deposited in tectonically active marine environment. From base to top these are: (1) Bozhane fm., consisting of terrigenous turbidites intercalated with thick and coarse-grained volcaniclastic beds, (2) Garipçe fm. composed of coarse-grained volcaniclastic sediments containing volcaniclastic boulderstones, volcanic breccias, hyaloclastites and sandstones with minor lava flows, (3) Kısırkaya fm. which is made up of basic lavas interlayered with associated volcaniclastics and occasional limestone lenses.

Our geochemical database indicates that there are two distinct magmatic series in this sequence: (1) calc-alkaline series (CAS) displaying a distinct subduction signature with a lithospheric mantle origin and (2) alkaline series (AS) exhibiting a within-plate geochemical signature, implying an asthenospheric origin. Volcanic products of the Bozhane and Kavaklar formations are represented by CAS, whereas those of Kısırkaya fm. correspond to AS. Lavas of the CAS span a compositional range from basaltic andesite to dacite. They may be divided into three petrographic types: (a) aphyric, (b) Plg+Px-phyric (An_{40-85}; ferroan diopside and enstatite, Mg-rich augite) and Plg+Amp-phyric (An_{46-60}; ferrohornblende and pargasite) lavas. In contrast, lavas of the AS are represented only by olivine-basalts.

Variation diagrams involving highly incompatible and compatible element pairs indicate that mixing of magmas derived from lithospheric and asthenospheric sources was a major process in magma chamber evolution of CAS. Neither stratigraphy nor tectonics is consistent with an arc setting during the Upper Cretaceous in the region. Furthermore, an arc-massif is missing all over the Western Pontides. Therefore, we argue that this sequence represents an extensional volcanism, related to the opening of the Black Sea by rifting during the Mid- to Late Cretaceous period. We believe that the arc signature in the CAS may not be related to an active subduction. A plausible explanation for this may be inheritance from an earlier subduction event that imprinted its signature on sub-continental lithosphere. We propose a model where magma generation is associated with lithospheric thinning which caused derivation of magma from progressively deeper zones in the mantle during the opening of Western Black Sea.

The Geological and Geodynamic Evolution of the Turkish and Central Regions of the Black Sea Basin.

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The geological history of the Turkish and central regions of the Black Sea has been studied using a combination of commercial seismic data, fieldwork and published material. The results from this basin analysis exercise have been used to produce regional cross-sections that show structural and stratigraphic components across the basin. These sections show that the Black Sea has evolved via a sequence of inter-related tectonic events that began with Late Cretaceous rifting followed by several phases of compression during the Tertiary, mainly confined to the edges of the basin. In addition, there was a large magnitude (approximately 13 km) of regional subsidence that occurred in the central part of the basin throughout the Tertiary. A numerical model has been developed, which integrates structural, thermal, isostatic and surface processes in both two- and three-dimensions. It enables the forward modelling of extensional basin evolution followed by deformation due to subsequent and sequential extensional and compressional events. The model has been used to test possible mechanisms that may have generated the subsidence history of the Black Sea and, in particular, to explain the anomalously thick regional subsidence that occurred in the basin during the Tertiary. Models assuming uniform lithosphere extension do not generate the observed thickness of sediment infill in the basin. Similarly, modelling the compressional deformation around the edges of the basin structure does little to explain the large magnitude of subsidence within the centre of the basin. It is suggested, therefore, that deep crustal and mantle lithosphere processes have played a significant role during the evolution of the Black Sea. Modelling has been used to investigate the effects of both enhanced extension in the mantle and transient thermal anomalies, which create subsurface loading and significantly increase basin subsidence.

Interaction between magmas derived from diverse lithospheric and asthenospheric sources during the opening of the Black Sea, Western Pontides, Turkey

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Volcano-sedimentary units of the Late Cretaceous age are exposed as an approximately W-E extending belt throughout the whole extent of southern cost of the Black Sea from Bulgaria to Georgia. These successions are of great importance in understanding the Mesozoic evolution of the Alpine-Himalayan belt, since they contain a well-preserved record of coeval sedimentation and volcanism.

Geochemical studies on these volcanic units to date have revealed two important findings: (1) the lavas have a distinct arc-signature and, (2) volcanism starts with calc-alkaline lavas and changes gradually or abruptly into more alkalic (e.g. shoshonitic) series. These findings led most researchers to agree with a view of an ensialic arc tectonic setting since such an evolutionary trend is quite a common phenomenon for matured arcs all over the world. The Late Cretaceous also marks the period during which the Black Sea basin was opened.

To better understand the genesis, tectonic setting and temporal and spatial variations of the Late Cretaceous volcanism, we studied an area located between Ereğli (Zonguldak) and İnebolu (Kastamonu) in Western Pontides and sampled two formations containing volcanic intercalations: (1) Dereköy (Middle Turonian-Santonian) and (2) Cambu (Campanian). Our geochemical database indicates that lavas of the Dereköy formation are calc-alkaline in character (CA) and contain anhydrous fractionation phases. In contrast, lavas of the Cambu formation contain polybaric crystallisation assemblages: (1) unhydrous (POAM) and (2) hydrous. Hydrous lavas of the Cambu formation are all CA in character with a distinct arc signature, while those containing POAM phases are either alkaline (with a within-plate signature) or mildly alkaline.

Our geochemical data show that lavas displaying variable alkalinity may be explained by a model involving mixing of magmas derived from two contrasting sources: (1) metasomatised sub-continental lithosphere with a distinct subduction signature and (2) an asthenospheric source with a within plate signature. We propose that the magma generation was associated with lithospheric thinning which resulted in the derivation of magma from progressively deeper zones in the mantle during the opening of Black Sea as a back-arc basin.

A different sedimentological approach to the deltaic sequence of the Thrace Basin in the European part of Turkey

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The Thrace Basin forms one of the largest Tertiary sedimentery basins in Turkey. Paleontological and sedimentological evidences suggest that sedimentation and basin formation commenced by a major transgression from the soutwest in the Middle to Late Middle Eocene.

Sedimentological studies indicate that two major depositional cycles prevailed during the formation of the Basin. The lower sequence of sediments (first cycle) belonging to the Keşan group were deposited in deep marine environments by turbidity currents as submarine fans (App.3500 meters in thickness) At this time, the rate of subsidence was higher than the rate of sedimentation.

The upper sequence of sediments (second cycle) belonging to the Yenimuhacir group deposited in various subenvironments of which deltaic depositional conditions were the most prominent and 2600 m. thick sediments were laid down. Deltaic deposition started in the beginning of Oligocene when the rate of subsidence slowed down and the basin was relatively filled to its maximum capacity and shallow marine conditions became prevalent. The total sedimentary thickness (6100 m.) deposited until the end of Oligocene indicate that rates of subsidance and deposition were quite high. Sedimentation in the Basin continued from the beginning of Middle Eocene to the end of Oligocene. There was no break in sedimentation. Depositional environment changed from deep marine fan deposits to deltas.

Deltaic sediments, stratigraphically positioned in between the Keşan group below and the Ergene group (Plio-Quaternary in age) above, are consisted of the Mezardere, Osmancık and Danişmen formations each representing one of the three subenvironments of the delta.

Deltaic sequence has been divided into 13 coarsening upward depositional cycles by using GR-SONIC logs of 37 wells located in the study area. These cycles have been correlated in 7 stratigraphic sections flattened at a tuff level observed in GR-SONIC logs at the upper most part of the Osmancık formation as marker datum. Thickness of the cycles range from 21 m to 523 m. These correlations show that progradation of the delta is from north, northwest and west to south, southeast and east. Using GR logs, lithological separations and sand ratios of each cycle have been determined. Based on these determinations and thickness distributions of each cycle in the deltaic sequence, several exploration areas are delineated in the study area in which stratigraphic traps may have the most potential.

Continental Crust Formation and Thermal Consequences of Cenozoic Thickening of the Eastern Pontides Tectonic unit: Preliminary Temporal Constraints and Implications

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The Eastern Pontides tectonic unit extends for approximately 650 km from the Lesser Caucasus in the east to the west of Samsun in northern Turkey. The Eastern Pontide tectonic unit (EPTU) formed as a discrete crustal entity during subduction of Neotethyan oceanic crust beneath the Eurasian margin from the Late Cretaceous to the Late Eocene, although earlier episodes of Palaezoic plutonism are preserved in basement rocks. The significance of the EPTU lies not only in it's importance to our understanding of regional tectonic evolution of the Eastern Mediterranean, but also in that it represents a fine example of long-term crustal evolution from pre-subduction rifting, through convergent margin volcanism and plutonism to pot-subduction intraplate volcanism.

Despite the apparent temporal coincidence of major Mesozoic-Cenozoic crust formation events in the EPTU with major events recognized elsewhere in the Eastern Mediterranean, the actual timing of these events and related igneous activity are poorly constrained. We collected samples of ?Eocene volcanic rocks from across the width of the EPTU and granitoids that cross-cuts them in both southern and northern zones. These intraplate rocks are products of volcanism triggered by crustal thickening at the termination of subduction during Eocene. The results of U-Pb age determinations reveal that granitoid intruded the ?Eocene volcanic rocks 44.3±0.2 (2σ) mya (zircon U-Pb age by TIMS), providing an upper age constraint for the ?Eocene rocks in the south of the EPTU. Two ion-microprobe (SHRIMP II) U-Pb ages (titanite and zircon) for two ?Eocene volcanic samples from the north of the EPTU indicate that volcanism continued here into the Miocene.

These results may reflect the subduction-imposed thermal structure under the EPTU during the Tertiary Period, indicating that it may reflect differential crustal responses to thickening across the EPTU prior to and after cessation of subduction.

Morphotectonics of the Southern Asia From Earth Surface up to Core-Mantle Boundary

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1-In the southern flank of the Mediterranean mobile belt in Asia there is a row of large morphotectonic elements changed each other from east to west: covered-thrusted Himalayas, folded Makran and Zagros, Taurus block uplift and rifts of the Aegean region. Here decrease of degree of recent tectonic clustering of lithosphere firstly takes place and than it is changed by rifting.

2. What is Taurus from the morphotectonic point of view? This is a large uplift with gentle northern flank and steep southern slopes. It can be supposed that Taurus is a shoulder-counteruplift behind of young buning of north eastern part of Mediterranean sea.

3. In the South Asia connection between a morphotectonics of earth surface, geoid relief and a boundary of core-mantle is observed. The main lineaments-submeridional Eastasian and Ural-Oman-Madagascar and sublatitudinal Mediterranean - are traced from earth surface up to a core-mantle boundary. They dissect gigantic core-mantle blocks of more 1000 km vertical sizes. Horizontal displacements of these blocks determine a morphotectonic development of the Mediterranean mobile belt . Heavy Indo oceanic block is displacing to the north with maximum speed and determines a morphotectonics of the Himalayas and Central-Asian collision system and overtakes the Arabian geoblock in 20^0 on latitude. In the East Mediterranean region back-arched rifting prevails.

4. Displacements of gigantic core-mantle geoblocks are the basement of the recent geodynamics of Asia and are added by a tectonics of lithospheric plates and by formation of large asthenoliths.

2-D and 3-D Geodynamic Modelling - Application to the eastern Black Sea.

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2-D and 3-D geodynamic models have been developed to investigate the geological evolution of sedimentary basins. The main advantage of this numerical modelling is that it provides insights into the regional geological and geodynamic evolution of basins that are poorly constrained by geophysical and field data. The models have been applied to help explain the complex subsidence history of the eastern Black Sea.

The models simulate multiple phases of rifting and/or inversion and can replicate the varying styles of extensional/compressional deformation often encountered throughout a basin's evolution (e.g. discontinuous depth-dependent stretching and migration of the rift locus through time). Mechanical deformation of the lithosphere is initially defined by a pure-shear (Beta) profile. The lithosphere temperature field is defined by a pre-rift thermal state and, over time, perturbations occur due to tectonism and changes in the background temperature (e.g. due to the migration, growth and decay of anomalous 'hot-spots' or temporal changes in the thickness of the thermal lithosphere). Loading can be isostatically compensated for either locally or regionally and temporal change in the effective elastic thickness is also accommodated. Model results are visualised in the form of cross-sections and surface plots showing basin geometry, stratigraphic architecture and underlying crustal structure.

The models have been used to explain the subsidence history of the Turkish and central regions of the eastern Black Sea, which have evolved through an interplay of extensional and compressional tectonic events since the late Mesozoic. Model results show that 'uniform' extension of the lithosphere cannot account for the observed depth of the basin. In addition, simulation of the compressional deformation and structural loading around the basin's periphery does not have any significant contribution to subsidence in the central basin. The modelling suggests the influence of additional post-rift subsidence mechanisms, such as the decay of background temperature anomalies, which may account for the observed subsidence in the eastern Black Sea.

Early Jurassic Pre-, Syn- and Post-rifting Sedimentary Records in the Eastern Pontides (NE Turkey)

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The main geological framework of the southern zone of the Eastern Pontides belt (NE Turkey) during Mesozoic are formed by two distinct phases, one in the Liassic and other in the Upper Cretaceous, separated by a quiet tectonic period. The first rifting phase started in the Early Liassic and ended in the Late Liassic corresponds to a continental rift-early Red Sea stage. Pre-, syn- and post-rifting deposits related to the first rifting phase indicate an extensional tectonic regime during the Liassic period. **Pre- earliest rift deposits** are characterized by lenticular conglomerates, wavy to cross-bedding, thick sandstone composed of quartz and feldspar grains dominantly, peat and lignite quality coal, clay and marl. **Syn-rift deposits** are consists of siliciclastic rocks which are deposited in grabens-half grabens, and condensed carbonates deposited on the horsts. The volcanic and terrigenous grainstone/packstone facies is characterized by thick to medium bedded, yellow tuffite, basaltic lava; thinly terrigenous grainstone/packstone bearing abundant micro and macro fossils and angular to subangular terrigenous particles; thick to medium bedded marl; red nodular limestones with abundant pelecypoda, ammonites, crinoids and belemnites are developed in an ammonitico rosso facies. Syn-rift deposits are characterized by a thining and fininig upward megacycle, accumulating after discrete rifting events. The pre- and syn-rift deposits have got considerably different thickness, between 20 and 2000 meters. Lateral and vertical transition and thickness differences are recognized in the study area are related to paleotopography and asymmetric geometry of the rift basin. The extensional tectonic are culminated in the end of Late Liassic and the movements of the first rifting phase in the eastern Pontian belt are completed. **Post-rift sediments** characterized by platform carbonates corresponding to the Berdiga Formation. The thickness of formation is approximately 500 meters. This formation is accumulated in quite tectonic regime and shallow marine environment and characterized by variable limestone sub-facies which are oolitic grainstone, small benthic foraminiferal packstone/wackestone, ostracoda-milliolidea wackestone, dolomite, dolomitic limestone, peloidal packstone, bioclastic grainstone and calciturbidites.

Three Axial Extensional Deformation and Formation of the Liassic Rift Basins in the Eastern Pontides (NE Turkey)

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Eastern Pontide orogenic belt extends along the southeastern coast of the Black Sea and comprises of the three subtectonic unites from north to south as the northern volcanic zone (magmatic arc), southern and axial zones (back-arc). LANDSAT images, Bouger gravity and magnetic anomalies and geologic map cryteries imply that polygonal networks of extensional faults are responsible for formation of the Liassic rift basins in the eastern Pontides. En-echolen zigzag fault patterns with NW, E-W, NE directions correspond to the contemporaneous three pairs of the conjugate normal faults that are formed by the three axial deformation during the Liassic rifting. The blocks of the Hercynian basement in the southern and axial zones such as Agvanis and Pulur metamorphic massives and Gümüşhane-Köse Granites are rombusal or lozenge-shaped in plan view that are framed by the zigzag-shaped fault systems. The alignment of the Upper Cretaceous calderas in the northern zone and of the Kop peridotites in axial zone, are also controlled by these basement-involved fault systems. Extensional palaeostress that are responsible for the formation of the Liassic rift basins and their zig-zag fault patterns of the southern zone are deduced by the Liassic neptunian dikes that are filled and covered by the red pelagic limestones of the Ammonitico Rossa in the Gümüşhane-Köse granite. The local orientation of the neptunian dikes of the mesozcopic scale are parallel to regional fault systems of NW, EW, NE directions or to the three different extension of the main Liassic rift basins. Such three pairs of the contemporary conjugate neptunian dikes pattern arranged in the geometry of polygonal fault systems, may be produced by the stretching in three dimensional strain field rather than multiple phases of faulting or preexisting basement faults. Synchronous opening of the Liassic rift basins in the NE,N,NW directions along the mutual three different fault systems in the whole eastern Pontides, testify the three axial extensional deformation of the Hercynian basement. On the otherhand multidirectional normal faults, block-edge folds, dogleg structures and trap-door blocks, angular unconformity caused by the block tilting, are evidences of the extensional fault block style of the Lias.

Geological, geochemical properties and geotectonic setting of the Mesozoic-Cenozoic magmatic rocks, Tirebolu-Doğankent (Giresun), NE Turkey

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The geology of the area between Tirebolu-Doğankent (Giresun) in the northern zone of the eastern Pontides consists mainly of thick volcanic and volcaniclastic rocks. The basement of the study area is made up of Liassic spilitic basalt, basalt, andesite,, and dacite association known as Hamurkesen formation. This unit is overlain by Malm-Lower Cretaceous Berdiga limestone. The Upper Cretaceous rocks which widely occur in the region are subdivided into six different lithological units. The lowermost one of these Upper Cretaceous units is the Sekü Formation which is comprised of basalt, andesite, dacite with intercalation of limestone and marls. These units are crosscut by Upper Cretaceous Harşit Granitoid. The Sekü formation is overlain by a package of biomicritic limestone lenses, hematitic dacite and rhyodacite interbedded limestone and marls (Kızılkaya Formation). The Kızılkaya Formation is covered by limestone and reddish biomicrites interbedded with volcaniclastic rocks (Danışman Formation). This formation grades upward into the basalt and andesite interbedding with biomicrite and marl (Çağlayan Formation). The Çağlayan Formation is covered by the Çayırbağ Formation which consists of biotite-bearing rhyolite and rhyodacite. Kızılkaya and Çayırbağ Formations are very significant in terms of hosting volcanogenic massive sulfide deposits (VMS). The uppermost part of the Upper Cretaceous sequence is composed of sandy limestones, biomicrites and marl alternations (Bakırköy formation). The sequence is overlain unconformably by the Eocene Yardere lithodeme, which is composed of olivine-augite basalt and by the Neogene Hasandağ lithodeme, which is composed of basalt.

Study area is charecterized by three volcanic cycles erupted in Liassic, Upper Cretaceous and Eocene times. Of these Liassic and Upper Cretaceous volcanic rocks are tholeiitic-calc alkaline, Eocene volcanic rocks are generally alkaline. Geochemical studies are carried out in order to define geotectonic charesteristics of the Lias, Upper Cretaceous and Eocene volcanic rocks reveal that fractional cristallization processess played an important role in their evolution. Fractional cristallization was controlled by plagioclase and clinopyroxene differentation in basalts and by hornblende and apatite in dacites, rhyodacites and rhyolites. Volcanic rocks are enriched in LILE and LREE with respect to chondrite and MORB. This enrichment is probably due to subduction related processess. However, these rocks are depleted in HFSE and HREE with respect to chondrite and MORB, suggesting either a garnet diferentation or garnet residue. It is concluded that the investigated area known to host several fairly good size VMS deposits located either in intra arc or rift environment which is near the arc, and the mafic rocks are possibly formed from upper mantle through subduction, and felsic rocks are the fractionated products of the mafics with a little crustal contamination.

Geology of the Gulf of İzmit, NW Turkey

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Gulf of İzmit forming eastern end of Sea of Marmara, NW Turkey, is a young depression situating on the northern branch of North Anatolian Fault (NAF), one of the world's most active and longest strike-slip fault systems. The goal of this paper is to present the geology of the Gulf of Izmit and to discuss its evolutionary history. Our data come from 1:25.000 scale geological mapping of the surrounding area, digital elevation models, multibeam bathymetry, remote sensing (SPOT and LandSat data), borehole data, and seismic reflection profiles.

The Gulf of İzmit started to open during the Late Pliocene as series of pull-apart basins between the en-echelon strands of the North Anatolian Fault. During the Quaternary these strands were combined into a single fault and cut the older pull-apart basins.

Geology of the Northern part of the Gulf of İzmit, NW Turkey

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In the Izmit region, eastern part of the Bhytnian Peninsula, a thick sedimentary succession of Palaeozoic age forms the basement. This succession starts with Lower Ordovician fluviatile clasticas then grades into Silurian beach sandstones and following platform carbonates of Devonian age. The uppermost part of the Palaeozoic sequence is Carboniferous clastics which is represented by shallow water to terrestrial clastics in the east and deep-water flysch-type sediments and radiolariolarian cherts in the west.

An Alpine-type Triassic sedimentary succession unconformably overlies the Palaeozoic sequence. It starts with continental red beds and grades upwards into shallow and deep water Ammonite-bearing clastics and carbonates. The uppermost part of this sequence is represented by regressive sediments.

The study area lived an erosional period during the Jurassic and Early Cretaceous. Following this erosional period a new transgression covered whole region since Late Cretaceous and lasted until the Middle Eocene. Products of this transgressive period are represented upward deepening clastics, carbonates and flysch deposits. The youngest units of the region are continental clastics of probable Upper Pleistocene age.

Three phases of deformation have been identified in the region. The first deformation affected the Carboniferous and older units while the second one can be recognized in the Middle Eocene and older rocks. These two phases were compressional in nature. The last phase of deformation is created by North Anatolian Fault and its branches and is characterized by dextral faults.

Karangatian (=Early Upper Pleistocene) moluscan fauna from Yalova region and its paleoecologic features (NW Turkey)

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In this study, six measured sections were taken from terraces having altitudes between 10-65 metres in Yalova and surrounding region. Total 40 Molluscan species and subspecies (19 of the from Gastropoda and 21 of them from Pelecypoda classes) were identified from the sandy levels of these sections. spetotal forty molluscan species of which are nine-teen from Gastropoda and twenty-one from Pelecypoda Classes.

Two kinds of Molluscan fauna were found in Yalova region. One of them is Mediterranean origin and the other is Black sea origin. Studies on the paleoecologic features of all the fauna, it is clearly indicates that almost them has euryhaline charactes which can adapt salinity changes in the environment.

The Black Sea originated fauna includes the species such as *Venerupis senescens* (Cocconi), *Mytilaster* cf. *lineatus* (Gmelin in Linné), *Gouldia (Gouldia) minima* (Monterosato), *Lasaea nitida* (Turton), *Mysella bidentata* (Montagu), *Rissoa (Rissoa) splendida* (Eichwald), *Rissoa (Rissostomia) membranacea* (Adams) are characteristic euryhaline species for Karangatian which was described for Black Sea region is a period of which sea level 8-10 metres higher than that of today.

The other fauna belongs to Mediterranean origin with again euryhaline characters as *Ostrea (Ostrea) edulis* Linné, *Chamalea gallina gallina* (Linné), *Bittium (Bittium) reticulatum* (Da Costa), *Cerastoderma (Cerastoderma) edule* (Linné), *Parvicardiuum exiguum* (Gmelin in Linné), *Loripes lacteus* (Linné).

There was a widespread and stable connection with Black Sea and Mediterranean during the Karangatian which is equivalent Tirrenian II period. At the result of the faunal exchange, only euryhaline taxa could migrate from Mediterranean to Black Sea and Black Sea to Mediterranean. Because of the unsuitable salinity conditions, most of the stenohaline Tirrenian genus and species which can not adapt salinity changes couldn't come to the region.

Consequently, the molluscan fauna obtained from the terraces of Yalova region can be correlate with Karangatian fauna. Thus, Yalova and surrounding region had similar paleogeographic features to Black Sea region during early Upper Pleistocene.

On the Lower Cretaceous Sequence Stratigraphy (Georgia)

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Two supersequences are revealed and studied within the Barremian-Aptian on the territory of Racha-Imereti (Western Georgia). Boundaries of these supersequences in the most studied sections are clearly fixed by sedimentological breaks, and some of them are well traced spatially up to their correlative conformities. In many sections of Western Georgia the upper Barremian begins with a slightly reworked breccia-conglomerate layer (up 2m) with glauconitic matrix. Upwards there follow fine grained and – micritic limestones and marls with abundant ammonites, belemnites, brachiopods and foraminifers. Such a change in lithofacies indicates a relative deepening of the basin. At the top of the upper Barremian in Kumistavi, Tskaltubo and Godogani sections the terrigenous material increases and thick-walled ostreas (*Amphidonta* sp.) appear, pointing to a shallow marine condition. In the early Aptian, a high-amplitude sea-level fall caused a hiatus with an eroded surface closing the deposition of lower Aptian limestones (*Deshayesites deshayesi* Zone). This uneven erosion surface is covered by a breccia-conglomerate layer (with glauconitic matrix) (up to 0,4m), which fills the erosional pockets and contains partly reworked ammonites, belemnites and bivalves. This layer is the basal part of the next supersequence. Above this breccia-conglomerate bed follow the middle Aptian (*Epicheloniceras subnodosocostatum* Zone) clayey micritic limestones with ammonites and belemnites, which indicates a deepening of the basin again. In the Tvishi and Znakva sections the upper boundary of this second supersequence is situated between the thin-bedded marls and limestones of the middle Aptian (*Colombiceras tobleri* Zone) and the basal breccia-conglomerate layer (0,3m) of the upper Clansayesian. Thus, in the Barremian-Aptian of western Georgia two sedimentation cycles (corresponding to supersequences are situated: 1) below the upper Barremian *Ancyloceras vandenheckii* Zone (perhaps in the upper part of the *Holcodiscus caillaudianus* Zone), 2) in the lower part of the *Deshayesites deshayesi* Zone and 3) in the middle of the Clansayesian. The formation of these sequence-boundaries was related to global high-amplitude sea-level falls, mainly caused by eustacy, although the role of the regional tectonic movements should also be taken into account.

Collision Geodynamics of the Greater Caucasus and the Adjacent Transcaucasus

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In Late Miocene - Anthropogene the considered region located in the Caucasian collision zone, underwent intensive cross segmentation. In the beginning of the collision stage folded system of the Greater Caucasus and bordering to it from the south the Black Sea-Transcaucasian microcontinent (microplate) being of general northwest strike, were divided into two segments suffering compression of different directions: submeridional - Western and north-eastern - Eastern. Within the limits of the Western segment the plate drew nearer in a submeridional direction to the Greater Caucasus, and in the Eastern-underthrusted nearer, moving together with it in a north-eastern direction, along the dividing them Choji-Aragvian left-shifted zone.

At a late stage of collision the Greater Caucasus was dismembered with crosses faults on four segments, and the Black Sea-Transcaucasian microplate was divided into much more fine plates of the third order-nannoplate. The cinematics of these plates at the collisional stage of the development of the region was different. The northwest nannoplate remained almost motionless during this period, and the Central one - moved in northern direction, 15-20° counter-clockwise motion, causing slanting compression of the Central Caucasus. The Eastern nannoplate advanced in a north-east direction and underthrusted the Eastern Caucasus and together with it moved in the same party. The South-Eastern nannoplate advanced to the north and obliquely underthrusted the South-Eastern Caucasus, suffering thus horizontal rotation by 15° counter-clockwise motion. Moreover the intensive submeridional compression, caused clastation of nannoplates on separate fine blocks named schols. During the collision took place their moving in along the southern edge of meganticlinorium of the Greater Caucasus, that caused its local cross deformations. Hence, in this period there was a consecutive dissection of microcontinent on more and more fine plates in the following order: Microplate - Western and Eastern microplate - Nannoplate-Schol.

As a result of northward dislocations of separate segments the Greater Caucasus on the whole simultaneously underwent counter-clockwise rotary movement. Thus the northwest pericline remained in its place, and meganticlinorium moved in the same direction rerative to its initial position, its increased to south-east. Within the limits of the Central Caucasus it has made 25-115 kms, the Eastern Caucasus has advanced on 125-140 kms, and the South-Eastern pericline has moved on 180 kms. The rotation of the Greater Caucasus is caused by diversely directed movements of the Arabian plate during the collision stage causing non-uniform deformation of the Caucasian sector of the Mediterranean mobile belt.

ENGINEERING APPLICATIONS

Berke Arch Dam, Turkey: Grouting Application of karstic limestone foundation

Saydın ALTUĞ

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Berke Hydroelectric Project, which is now constructed by Yapı ve Ticaret A.Ş., is located on the Ceyhan River in the south of Turkey, 130 km northeast of Adana. The owner is Çukurova Elektrik A. Ş. (ÇEAŞ – Entrusted Company), design consultant, Coyne et Bellier – Aknil, grouting special consultant Altuğ, S., and supervisor Joint Venture, Yapı Teknik – Su Yapı–Eltem Tek (BTM).

Berke Hydroelectric Project consist of a 201 m high – thin arch dam with double curvature, 1921 m long headrace tunnel and underground powerhouse (installed capacity 3 X 170 = 510 MW). The reservoir volume is 427 X 10^6 m^3.

The rocks, which are exposed at the Berke Dam site and the close vicinity, consist of the imbricated tectonic slices of Mesozoic age. The majority (85 %) of dam curtain foundation rock is composed of pervious and karstified limestone (chimney-voids: 20 to 200 cm).

The main grout curtain of the Berke Dam with a surface of 533 000 m^2 is one of the largest curtain in the world. The spectacular section of the grouting system is the Berke Mountain – suspended vertical panels (390 000 m^2). This system with a drilling of 499 km covers 69 % of total drilling of 718 km. The depth of the lowest panel is 229 m (from el. 175 to el. –50).

In Turkey, a high blain cement (5500-6500 cm^2/gr) has been firstly used at Berke Dam grout curtains. The admixtures for concrete (superplastisizers / accelerator / retarders) are successfully adapted to the grout mixes. The special mixes with the dispersing agent Addiment – PGA 1 are effectively applied for grouting of micro fissures and consolidation of silty-sandy-clayey matrix. Up to now, 110 400 tons dry material were injected; 692 000 m were drilled (average take 159.5 kg/m, max. take:1200 ton/m). Total 3500 nrs of Lugeon tests were performed for checking the final permeability of the completed panels. The great majority (97%) of the cumulative Lugeon values are in the range 0-5 LU. In the limestone foundation, all the grout panels indicate a distinctive rate of takes from primary (P) to quaternary (Q)/quinary (B) holes. The decreasing rate of the takes and permeability test results are the evidences for the successful application of high pressure (60-70 bars) grouting technique and grout mixes with additives.

Basic criteria to assess pipeline alignment alternatives: BTC (Bakü-Tbilisi-Ceyhan) pipeline

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Engineering assessment based upon the alignment selection criteria given below, but not limited to, is crucial part of a pipeline project. A linear engineering structure project such as pipeline, railway, and highway consists of four main phases. These are; **1) Corridor selection** [Planning phase: identification of possible corridors mainly based upon desktop study accounting all the criteria given below]. **2) Route selection** [Preliminary phase: identification of possible routes considering all the criteria given below by carrying out literature survey and field observations], **3) Alignment selection** [Basic study phase: identification of possible alignments considering all the criteria given below by conducting literature survey, site inspection, and practical in-situ tests], **4) Construction line** selection [Detailed engineering phase: identification of possible Construction lines by carrying out detailed subsurface investigation including in-situ and laboratory tests and then, design]. All parties in a pipeline project should follow the common nomenclature as; **corridor** (consisting of more than one route), **route** (including more than one alignment), **alignment** (which is a line that can be realigned, in general within a maximum range of a few hundred meters to find the best construction line), and **construction line** (along which the pipeline is going to be constructed).

More than that, technical assessment of alternative alignments on the basis of;

- Length, Excavation, Low - High Points (□H, M), Slope (Longitudinal), Slope (Transversal), Property Crossings, Fault Crossings, Liquefaction, Landslides, Environmental Impact Assessment, And Karst Hazard has vital importance.

Mean residence time distribution of environmental tracers in the Aladağ karstic aquifer (Kayseri-Adana) Turkey

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Mean residence time (MRT) distribution of groundwater in the Aladağ karstic aquifer of west-eastern Taurids has been investigated on the basis of environmental tritium and chlorofluorocarbon (CFC, CFC-11 and CFC-12) gas tracers. The allocthonous carbonate nappes of the Aladağ mountain range extending over 700 km^2 comprise of the aquifer. The aquifer is drained towards Zamanti River located to the east and discharges through several karstic springs that serve as spillways or bottom outlets. Determination of MRT in those springs is essential to understand the regional flow dynamics and utilize more efficiently from the water resources potential. Lumped parameter models have been used to determine MRT in the major karstic springs. Validity and efficiency of models including plug and mixed flow type aquifers connected in parallel or in series with dead water volume, rapid bypass flow component and dispersive flow have been applied. Effect of CFCs delay through the unsaturated zone on MRT distribution were also investigated. MRT were found to range between several years to more than 10 to 15 years among karstic discharges.

Engineering analyses of dam and pipeline projects in an active fault zone: Ecemiş Fault Corridor

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Ecemiş corridor is a suture zone of Cretaceous age. Aladağ and Karadağ–Bolkar mountain ranges bound this trough from east and west respectively. The delineated area takes place within the middle portion of the corridor with a length of 40 km. Ecemiş fault, which is left strike slip in character, created 0.5 – 5 km wide plastic deformation zone. Volume of slide masses, in places, exceeds one billion cubic meters. The trinity WDC (water-discontinuity-clay) is well developed within this middle portion. Consequently distinct and appreciable fertile lands have been formed. State Highway Department decided to locate the Ankara-Pozantı Motorway within this corridor in 1986. The actual field geotechnical model had been prepared in the period of 1986-1994. Finally the decision makers have been convinced to realign the motorway alignment 30 km west of the Ecemiş corridor.

However, recently a dam project is planned which will be constructed at the down stream part of the study area. This project will reduce the effective normal stress along toes of the existing landslides, which in turn fill up the reservoir. Ultimately, the economic life of the dam will end within a few years and destroy all the attractive and charming farm fields and kill the lovely nature. The recommended project consists of 5 small dams on the tributaries, 3 regulators, pipelines to practice Torricelli principle, and 5 power plants. Thus twice times more energy can be generated than the single dam planned on the main stream will produce. Furthermore, the recommended project saves the entire environment and enhances farmers to gain new irrigable lands.

A radical solution to mitigate earthquake catastrophe in Turkey

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The Arabian plate pushes Anatolia northwards. In consequence of this push inner Anatolia moves westwards. Thus the North Anatolian Fault (NAF) in E-W direction, East Anatolian Fault (EAF) in NEN-SWS, and Ecemiş Fault (EF) in NEN – SWS direction have formed. NAF is right strike-slip whereas EF is left strike-slip in character. Both are active and capable of produce earthquakes with magnitude greater than 5.0. Both place within suture zones develop during the Late Cretaceous – Early Tertiary period. Fortunately they have created very fertile farm lands and in places hot springs. Furthermore, historical data indicate that earthquake of these fault destroy buildings within their fertile lands. The last earthquakes occurred in Erzincan ’92, Adana ’98, Kocaeli ’99, Düzce ’99, Orta ’00 in Turkey have indicated once more that the deformation boundary coincides with boundary of the fertile plains.

The major reasons why the earthquake catastrophe happens over the fertile plains of soil are: lower frequency, longer wave length, and lower velocity of seismic waves causing oscillation, lover modulus of elasticity, lower material strength, and vulnerability to liquefaction, recompaction, and rapture.

If the thickness of soil blanket is greater than 20 m and depth to the water table is less then 10 m, the amplitude of shaking increases, which in turn, magnifies overturning of buildings. Luckily the earthquakes do not create problems outside of fertile plains if the buildings are constructed in accordance with international standards.

Engineering Properties and Dynamic Behaviour of Caliche Deposits, Kızılkaş-Kılıçlı Area, Eastern Adana

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Late Quaternary deposits in Çukurova Basin contain sediments deposited in subhumid and semi-arid climates. Most of the soils of Çukurova have layers of caliche either on or under the surface. The topographic elevation of the caliche deposits above sea level ranges from 150 m to about 300 m. Caliche is a layer of soil in which the soil particles have been cemented together with calcium carbonate, seems to be one of the hardest material to deal with when building something in Çukurova. This material can exist in thin laminations or can be several meters in thickness. Materials is classified as soft pan and hard pan due to changes in the relative hardness of the layers of caliche. It consists chifly of calcium and silica in the form of clays, sands and gravels. These materials are sometimes cemented into a conglomerate by calcium carbonate deposited from the evaporation of ascending or descending waters. There is a large area east of the town of Adana that is composed of caliche, or cemented calcium carbonate material underlying the structure. The 1998 Adana-Ceyhan earthquake caused severe damage in the region located to the northern part of epicenter. Occasional single storey reinforced concrete types are found in many of the small villages. Masonry type single or two storey buildings are also common throughout the region. Rural structures are mostly single storey or two storey adobe, brick, or stone buildings. Timber-framed buildings with adobe and stone fillers are also common. Prefabricated structures are found throughout the region.

The suitibality for construction use of this material should be determined by tests. One quality that makes caliche valuable for road construction is its tendency to recement after being saturated with water, compacted, and allowed to set. This is especially true of caliche that is cemented with lime or salt. It normally provides a good foundation for a structure if it underlies the entire foundation under the effect of static conditions. A thick, shallow caliche layer underlying an entire building is almost like a big concrete foundation for the building.

Dynamic behaviour of relatively thick hard caliche deposits is different. The most widespread structural damage during the 1998 Adana-Ceyhan earthquake occurred in the Çukurova basin in areas underlain by soils comprising either fine-grained alluvial deposits, or caliche soils. The localised damage, attributable to local geology and topographic conditions was particularly highlighted where structures were similar over a wide area. Topographic amplification of seismic ground motion appear to have been an important factor affecting the distribution of ground failures, especially within the hard pan part of caliche deposits. Damaged high storey buildings was on the alluvial deposits whereas damage to weak masonry, adobe buildings, and poorly designed single or two storey reinforced concrete structures on caliche deposits was more than might be expected. Major damage was observed to structures close to edge of top of the caliche slopes. Most of the caliche slopes in the epicentral region showed instability.

Observation of Ground Displacement in the Kızlaç T3A Tunnel (Osmaniye, Turkey)

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The study briefly describes deformation monitoring for the Kızlaç Motorway Tunnel, Osmaniye for the T3A section with 340 m long. The area consists of Devonian meta-detritic rocks. The study area rock strength were highly affected by Weathering and discontinuity pattern. Deformations with respect to the time as well as the face advance after blasting were regularly recorded. The tunnel was subjected to excavation-induced strain changes.

Horizontal, vertical and longitudinal components of tunnel deformation were regularly measured using geodetic monitoring. Horizontal displacement magnitude changes between 4.5 and -4 mm. The settlement magnitude is 12 mm at top heading and maximum 2 mm at bench. But magnitudes of longitudinal displacement changes between 1.5 and -1.5 mm. Typical tunnel movements over time and face advance are presented. Resultant displacement vector orientation was identified from the angle ratio between the longitudinal displacement and vertical displacement components. Rate of convergence and divergence were found to depend mainly upon stiffness of rock, fault zones and discontinuity orientation. Left sidewall resultant deformation/crown resultant deformation ratio (20-275%) is bigger than the right sidewall resultant deformation/crown resultant deformation (20-150%). When the excavation approached to stiffer rock displacement vector orientation is negative whereas it is positive next to the weak zone.

Three zones are delineated within the context that: a) relatively stiff rock zone consists of sandstone-shale alternation, b) poor zone consists of fault gauge, shale, sandstone-shale alternation, c) moderately stiff rock consists of shale, sandstone-shale alternation.

How to orient a linear engineering structure with respect to an active fault: Motorway and pipeline

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Linear engineering structures (LES) such as pipeline and motorway may cross several active tectonic entities in their routes. It is therefore essential and crucial that the design of LES take into account the physical and seismic properties of these entities. Special emphasis has to be devoted on their potential for producing significant earthquakes with great (d>2 m) displacement. Active faults with potential of producing large earthquakes with high magnitude (m>4.5) are in general strike slipe and reverse in character. Gravity faults create earthquakes mostly with a magnitude less than 4.5. Luckily, strike slip faults create a distinct linear geomorphology and repeat themselves within the same plastic deformation zone. Thus they are effective in their deformation zone. The width of deformation zone is directly governed by and inversely proportional with the elastic modulus of the geological units adjacent to the fault plane. Almost all of the strike slip faults develop within suture zone comprising serpentinites and major sub vertical shear planes.

Severe earthquakes are not random phenomenon. They are associated with geomorphologically distinct and recognizable faults. Therefore, it is not a difficult to trace active faults producing significant surface displacement. All linear engineering structures should cross fault zones at a right angle to be out of the plastic deformation zone at a shorter distance. Alignments within the deformation zone, parallel and sub parallel to the fault line are vulnerable to fail through liquefaction, osculation, unbalanced stress condition in tunnels, displacements, rupture, and/or bending of pipes beyond elastic limits. In the case of motorway: high embankments and deep cuts may replace orderly viaducts and tunnels where crossing the active fault zone. Whereas in the case of pipeline: proper orientation and special design for trenching and backfilling can mitigate earthquake disaster. Veezee-rule is adaptable to cross any kind of faults. Trench with a slope of 0.5 and cohesionless backfill are the essentials at fault crossings.

Cost comparison of two extreme engineering approaches in a motorway project: Taurid Mountain crossing of Çukurova Motorway

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The Taurid Mountain range, between Mediterranean region and Central Anatolia, is a bottleneck from transportation point of view. In 1970's, five of the developed countries have decided to construct a motorway network, namely Trans European Motorway (TEM). TEM starts from Gdansk and goes through 9 countries in Europe and reaches Turkey. About 35% of the TEM is over Turkey.

The Kırkgeçit Creek is the middle route out of three. It is in rejuvenation phase, so deepens its course keeping the bedrock exposed. The mean grade of the delineated portion is 1.2%. The valley is barren because of (a) the dominating strong and crystallized rocks, (b) the steep slope of the hillsides which propagates sheet-wash erosion, and (c) ongoing rejuvenation phase that causes erosion within the stream course. Under such conditions, artificial dikes which could be erected across the narrowest section (gorge) of the valley can provide (a) a large ($A > 10$ km^2) flood plain, (b) new aquifers characterized by thick and permeable ($K>10^{-4}$) alluvium, (c) the required condition for water-loving industrial plants over the aforesaid plains, (d) a dense vegetation over hillsides via forming terraces and irrigating a few years after the plantation, and (e) a wide platform to locate the motorway and to accommodate with high geometric standards both horizontally and vertically. Moreover, it enables to substitute culverts and cuts for viaducts and tunnels respectively.

An artificial dike resembles a rock fill dam with a core having thickness of 0.50 - 0.80 m and composed of mortar and stone. The function of the core is simply to retard the leaching of silts. The excess earthwork material in motorway construction would contribute to fill in the reservoirs, particularly adjacent to spurs, which will be excavated for the motorway. Conclusively this method provides a new aquifer with a volume 30 million cubic meters. More than that, it saves 250 million Dollars as a construction cost of a 30 km long portion of the Pozantı –Ankara Motorway if this corridor would be selected. Conventional construction cost of the 60 km portion of the alignment is estimated as 650 million Dollars. However, the cost becomes half in the case of artificial dyke method. Moreover, the geometrical standards and driving comfort increases appreciably.

Optimisation of dam projects to based upon engineering assessment: Hasankeyf

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Hydroelectricity is the conversion of potential energy of water through the equation m*g*h, where mass of water, gravitational acceleration, and drop height respectively. It has been the greatest dilemma in engineering projects whether to preserve historical remains and fertile lands or to behave in favor of the construction. Implementing more professional engineering approaches and practical engineering woks can avoid the engineer from being in a critical situation. Hasankeyf is one of these cases where a careful consideration of the problem would result in beneficial solution in both ways. The Tigris basin bears fertile lands and invaluable international heritages.

The planned Ilısu project will burry invaluable international heritages of Hasankeyf civilization under deep reservoir water and then silt will deposite. Instead of a large dam on tributaries of Tigris (Ilısu Dam), a recommended system consisting of small dams and pipelines savaged almost all heritages and produce more energy. Besides, it will suggest an alternative project that will contribute an absolute solution to the problem. With this proposed project not only an invaluable historical heritage will be salvaged but also, energy production capacity will be increased almost by two that the current dam project under design will. There are already 5 dams at the upstream part of the planned Ilısu Dam. They are already in operation. Their foundation levels are 65 to 340 m above the maximum water level of the Ilısu Dam.

As the case for the major tributaries, there is no dam on Tigris between Dicle Dam (elevation of river bed is 640 m) and upstream reach of Ilısu Dam (elevation of river bed is 400 m). It is just because of the presence of large city centers, such as Diyarbakır and Batman in this section. Their population is greater than 1,500,000 and 300,000 caps respectively. It is almost impossible to relocate such big cities and towns located along the fruitful valley of the Tigris River. However it is easy to pass by those cities in pipeline and get energy at downstream part.

Assessment of Potential Strong Ground Motions in the city of Bursa

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The amplifications due to near surface material and the effects of alluvial basin geometry are the main factors controlling the damage in urban areas from large earthquakes. Local site conditions can profoundly influence all of the important characteristics of strong ground motion such as amplitude, frequency content and duration. The extent of their influence depends on the geometry and material properties of the near surface layers under the site, and characteristics of the input motion. Basin trapped body waves can produce stronger shaking and longer duration, which are suggested by damage patterns in earthquakes. Therefore successful prediction of ground motion is necessary and urgent to earthquake hazard assessment, especially in deep sedimentary basins. Since the city of Bursa is located at the southern branch of the North Anatolian Fault zone in Marmara region and the major part of the city is located on a sedimentary basin, the importance of the seismic risk in the region appeared to be progressively more crucial. Therefore, stochastic model simulation (Boore, 1996) used to estimate ground motions at different geological sites around the city of Bursa to estimate the effects of near surface site conditions and soil column thickness. To obtain more realistic site effect and to evaluate the differences between the methods, the average amplification values obtained from three different site amplification determination techniques (non-parametric inversion, standard spectral ratio and horizontal to vertical spectral ratio techniques) were used. By developing 5% damped Spectral Acceleration (SA) values, site-specific hazard distribution was obtained for different geological sites around the city of Bursa. SA values show strong dependence on the site conditions, suggesting that geologic site characteristics and soil depth should be included in seismic hazard calculation at regional and local levels. The results also showed that ground motion attenuation relationships determined for one geologic site characteristics could not be simply scaled for use in another.

A geotechnical risk assessment of the settlement area of Küçükdere village in Denizli (Turkey)

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Settlement places in rocky areas are usually under the risk of rock failures in different modes. Rock blocks can be unstable in different sizes. When the size of a block gets bigger, the risk of damage and life loss at settlement place increases. Therefore a stability risk assessment of slopes is required to be carried out for these places.

In this study a stability risk assessment of Küçükdere village in Denizli is studied. Küçükdere village is located 15 km distance at north east of Denizli city centre. It is also 2 km far from Pamukkale where there is cotton white travertine deposition of thermal waters and Roman times ruins. Küçükdere village has been settled along the Küçükdere stream abutments. The slope angle is between 20° and 30°.

Küçükdere village is settled on Kolonkaya formation which mainly consists of Pliocene aged siltystone, claystone, marl and limestone succession. On this strata Pleistocene aged travertine deposition sits unconformably. Travertines are fractured due to an active tectonism of the region and also erosion of the marl and claystone-sandstone strata at the base.

A travertine block of about $60m^3$ toppled from the top of the slope and threatened the houses in the village. Luckily there is no damage and injury caused by the toppling failure. There are also some other blocks that have a risk of failure. Stability analyses of these travertine blocks were carried out under static and dynamic conditions. It has been found that some blocks are stable while the others become unstable with the effects of toe erosion and dynamic loading due to the earthquake activity of the region.

Seismic microzonation for existing built–up areas: an example from Bakırköy–Ataköy district, İstanbul, Turkey

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The damage resulted from Marmara Earthquakes, 1999 claimed the importance of the seismicity analysis in Turkey. For virgin lands without any existing information on site characteristics, seismicity analysis is essential to ascertain the suitability of the site for the planned project. For existing built-up areas, on the other hand, seismic microzonation can provide information to evaluate the seismic hazards of a possible future event. The products of the microzoning are generally used for future urban development planning and urban disaster prevention planning. The approach and methodology of seismic microzoning are based on historical urban disaster experience. While it was important to apply global knowledge, theories and previous experience to the seismic microzonation, more emphasis places on existing knowledge and experiences in the field, since every microzonation study has its own unique character.

A seismic microzonation study is carried out in the *"Geological Study and Seismicity Analysis of Bakırköy–Ataköy District"* project executed by Applied Geology Division. During this study all the geological and geotechnical data gathered during the project is evaluated. In the beginning ground classification of the study area is revealed according to the 1997 Turkish Earthquake Code. Then shear wave velocities of the strata identified in the borehole logs are calculated using the empirical relations correlating the SPT-N value and V_s. SHAKE, a computer code based on equivalent linear analysis, is utilized for computing the non-linear site response of the study area. By this analysis predominant periods, spectral amplifications and spectral accelerations of the study area are obtained. Contouring and overlaying the distribution of these values, seismic microzoning of the study area is accomplished. According to this study identified seismic microzones are conformable with the geophysical values measured in the field.

Distribution of landslides in Eocene Flysch Unit: Çaycuma Formation (Western Blacksea)

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Eocene flysch, namely Çaycuma formation, is one of the most widespread stratigraphic unit covering an area of 1250 km^2 within the Western Black Sea region. Slope instability problems encountered in the unit is considerable. The aim of this study is to identify the principal factors that control the dynamic and spatial distribution of landslides within the unit.

Çaycuma formation presents wide-soft morphology in the rugged and dissected topography of the region. It presents a broad synclinorium trending NE-SW and preserved thickness of the unit in the Filyos basin attains to 1200m. The unit mainly comprises the alternation of claystone, siltstone, mudstone and sandstone layers. The proportion of these layers differs from one site to another. The thinly and moderately thick bedding planes are extensive and persistent types of discontinuity. Thickness of the colluvium or residual silty clayey to clayey soil in places reaches 20m particularly over the toe of hillsides. The average annual precipitation is 800 mm. The groundwater elevation is mostly close to the ground surfaces.

The two principal types of landslide movement are sliding and flowing. In between the slides, translational slides have been occured in the intermediate and proximal parts of the unit. High ground water conditions and alternation of very weak clay-claystone and siltstone units with relatively thicker sandstone layers cause planar failure where appropriate conditions exist (i.e. slope angle, outslope bedding conditions and natural or manmade erosinal factors at the toe of the slopes, excessive pore water pressure, low shear strength parameters of clayey units). The areal extent of some of the translational slides pass over 1.5 km^2. Rotational or complex landslides are more common and have occured where alternation of thinly bedded sandstone and exteremly weak to weak claystone, siltstone and mudstone layers exist. The density of the landslides are concentrated on south eastern parts of the unit because of steeper slopes (20-30°) and relatively higher altitudes (200-300m).

Colluvium on slightly inclined slopes and undrained morphologies reach up to a thickness of 4-5m. In this parts of the formation creep movements are prevailed by typical micro-morphological structures such as swellings, sags and bulges. These type of movements are characteristic on the slopes of 5-15°. Earth and debris flows are mainly observed in the slide masses, on the slopes of over 20° and in pre-existing drainage paths. As the scarps of the flows heal quickly, because of wet climatic conditions, they are ascertainable after a short period of time.

Landslides with different state of activities occupy over 30% of the hillsides. Most of the landslides have considerable displacements between several centimetres to several meters per year. Dwellers severely suffer from instability problems, which destroy houses, public

properties and farm fields. To prepare effective land-use plans for the areas to be developed in the future, these on-going or hazardous processes should be studied in detail.

Engineering Geology of the Arsin-Trabzon Section of Trabzon South Expressway Possible Route

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The engineering geological properties of the rocks and soils outcropping in the Arsin-Trabzon section of the possible Trabzon south expressway route were determined both the field and laboratory studies. For this purpose, this route was mapped geologically with a scale of 1/25.000 initially and afterwords, enginnering geological map with a scale of 1/10.000 based on weathering grades was prepared.

Six different geological units were differentiated. They are rhyolite-rhyodasite and dacite (Upper Cretaceous-Paleocen), alternation of limestone, marl, sandstone and tuff (Upper Cretaceous-Paleocen), andesite-basalt and pyroclastic rocks (Eocen), poligenetic-heterogen conglomerate and breccia (Pliocen), terrace and alluvium (Quaternary) from down to up.

The six geological units distinguished in the engineering geological map were considered seperately from their point of engineering properties, and possible geotechnical properties for each unit were examined. These units which are rock are limestone, rhyodacite, rhyolitic breccia and conglomerate-breccia. Limestone and rhyodacite are good quality , middly fractured, middle-upto wide spaced, slightly amd middly roughly, partly weathered and hydrotermally altered as well middle strength rock. Rock mass classification of these rocks was carried out and investigated in terms of being tunnel, foundation and slope rocks. Accordingly, it is concluded that limestone and rhyodacite are suitable for tunnel and foundation rock but not for slope rock. The other rock units turned out to be poor quality in terms of engineering properties due to their highly weathered nature and poor cementation. Two different soil types were distinguished based on their clay mineralogy. These soil types have high placticity.

Slope, aspect and height value maps of the study route were produced by GIS technique and then these maps were used to create a mass movement risk map for the study area. Areas with risk and without risk were thereby distinguished. In addition to this, 3D digital elevation modelling for the investigation site was produced.

Investigation of failure mechanism in agglomerates by finite element method

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For rocks formed by blocks and weak cementing materials such as agglomerates, in most cases, due to scale effect, it is very difficult to obtain representative test specimens, or it is not possible to obtain the testing requirements in the laboratory conditions. For this reason, the predictive models related to mechanical and petrographical properties of rocks become important. The finite element method is used, in order to obtain the effect of the relationship between the block and the cementing material in the failure mechanism of agglomerates. In the present study, the agglomerates consisting of andezites as blocks and tuff as cementing material have been investigated. The finite element models simulating the physical structure of the agglomerates have been prepared. By finite element analyses, assuming the plane strain conditions, the distribution of the principal stresses, nodal point diaplacements and shear stresses have been determined. In these finite element models, under uniaxial compressive stress conditions, the failure mechanism of the hypothetical failure plane have been analytically investigated. The failure mechanism of the agglomerates is generally controlled by the tuffs. The shape and the position of the andezite blocks on the hypothetical failure plane have no effect on failure mechanism. The size and the number of the blocks on the hypothetic failure plane, proportionally increases the uniaxial compressive strength of agglomerates. In all proportion values between the andezite blocks and tuff, failure propogates through the tuff indicating an intragranular failure. This result which is obtained for hypothetical failure plane may be valid for whole agglomerate models.

A Method for Assessing the Efficiency and Applicability of the Contact Grouting Applications

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Contact grouting is applied for filling the cavities between tunnel lining and the rock and for sealing the joints against water penetration into the tunnel. The paper presents an easy and quick modeling method for determining the relationship between contact grouting and the geological properties of a formation for assessing the efficiency and applicability of a grouting application in a tunnel. This is done by calculating the amount of the grout mix and modeling the movement of the mix through the tectonic features of the surrounding rocks. Thus, a more realistic cost and feasibility analysis can be made for further grouting activities. The research was carried out on an approximately 1000 m long route of subway consisting of two parallel tubes between Mecidiyekoy and Gayrettepe stations. Isogrout maps, modeling the amount and the flow characteristics of the grout mix, were created and overlaid by the geological maps in order to investigate the relationship between grouting features and the petrophysical and tectonic properties of the rocks. The isogrout maps present the amount of grout mix pumped into the grouting holes and the mix distribution geometry. The grouting properties of four different types of rocks and faults, thrust zones, anticlines and synclines are discussed and compared. The influence of the petrophysical and tectonic properties on the efficiency of contact grouting is investigated on a quantitative base. Generally, the ceiling of the tunnel accepts more grout mix particularly in the fine-grained units. There is also a significant increase along the faults and the thrust zones. On the other hand, the filling material of the formation does not have a significant influence on the grouting efficiency. Related to the blasting, applied along the volcanic dike complexes, the grout mix acceptance of the environment extremely increases. The grouting is more effective in the highly weathered zones where the water may easily penetrate into the tunnel. Similar conclusions are presented for further research and tunneling activities in the area.

The influence of weathering on the engineering behavior of weak rock

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Burdur formation outcrops in the southern part of the Burdur Lake, SW Turkey. The formation is mainly composed of pebblestone, sandstone, marl and claystone. All these ingredients are affected by the weathering. Urban area of Burdur is located upon these weathered base rocks. When making the engineering geological studies of the site, weathered rocks and its product were examined by drillholes. The clay and clay units derived from the alterated products of host rocks were also recognized in the cores. This study describes the geological and geotechnical properties of the urban area under the light of the data collected during this investigation. For the design and the construction of building foundations in Burdur area the following features are considered as important:

- Index tests
- Durability tests
- Mechanical tests

The Relationship Between Susceptibility and Rebound Number of Shcmitch Hammer; An Example

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In this study, the measurements of magnetic susceptibility are taken for the field of study and variations of these measurements against rebound number of Schmith hammer are evaluated. In the field study carried out for granite and agglomerate rock types, two methods are found to support each other. It is also shown that they can be used as an indication of the degree of weathering occurring in the rock units.

The relation coefficient between these two methods is found to be very high. The locations where the rebound number of Shcmitch hammer (R) for the granite rock unit are high encounter with the locations where weathering are low. In other words, with the increasing weathering degree, the rebound number of Shcmitch hammer (R) values decrease, while susceptibility values increase. From the field study, magnetic susceptibility measurements play an important role in determination of the transition of weathering degree which is an important parameter in engineering geology. The rebound number of Shcmitch hammer (R) and magnetic susceptibility method, which is a more practical and economical than other methods, is effectively used in weathering problems of engineering geology studies.

Hydrogeological and geochemical properties of the volcanic rocks exposed in the Karasu (Hatay) graben (Southern Turkey)

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K-Ar isotopic age determinations performed by Çapan et al. (1987), Parlak et al. (1998) and Rojay et al. (2001) indicate that the volcanics of the Karasu graben is Plio-Quaternary in age. The volcanic rocks in the study area are characterized by alkali olivine basalts. Primitive mantle-normalized trace element patterns of the volcanics are similar to typical OIB pattern. Some of the incompatible trace element ratios such as La/Ba, La/Nb, Ce/Y and Zr/Nb are also akin to OIB values.

Volkanic rocks within the Karasu Graben are composed of several distinct lavas. Different volcanic rocks in this area show great variatians in size and shape, and in their surface features, so physical properties of different lava flows formed different hydro geological conditions. Lava flows in the Karasu Graben were investigated their hydrogeological properties. The opened wells in the lava flows are determined their hydrogeological features. Their pumping rates, specific capacity, transmissibility and hydraulic conductivity are more productive.

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Effect of geothermal fluid discharges on surface and groundwater pollution in Akarçay basin, Central Turkey

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Akarçay Basin with a surface area of 8000 km^2 is located between 30°-32° east longitudes and 38°-39° N latitudes extend in NW-SE direction in and around the Afyon province. Hot groundwater exploited from Gecek, Ömer and Gazlıgöl geothermal fields located on the west of basin has been used for hydrotherapy and district-heating purposes. Thermal water upon lost of its heat is either released over land or is discharged directly into the Akarçay River. The river is the main stream draining whole basin and flows eastward to Eber Lake whose natural connection to terminal lake of Akşehir at the downstream has been closed for last 15 years. Geothermal and freshwaters in the basin are characterized by NaCl and $CaHO_3$ facieses. Release of saline geothermal fluid into the main stream increases the salinity along the way to Eber Lake.

Present state and future effect of geothermal pollution on surface and groundwater bodies has been investigated by means of a hydrochemical survey comprising of major ions, heavy metals, trace elements, N and P. Evident geothermal pollution in surface and groundwater particularly around the production fields have been determined. Contribution of geothermal release elevates stream water's background electrical conductivity (350-450 microS/cm) to 600-700 microS/cm whereas; NaCl is increased about 11 fold. Geothermal discharge raises background heavy metal concentrations more than 35 per cent whereas, sorption and oxidation-precipitation over streambed removes considerable amount of element. Cation exchange capacity of the bed material ranges between 4.8 and 40.9 meq / 100 g and is correlated well with the equivalent fraction over sediment. Accordingly, retardation values reaching to 250 imply that metal removal is much slower than stream water's velocity.

Release of thermal water from district-heating facility considerably raises Na and Cl concentrations, which rapidly contributes to the salinity of Eber Lake, an invaluable fresh water resource in this semi-arid basin. Groundwater around geothermal fields has clear indications of thermal water contribution but does not pose risk in terms of potable or irrigation water use.

Engineering geological assessment of the Diyarbakır landfill area

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Site investigation of landfill area have significant, albeit difficult role to play in waste management. In the present economic conditions, with the environmentally sensitive regime, adequate desk-study and model development are essential ingredients for a successful site investigation of landfills. The study area is located in the Southeast Diyarbakır city, in the vicinity of the Diyarbakır-Mardin highway in the southeastern Anatolia. The population of Diyarbakır increases each year and already exceeded one million. The main problem of this city is to find suitable area for landfill. For this reason, Diyarbakır landfill area investigated the geologic, hydrogeologic, and geotechnical properties.

A gentle to smoothly dissected topography prevails in Diyarbakır and surrounding areas. The oldest units are represented by Upper Miocene-Pliocene claystones, clayey sandstones and loosely cemented (grain supported) conglomerates. Quaternary basalts and fluvial deposits overlie these units.

Rock falls are common along the southwestern slopes, made up basalts with cooling cracks.

Geotechnical, hydrogeological and topographical properties of the investigated area indicate that suitable conditions for the landfill, with some remedial works.

Koyulhisar (Sivas) Landslides, their Classifications and Investigations

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During the last years, the northern part of Koyulhisar has been affected by many landslides. In 1998 and 2000, which were very wet years, several landslides of different volumes occured. These mainly affected the Igdir formation, Erdembaba volcanics and Yesilce formations, which are well known for being prone to slope movements of many types and sizes. Detailed geological, geomorphological and geotechnical surveys were carried out, and stability conditions in Koyulhisar village located NE of Sivas (Turkey) were discussed in this paper. The rocks in the study area had been fractured by faulting. The rocks in the study area were classified from weak (Igdir formation) to medium (Erdembaba and Yesilce formation) according to Rock Mass Classification (RMR). According to the SMR, rocks were in the class of partially stable, some joints or many wedges (Erdembaba abd Yesilce formation) and the class of unstable, planar or big wedges (Igdir formation). Investigations have shown that jointing and faulting in combination with persasive weathering, steep topography, water incisions, tectonic activity and heavy rainfall have played a significant role in the occurence of the landslides. According to the kinematical analyses, potential slope movements will threaten in the direction of S, SW and SE. These directions are similar to the principal slope directions in Koyulhisar. Landslides in the study area can be classified as; planar, wedge and circular. All the slope movements had been observed between Şıhlar fault in the south and Dumanlıca fault in the north, and it can be said that all slope movements placed in a base landslide from Dumanlıca fault to Şıhlar fault.

Hydrogeochemistry of Kamara and Çizmeli (Yenice-Denizli) hot and mineral waters

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Denizli region is one of the important geothermal areas of Turkey. The temperature of many thermal waters discharging through the fault zones at the intersection area of Büyük Menderes and Gediz Grabens changes between 30^0C-100^0C . Kamara and Çizmeli thermal waters are located at the eastern end of fault zone of Gediz graben fault zone.

In the study area Paleozoic aged basement rocks consists of schists and marbles which are upper formations of Menderes Massive Metamorphics. Upper Miocene fluvial-laguner deposites lie above this formation with a discordance. Quaternary river terrace deposites, travertine and alluvium cover the lower formations with a discordance. The normal faults, which were formed in the Neotectonic period and causing graben and horst structures have 200-600 meters of vertical displacement.

The Kamara and Çizmeli hot waters which are located in the study area, reach to the earth surface by means of relating graben-horst system. These thermal waters, which are product of cyling hydrothermal system, are of meteoric origin. The Kamara thermal water (artesien), which discharges from a well drilled near the dried spring, has 56.7^0C temperature, 4 l/s of flowrate. Its dominant ions are sodium and bicarbonate. In Çizmeli thermal water which has 39^0C temperature and 1.5 l/s of flow rate, calcium and bicarbonate ions are dominants. Both of these thermal waters are older than 50 years according to the results of isotope analyses.

The reservior of the thermal waters of Kamara and Çizmeli consists of Paleozoic quartz-schists and marble. Reservoir temperature of the thermal waters is calculated to be 110^0C-120^0C by means of chemical geothermometers, 100^0C-120^0C by using fluid/mineral equilibrium and 135^0C by using silica mixture modelling.

The reservoir of the thermal waters of Kamara and Çizmeli consists of Paleozoic quartz-schists and marble. Reservoir temperature of the thermal waters was calculated as 110^0C-120^0C, 100^0C-120^0C and 135^0C by using chemical geothermometers, fluid/mineral equilibrium and silica-enthalpy mixing model, respectively.

Geotechnical Land Use Map: A Case Study from Bodrum Penisula, Muğla, Southwest Turkey

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Geotechnical land use maps are of great help to planners and field engineers for selecting locations to implement schemes in hummocky topography, as well as, for adopting appropriate mitigation measures in unstable hazard-prone areas. A new semi-quantative approach has been evolved, based on major factors of affecting land management and development planning purposes. A case study of the geotechnical land use map in the Bodrum Penisula, with the aim of providing systematic geotechnical input , has been presented.

The Bodrum Penisula study area is located to the southwest of Muğla, which is one of the most popular touristic region. The land usage in construction is growing each year. The west part of the region is situated on alluvium, next to the Aeagean Sea coastline. To the east, volcanic rocks forms the area reaching up to 400 m. An area of approximately 80 square kilometres was investigated. The geotechnical land use map of the Bodrum Penisula has been compiled from terrain classification based upon slope morphometry and geomorphological interpretation, weathering profile, assessment of the uniaxial compressive strength data, relative relief, land use and land cover, hydrogeological conditions and field reconnaissance studies. The terrain within the study area was initially classified on a landform basis, and each landform unit was assigned a geotechnical land use map class. The separately classified units then combined to form the map units of the geotechnical land use map. Three classes are defined; low geotechnical limitations, moderate geotechnical limitations, and high geotechnical limitations. The original study results are synthesized on a series of maps at a scale of 1:25 000.

Turkish Landslide Inventory Mapping Project: Methodology And Results On Zonguldak Quadrangle (1/500000)

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Turkey is heavily exposed to natural hazards such as earthquakes, landslides and floods. The total loss of landslides by means of affected buildings, in a period of 35 years, constitutes 27 % of the entire loss and takes place in second range after earthquakes. There is no available data on other direct and indirect costs of landslides on a national scale. However, it is known that despite the improvements in recognition, prediction and mitigative measures, damages and losses from landslides are increasing worldwide.

The 'Turkish Landslide Inventory Mapping Project' has been started by the General Directorate of Mineral Research and Exploration (MRE) in 1997, to help lead to a greater understanding of regional and national landslide issues. The purpose of the project is to establish medium (1/25000), regional (1/100000) and national (1/500000) scales of landslide inventory maps. In this scope, applying the direct mapping methodology, the existing landslides are being mapped on 1:25.000 scale topographic base maps by field studies and analysis of 1:20.000 -1:35.000 scale aerial photographs. The base maps (1/25000) are then digitised and stored in a GIS base data by the Geological Research Department of MRE. Hence, regional and national scale landslide maps could be available after rearrangements on medium scale maps.

The classification of landslides and determination of project standards have been the most discussed part of the actual study. Only the common types of landslides are classified as falls, topples, slides and flows. The creep movement dominant in certain formations is also depicted separately. The landslides applicable in 1:25.000 scale are only mapped. The studies achieved in the period of 1997-99, 1:500.000 scale Zonguldak quadrangle (composed of 272 quadrangles of 1/25000 scale) is accomplished. In Zonguldak quadrangle, Paleozoic meta-detritics, Jurassic-Cretaceous limestones, Cretaceous and Eocene flyschoid sediments and Miocene volcanics are the most widespread rocks units. Miocene volcanics, Cretaceous and Eocene flysches are the units where landslides are mostly populated.

This study is the first one of its kind to be applied in this country. It is believed that, some of the essential parameters of landslide hazard and risk maps and of large-scale national land use planning will be available by this project.

Karstic structures and its relationship with faults, and physical and chemical properties of karstic springs in Kalecik (Gümüşhane, NE Turkey)

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Formation and origin of karstification in Kalecik (Gümüşhane, NE Turkey) were investigated, and physico-chemical properties of karstic spring determinated in this study.

Hercynian basement of the Eastern Pontide orogenic belt, NE Turkey, is made up from the metamorphics and crosscutting granitoids outcropping mainly in Gümüşhane area. In the area studied Liasic Zimonköy Formation consisting of volcano-sedimantery rocks overlay unconformably the granitoids. Berdiga Formation containing limestone has deposited between Dogger and Lower Cretaceus. Upper Cretaceus Kermutdere Formation consisting of limestones, sandstones and claystones have deposited in flysch facies and overlies unconformably Berdiga Formation. The youngest litologies are alluvial and travertine.

Alluvial and travertine are the highest permeable rock in studied area. Hence the travertine consists of calcite completly, it is considerable for karstification. In region, the rock of flysch fasies considered unpermeable formation, because they consist of claystones and sandstones. However in the study area, sandly limestones of Kermutdere Formation are semi-permeable. The Formation has limited karstification since it does not entirely limestone.. Permeality of Berdiga Formation is controlled faults. Liasic Zimonköy Formation is unpermeable and has only permeable through faults and joints.

From the karstic structure observed in the studied a karstic cone formed as a result of two faults crossing each other. Furthermore karrens developed on the slope of the karstic cone. One of two faults controling karstic cone formed is vertical with NE-SW direction. The other fault is vertical with NW-SE direction. The karstic cone has about 10 meters in diameter and 15 meters in depth.

Cold water samples collected from karstik springs in studied area show similar chemical characteristics. Ca and HCO_3 ions are more abundant than other ions. The spring waters are saturated with calcite and dolomite. Besides, deposition of travertine is observed at around the outlet. Electrical conductivity value of spring waters from karstic structure are 1000 µmho/cm. Average temperature is 16^oC and discharge ranges from 0,32 and 4,5 l/s and pH values are between 6,55-6,67. Based on chemical analyses, total dissolved material is between 1431,5 and 1425,82 mg/l. Free CO_2 content is lower than 31,3 meq/lt in waters and $CaCO_3$ content, which can be solved by spring water, is 80 mg/l. Considering the chemical properties, according to TS 9130 (Mineral water-drinkable), investigated spring waters are drinkable.

Ilıcaköy hot water springs hydrogeochemical properties (İkizdere–Rize, Turkey)

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In this investigation Ilıcaköy (İkizdere- Rize) hot water springs has been studied from the point of the geology, hydrogeology, hydrogeochemistry, recharge, discharge and origin. The study area, located around Ilıcaköy, covers 20 km^2 . In the study area the oldest rocks are Late Cretaceous İkizdere Granitoid , which are composed of granite, K-feldspar granite. İkizdere Granitoid is cross cut by dykes and overlain by talus and alluvial material.

There is a number of faults directed NE-SW, NW-SE and E-W, from which NW-SE and E-W directed faults control Ilıcaköy hot water springs to come out to the surface.

In 1998 Ilıcaköy –1 and 2 hot waters are drilled by M.T.A. and for the Ilıcaköy-1 hot water 2,5 l/sec discharge rate and Ilıcaköy-2 hot water 6,1 l/sec discharge rate are obtained. The drilling depths of springs are 40 m. for Ilıcaköy-1 and 266 m for Ilıcaköy-2 .

Hot waters are analysed by MTA. According to the analyse results total dissolved ion matter for Ilıcaköy-1 4012,1 mg/l and Ilıcaköy-2 4115,21 mg/l are obtained. The temperature of the springs are 54 ^{0}C in Ilıcaköy-1 and 63 ^{0}C in Ilıcaköy-2.

The hot water springs are classified according to the following criterias :

- according to the structural properties “fault springs”
- according to the temperature “very hot waters”
- according to the hardness “very hard waters”
- according to the geothermal energy “low entalphy geothermal systems”
- and according to the hot water analyse results cation and anion trends of the hot springs are
  for Ilıcaköy-1 ; $rHCO_3 > rNa^+ > rCl^- > rCa^{++} > rSO_4^{--} > rMg^{++} > K^+$
  for Ilıcaköy-2 ; ; $rHCO_3 > rNa^+ > rCl^- > rSO_4^{--} > rMg^{++} > K^+ > rCa^{++}$

Ilıcaköy hot water springs which deposite travertine are saturated with respect to calcite and dolomite.

Because of the analyse results of hot waters are similar to the results of cold waters, the origin of hot waters are meteoric.

According to the calculations by way of geothermal gradient hot water springs are originated from 573 m. of depth for Ilıcaköy-1 and 690 m. of depth for Ilıcaköy-2.

The heat flow value which belong to the reservoir of the granitoid is 7,54 cal/cm^2sec .

Using the Na-K-Ca geothermometer the temperature of the reservoir are obtained 198,76 ^{0}C and using the Na-K geothermometer yhe temperature of the reservoir are obtained 264,96 ^{0}C.

EARTHQUAKES IN TURKEY

Investigations of Micro–Earthquake Activity within the Sea of Marmara and surrounding regions by using Ocean Bottom Seismometers (OBS) and land seismographs: Initial results

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We have conducted seismological observations within the Sea of Marmara and surrounding regions in order to investigate the microseismic activity induced after the Gölcük earthquake (Mw=7.4) of August 17, 1999 by using ocean bottom seismometers (OBS) and land seismographs consisting of three-component sensors and digital recording units for an efficient survey. The Marmara Sea OBS project has been conducted in two legs involving deployment of 10 OBSs each time within the Çınarcık (eastern Marmara Sea) and middle and Tekirdağ (western Marmara Sea) basins during 28 April–17 July 2000, and have been supported by a small array of land stations operated for a longer period in order to cover the azimuthal gaps and to provide a better resolution in determining various seismological parameters. This presentation simply summarizes preliminary initial scientific results from first leg. We have detected many earthquakes within the basins along the suspected strands of the North Anatolian Fault, which is thought to partition in the Çınarcık basin. The collected earthquake data quality is quite good and allows us to determine earthquakes as small as magnitude 1. The spacial distribution (azimuthal coverage) of especially OBS and land stations gives us a chance to reliably define micro-earthquakes' parameters as they were deployed nearby to the earthquake sources.

The seismotectonic pattern observed is similar to those of previous studies identified by using different seismological methods. We did not detect earthquakes deeper than 20 km during the OBS campaign, and the initial results will be improved with additional data, but the depth distribution is confined within the Çınarcık basin and comparable to those of the Gölcük aftershocks. The combined seismological, seismic reflection, geological, geomorphological, and space geodetic observations are consistent, and suggest that slip partitioning on the western part of North Anatolian Fault is still taking place.

A significant fraction of the slip in the region is likely to be accommodated seismically, but whether there is a substantial contribution from aseismic deformation processes is less certain, and should be questioned further. The westernmost continuation of North Anatolian Fault (NAF) into the Sea of Marmara in the vicinity of Çınarcık–Yalova clusters still requires further investigations to better understand the complexity of faulting associated with earthquakes within the Çınarcık basin.

The Dodurga (Orta-Çankırı) earthquake (June 6, 2000; M_w=6.1), Central Turkey: complex mechanism of extension in escape tectonics

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A moderate earthquake (M_w=6.1) occurred in the vicinity of the town of Dodurga, central Turkey, at 02.41 UT on June 6, 2000. The earthquake caused the formation of surface rupture that has discontinuously been observed along NE-SW trending fault segments with a total length of 20 km. The fault segments that are collectively called the Dodurga fault exhibit sinistral-slip deformation with a prominent dip-slip component. The surface rupture indicates a major part of the Dodurga fault was activated. The fault geometry, surface rupture and rupture process analysis suggest a complex mode of extension with a slip vector on the underlying sinistral transtensional fault to an oblique southwesterly orientation. This movement accompanies intraplate deformation and rotation within the Turkish plate that constitutes a well-known example of escape tectonics.

Seismicity of Settlement area in Denizli and its surrounding

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Denizli and its surrounding area located in the western Anatolia in Aegean Graben System and at a region in which some important grabens intersect each other. As it is known, Aegean Graben System which may cause has been destroying earthquakes one of the most important active system of our country and continuous today as well. Within the Neotectonic Period the Anatolian Plate started to be pushed westwards. So, in the southwestern of Turkey a great number of graben structures started the to develop which lay approximately at E-W direction on. The crust distance Aegean Region directed N-S has almost increased two times more from the begining of grabens up to this period. Generally N-S directed grabens in the western Anatolian Region are Lower Miocene in age, These were displaced by the E-W directed younger grabens which are Middle-Upper Miocene in age, Today, the faults which form E-W directed grabens are active and they have Listric fault geometry which decrease incline to deepwards.

According to Seismic Risk Zoning Map of Turkey, Denizli and its surrounding take place in the first level earthquake area and since the previous times at almost each 15-20 years earthquakes has occured which caused damage and many death. One can notice that a stabilize period had become since 1975 up to this time. When the former historical earthquake data and the tectonic structure of the region is evaluated, it can be seen that the stabilize period has almost lasted 10-30 years and the active period has lasted 15-20 years in the western Anatolia. In Denizli region, a great number of quakes has begun to occur soon after the earthquakes Kocaeli and Düzce. As it is known the intersection points of the active faults (especially the ones with each other) are the most intensive regions of seismicity. These faults are active and the potential energy that is accumulated in each one is easily conducted to the faults in contact. The most vital reason of the fact that frequent destroyable earthquakes had occured in Denizli, Sarayköy, Honaz and its surrounding in previous historical periods is intersection of the active graben side faults with each other in these regions. Another important reason of regional seismicity sources from the negative qualitites of the grounds on which Denizli and settlement areas around it locate. By this presentation, the active tectonic structure of Denizli and its near surrounding and the main factors causing the region's seismicity is going to be explained.

The June 27, 1998 Ceyhan–Adana earthquake (Mw=6.3) obtained from inversion of teleseismic body waveforms: broad-band source characteristics

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It is well known that the neotectonics of the eastern Mediterranean region is governed by the convergence of the African and Eurasian plates in the west and by the collision of the Arabian and the Anatolian plates in the east causing moderate to large size earthquakes.

We used teleseismic broad-band P- and SH- body waveforms and first motion polarities of P-waves to determine the source parameters of June 27, 1998 (Ceyhan–Adana, t_o=13:55:52.10, Mw=6.3, Ms=6.2, mb=5.8) earthquake. We compared the shapes and amplitudes of broad-band P- and SH-waveforms recorded by GDSN stations in the teleseismic distances 30° – 90°, and P-waves in the intermediate distances 15° – 30°, for which signal amplitudes were large enough, with synthetic waveforms.

The best-fitting fault plane solution of Ceyhan–Adana earthquake shows left-lateral strike-slip faulting with a rupture velocity of Vr=2.8 km/sec in the direction of NE (azimuth 65°). The source parameters and uncertainties of the June 27, 1998 Ceyhan–Adana earthquake obtained with directivity effects to be: Nodal Plane 1: strike 47° ± 5°, dip 76° ± 5°, rake 12° ± 5°; Nodal Plane 2: strike 314°, dip 78°, rake 166°; principle axes: P=1° (2°), T=270° (18°), B=96° (72°); focal depth 17 ± 2 km, and seismic moment Mo = 4.41×10^{18} Nm.

The above observations has also been indirectly confirmed by the strong-motion records operated within the Ceyhan-Adana basin and surrounding regions with clear propagation effects (northeastern directivity) observed at Ceyhan (CYH) and Karataş (KRT) strong motion records. The focal mechanisms of major aftershocks and their distribution also confirm that the earthquake nucleated at an unusually deep seismogenic zone, most likely within the lower crust. There is no clearly observed surface rupture associated with the faulting confirming the deep focal depth.

Source parameters of June 6, 2000, Orta–Çankırı earthquake (Mw=6.0) obtained from inversion of teleseismic body-waveforms

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This presentation is concerned with the seismotectonics of the North Anatolian Fault in the vicinity of Orta–Çankırı region, and consists of study of a moderate size (Mw=6.0) earthquake that occurred on June 6, 2000. The instrumental epicenter of this earthquake is considerably away from the North Anatolian Fault Zone (NAFZ), and rapid focal mechanism solutions of USGS-NEIC, and Harvard-CMT also demonstrate that this earthquake is not directly related to the right-lateral movement of the North Anatolian Fault. This earthquake is the only event that its magnitude greater than 5 since 1900 between Ankara and Çankırı therefore contains valuable data to improve our understanding of the neotectonic framework of the northwest central Anatolia. Field observations were carried out in the vicinity of Orta town and its villages immediately after the earthquake indicating no apparent surface rupture but reported damages being intensified in the villages located to the southwest of Orta town.

We used teleseismic long-period P- and SH- body waveforms and first motion polarities of P-waves, and broad-band P-waves to determine the source parameters of June 6, 2000 (Orta-Çankırı, t_o=02:41:53.2, Mw=6.0) earthquake. We compared the shapes and amplitudes of long period P- and SH-waveforms recorded by GDSN stations in the distance range 30° – 90°, for which signal amplitudes were large enough, with synthetic waveforms. The best-fitting fault plane solution of Orta-Çankırı earthquake shows normal faulting with left-lateral component with no apparent surface rupture in the vicinity of epicenter (Orta town).

The source parameters and uncertainties of the June 6, 2000 Orta-Çankırı earthquake obtained to be: Nodal Plane 1: strike 2° ± 5°, dip 46° ± 5°, rake –29° ± 5°; Nodal Plane 2: strike 113°, dip 70°, rake –132°; principle axes: P=338° (48°), T=232° (14°), B=131° (39°); focal depth 8 ± 2 km (though this does not include uncertainty related to velocity structure), and seismic moment Mo = $13x10^{17}$ Nm.

The June 6, 2000 Orta-Çankırı earthquake occurred close to a restraining bend in the E–W striking right-lateral strike-slip fault that moved in the much larger earthquake of August 13, 1951 (Ms=6.7). The faulting in this anomalous earthquake could be related to the local geometry of the main strike-slip system, and may not be a realiable guide to the regional strain field in the northwest central Turkey.

Source parameters of the Cyprean earthquakes obtained from inversion of teleseismic body-waveforms

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This presentation is concerned with the seismotectonics of the Cyprus region, and consists of study of a moderate size earthquakes that occurred on February 23, 1995, October 09, 1996 and October 10, 1996. The seismotectonics features of Cyprus is mainly governed by plate interactions (subduction and transform processes) between Africa and Anatolia along Cyprean arc. February 23, 1995 and October 10, 1996 earthquakes indicate clear thrust and strike-slip mechanisms, but October 09, 1996 earthquake shows normal faulting mechanism with a significant strike-slip component.

We used teleseismic long-period P- and SH-waveforms and first motion polarities of P-waves, and broad-band P-waves to determine the source parameters of February 23, 1995, October 09, 1996 and October 10, 1996 earthquakes. We compared the shapes and amplitudes of long period P- and SH-waveforms recorded by GDSN stations in the distance range 30° – 90°, for which signal amplitudes were large enough, with synthetic waveforms.

The source parameters and uncertainties of the February 23, 1995 Cyprus earthquake obtained to be: Nodal Plane 1: strike 15°± 5°, dip 75° ± 5°, rake 73° ± 5°; Nodal Plane 2: strike 24°, dip 23°, rake 137°; principle axes: P=119° (28°), T=263° (57°), B=20° (16°); focal depth 14 ± 2, km, and seismic moment Mo = 6.96×10^{17} Nm.

The source parameters and uncertainties of the October 09, 1996 Cyprus earthquake obtained to be: Nodal Plane 1: strike 38° ± 7°, dip 16° ± 5°, rake –161° ± 7°; Nodal Plane 2: strike 290°, dip 85°, rake –75°; principle axes: P=216° (48°), T=6° (38°), B=108° (15°); focal depth 12 ± 2, km, and seismic moment Mo = 2.083×10^{19} Nm.

The source parameters and uncertainties of the October 10, 1996 Cyprus earthquake obtained to be: Nodal Plane 1: strike 41° ± 7°, dip 59° ± 7°, rake 163° ± 7°; Nodal Plane 2: strike 140°, dip 75°, rake 32°; principle axes: P=268° (11°), T=5° (33°), B=162° (55°); focal depth 26 ± 2 km, and seismic moment Mo = 3.651×10^{17} Nm.

Source parameters of November 6, 1992 Doğanbey (İzmir) earthquake (Mw=6.0) obtained from inversion of teleseismic body-waveforms

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This presentation is concerned with the study of a moderate size (Mw=6.0) earthquake that occurred on November 6, 1992 in the vicinity of Doğanbey (İzmir), located near the Orhanlı Fault Zone (OFZ) that bounds Sereferihisar Horst on the eastern part.

We used long-period P- and SH- body waveforms and first motion polarities of P-waves to determine the source parameters of November 6, 1992 (Doğanbey-İzmir, t_o=19:08:09.5, Mw=6,0) earthquake. We compared the shapes and amplitudes of long period P- and SH-waveforms recorded by GDSN stations in the distance range 30°– 90°, for which signal amplitudes were large enough, with synthetic waveforms. The fault plane solution of Doğanbey (İzmir) earthquake shows right-lateral and left-lateral strike slip faulting on nearly E-W and N-S striking nodal planes, respectively. This earthquake is most likely associated with Orhanlı Fault Zone. The minimum misfit solutions obtained in the present study is in agreement with those of Harvard Centroid Moment Tensor (CMT) and first motion solutions, however is in great disagreement with previously reported field observations for the reasons that are not quite obvious to us.

The source parameters and uncertainties of the November 6, 1992 Doğanbey (İzmir) earthquake obtained to be: Nodal Plane 1: strike 255°± 5°, dip 85°± 5°, rake –158° ± 5°; Nodal Plane 2: strike 163°, dip 68°, rake –5°; principle axes: P=121° (19°), T=27° (12°), B=267° (67°); focal depth 13 ± 2 km, and seismic moment Mo = 1.531×10^{18} Nm.

Source parameters of December 15, 2000 Akşehir–Sultandağ earthquake (Mw=6.0) obtained from inversion of teleseismic body-waveforms

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The Aegean region has been subject to extension since Miocene time, and this extension has left a pronounced expression in the present-day topography. It is further widely accepted that the rapid extension observed in western Turkey is mainly accommodated by large active normal faults that control the geomorphology. The NE–SW trending Burdur, Acıgöl and Baklan, and NW–SE trending Dinar and Akşehir–Sultandağ basins all bounded by large faults form a system of half-graben whose orientation is evident in both the tomography and the tilting of Neogene sediments adjacent to them. The Sultandağ has a marked morphological expression ~1000m in elevation relative to the surrounding plains.

This presentation is concerned with the seismotectonics of the Akşehir–Sultandağ Fault in the Lake districts (Western Turkey), and consists of study of a moderate size (Mw=6.0) earthquake that occurred on December 15, 2000.

We used teleseismic long-period P- and SH- body waveforms and first motion polarities of P-waves, and broad-band P-waves to determine the source parameters of (Akşehir–Sultandağ, t_o=16:44:45.00, Mw=6.0) earthquake. We compared the shapes and amplitudes of long period P- and SH-waveforms recorded by GDSN stations in the distance range 30° – 90°, for which signal amplitudes were large enough, with synthetic waveforms. The best-fitting fault plane solution of Akşehir–Sultandağ earthquake shows normal faulting.

The source parameters and uncertainties of the December 15, 2000 Akşehir–Sultandağ earthquake obtained to be: Nodal Plane 1: strike 294° ± 5°, dip 40° ± 5°, rake –80° ± 5°; Nodal Plane 2: strike 101°, dip 51°, rake –98°; principle axes: P=327° (82°), T=197° (5°), B=106° (6°); focal depth 8 ± 2 km (though this does not include uncertainty related to velocity structure), and seismic moment Mo = $13x10^{17}$ Nm.

It is puzzling that there are disagreements in some of the earlier reported geological observations with others, most likely due to misinterpretation, and those of the seismological observations after the recent earthquake. The December 15, 2000 Akşehir–Sultandağ earthquake is the first reliable seismological evidence and well recorded event during the instrumental seismology period showing almost pure normal faulting mechanism, and still producing aftershocks in the source region.

1-D velocity structure of Erzincan and surrounding region

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In this study we aimed to obtain one-dimensional (1-D) P- and S- wave velocity structure of upper crust beneath in Erzincan and to achieve reliable and precise hypocenter locations. Arrival times of about 1561 aftershocks that were recorded during three months after 13 March 1992 Erzincan earthquake (Mw=6.9), were used for inversion analysis. 22241 P- and 10017 S-arrival times were determined from 58 temporary stations which consists of single component telemetric network, autonomous MEQ recorders, 3 component GEOSTRAS recorders.

Subsets of well locatable events were used to calculate a minimum 1D velocity model for both only P-wave and P- and S-waves. Well locatable events of 1049 for P-wave velocity and 881 for P- and S- wave velocity were selected for 1D inversion. Selection criteria were azimuthal gap less than 180° and minimum 10 P- and 5 S-observations. Totally 17898 P arrival times for P-velocity and 7848 P and 7817 S arrival times for P&S velocity were used to compute in iterative simultaneous inversion of velocity and hypocentre parameters.

Several tests were applied on minimum 1D velocity model for stability and hypocenter uncertainties. As almost all events occurred in the upper crust from 2 km to 22 km depth, the layers between these depths were well resolved. Our results will be used as initial velocity model for 3D velocity crustal structure and also can be a reference model for locating earthquakes in the region.

Source parameters of November 15, 2000 Van earthquake (Mw=5.7) obtained from inversion of teleseismic body-waveforms

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This presentation is concerned with the seismotectonics of the Van Lake district, and consists of study of a moderate size (Mw=5.7) earthquake that occurred on November 15, 2000. The combined seismological and geological studies have shown that the right-lateral strike slip faults (Tutak and Çaldıran) active in the eastern part of the Karlıova triple-junction. Teleseismic body waveform modeling results in this study confirms that clear thrust and strike-slip motion have been involved on the occurrence of this earthquake.

We used teleseismic long-period P- and SH- body waveforms and first motion polarities of P-waves to determine the source parameters of November 15, 2000 (Van, t_o=15:05:38.17, Mw=5.7) earthquake. We compared the shapes and amplitudes of long period P- and SH-waveforms recorded by GDSN stations in the distance range 30°– 90°, for which signal amplitudes were large enough, with synthetic waveforms. The best-fitting fault plane solution of Van earthquake shows thrust faulting with right-lateral component in the southern coast of the Lake Van. The minimum misfit solutions obtained differs than those of Harvard Centroid Moment Tensor (CMT) and USGS Moment Tensor (MT) solutions, and are good agreement with local geometry of the faults. It is, therefore, most probable that thrusts in the Muş region continues to the east through the southern shores of Lake Van.

The source parameters and uncertainties of the November 15, 2000 Van earthquake obtained to be: Nodal Plane 1: strike 100° ± 10°, dip 64° ± 10°, rake 111° ± 15°; Nodal Plane 2: strike 239°, dip 33°, rake 54°; principle axes: P=175° (16°), T=46° (65°), B=270° (19°); focal depth 18 ± 2 km, and seismic moment Mo = 3.825×10^{17} Nm.

Expanding Horizons in Mitigating Earthquake Hazard: Global Development of Real-Time Seismology and its Necessity For Turkey

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To minimize the immediate impact of large earthquakes in earthquake prone, modern urban regions a new approach, real-time seismology, has come up with the use of most advanced seismic receivers, data acquisition and telemetry systems. Real-time seismology systems provide rapid earthquake information, comprising not only basic information such as magnitude and hypocenter location but also spatial distribution of ground shaking by means of ground acceleration, velocity and displacement. The information is, then, used to effectively organize recovery efforts and emergency response and to minimize social disruption after the large earthquakes. In some cases, it may even provide early warnings before upcoming ground shaking to mitigate earthquake damage to power stations, main computers systems, subway operations etc. In addition, the acquired seismic records can be used to retrieve info on source characteristics of the major event, such as, faulting mechanism, rupture process, slip distribution and rupture directivity, in near-real-time to further assess the extent of faulting that may cause damage. The real-time seismology systems are functional in earthquake prone countries like Japan, USA, Taiwan and Mexico. They are in a development stage in Turkey and Romania. These systems, successfully, performed after the 1995 Guerrero earthquake in Mexico (early warning), 1994 Northridge and 1999 Hector-Mine earthquakes in United States and 1999 Chi-Chi earthquake in Taiwan.

Here, we briefly inform the global development of the real-time seismology systems, their configurations, how they performed after the most recent large earthquakes and discuss its necessity for Turkey.

Source characteristics of an intraplate earthquake in the Anatolian plate: the Orta earthquake of June 6, 2000

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The compression between the northward moving Arabian and relatively stable Avrasian plates gives rise to an escape tectonic regime of the Anatolian plate mainly accommodated along the North Anatolian fault zone (NAFZ). The NAFZ changes its direction from WNW to WSW just to the north of the Orta earthquake source region, indicating counterclockwise rotation of the Anatolian plate. Many secondary faults have developed within the Anatolian block to accommodate internal deformation resulting from this rotation. The Dodurga fault, striking NS and dipping east with a length of about 20 km, is one of these secondary faults that produced the Orta earthquake (M_S=6.1) of June 6, 2000, shortly after the devastating August 17, 1999, İzmit (M_S=7.8) and November 12, 1999, Düzce (M_S=7.2) earthquakes occurred along the western extension of NAFZ. In the present study we utilize teleseismic P and SH waveforms to investigate finite-fault characteristics of the Orta earthquake. A linear finite-fault inversion method with time-window parameterization is applied to 23 broadband P and 9 long period SH teleseismic velocity waveforms of the earthquake for the spatial distribution of coseismic slip. The time-window approach allows source complexities resulted from variable rise time and rupture velocity across the model fault plane to be accounted in the modeling. The earthquake rupture is represented by a 21 by 18 km rectangle fault plane with 358° strike and 47° dip. The rake angle is allowed to vary in the range -90°-0°. The finite-fault modeling, define four distinct circular source regions with radius of 2.0-2.5 km. The overall slip pattern indicates bilateral rupture propagation in dip direction and mostly unilateral (toward N) in strike direction. The slip, primarily, occurred over the northern half of the fault with the largest slip of about 40 cm at the hypocentral region. The average rake angles for the source regions are in the range from –15° to –40°. Estimated seismic moment for the slip model is 1.3x10^{18} Nm.

The Parameters of two Minor Fault Segments in the Source Region of the October 1st, 1995 Dinar Earthquake (Mw=6.2): Implications for Seismotectonics and Foreshock-Mainshock Interaction

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The surface ruptures associated with the October 1st, 1995 Dinar earthquake (Mw=6.2) depicted 15 km failure on the 75 km long NW-SE trending Dinar-Çivril fault. This part of the fault segment was broken by two subevents of magnitude Mw=5.8 and Mw=6.1 located to the SE and NW, respectively, of the source area. A foreshock activity commenced a week prior to the main-shock that took place along a narrow band perpendicular to the source area. Taking into account the foreshock distribution and the focal mechanisms of the largest two foreshocks (Mw=4.8) we claim the existence of a left-lateral strike-slip minor fault segment with small normal component, striking NE-SW which is parallel to the Fethiye-Burdur, Baklan and Acıgol fault systems. The foreshock activity occurred on this “tear” fault situated between the ruptured NW trending major segment and an E-W striking 2 km long normal fault.

The 2 km long E-W trending normal fault is situated just 2-2.5 km to the north of Dinar town which constitute the SE extreme of the ruptured zone. We observed uniform 30 cm vertical displacement along the entire segment. Assuming a rigidity of $\mu=3x10^{11}$ dyn.cm one may attribute a subevent of size Mw=5.6 that ruptured this segment. About 20 m deep trench excavated on this fault segment show very clearly previous seismic events that had been associated with vertical displacements between 25 and 40 cm affecting Plio-Quaternary deposits. The inversion of slip-vectors measured on these conjugate normal faults yields a N-S extensional direction.

Taking into account the results of previous source analysis studies of the main shock, the parameters of the strike-slip tear fault and the E-W normal fault as well as the aftershocks we propose the following foreshock-mainshock occurrence model for the 1995 Dinar earthquake. The foreshock activity on the tear fault increased the static stress on the fault segments located to the east and west. Then, the stress increase triggered failure on two segments ruptured by Mw=5.6 and Mw=5.8 subevents located to the east and west, respectively. Finally, The rupture propagated further NW where 6 seconds later the major segment was ruptured by Mw=6.1 subevent.

Fissure fill travertine as a recorder of secular variation and earthquake activity: An example from the Sıcak Çermik (Sivas) geothermal field

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Incremental deposition of travertine in developing extensional fissures incorporates small amounts of ferromagnetic minerals. These give the travertine as a weak magnetic remanence from which a time sequence of palaeomagnetic field directions can be determined. Growth of travertine on either side of the fissure axis can potentially provide a double record of field behaviours. We report results from an example in the Sıcak Çermik geothermal field of Central Turkey. Migration of the field is duplicated on either side of the axis and is interpereted as approximately one cycle of secular variation which correlates most closely wıth the palaeofield mıgratıon path for the Near East at ~ 2000B.C. to 500A.D. The remanence carrier is goethite in this example. Colour variations produce a banding that permits the record to be matched on either side of the axis but is not positively reflected in susceptibility and intesity variations. Susceptibilty does however correlate with aragonite:calcite ratios. This implies that deposition of iron minerals is diagenetic but must occur very soon after primary deposition since the fissure travertine is a hard and impervious deposit.

STRIKE-SLIP DEFORMATIONS

Stages in the development of the Northern Dead Sea Transform

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It is well establilshed that the Dead Sea Transform (DST), the plate boundary between the African and Arabian plates, formed in the Middle Miocene, later than 19.4 Ma. Although the DST has been the subject of numerous studies, its development in time and space, especially in its northern part (north of the Hermon and Lebanon mountains), is not well understood.

The Yizre'el Valley is a deep basin filled by Miocene volcanics (the Lower Basalt) and lacustrine sediments. It is bounded by the Carmel Fault, a splay of the DST. The Lower Basalt, dated at 17.5-9 Ma, is the only volcanic field along the DST having this age. The eruptions and the formation of the Yizre'el Basin represent extension, and thus it is suggested that the Carmel Fault and the Yizre'el Valley acquired their present structure simultaneously with, and as a part of, the formation of the southern DST at 18.5±1 Ma (between 19.4 and 17.5 Ma).

Field data from the DST in Lebanon, northern Syria and SE Turkey suggest that the amount of horizontal displacement in the northern part of the DST is smaller than in its southern part. This may be interpreted two ways: (a) the northern part of the DST formed later than the southern part, or (2) that part of the horizontal displacement was absorbed in the deformation of the Hermon and Lebanon mountains as a result of the right-stepping on the Yammunneh Fault.

The total displacement along the northern part of the DST has been suggested to be about 20 km. A Pliocene volcanic field, the Shin Plateau in NW Syria, was offset by 15-20 km some time after 6 Ma. This and other field data suggest that during the first formation phase of the northern DST, the activity was concentrated along the Roum Fault. At this time, the present known major faults in Lebanon (e.g., the Yammunneh Fault) were not yet active, and no major pull-apart basins had formed north of the Dead Sea Basin. The first pull-apart basin to develop was the Kinnarot Basin, in which a thick alluvial and volcanic sequence, penetrated by a deep well (Zemah 1), accumulated. According to radiometric dating, this basin formed at the Middle Miocene (about 12 Ma).

In the Late Miocene to Early Pliocene a major change in the plate tectonic kinematics of the Middle East took place. One of the most significant consequences of this was the formation of the North Anatolian Fault and the East Anatolian Fault. It is suggested here that this change was accompanied by the transfer of the major activity along the northern DST from the Roum Fault to the Yammunneh Fault. In addition, the triple junction in the northern Karasu Valley (SE Turkey) was formed. At this time, the Hermon, Lebanon and Anti-Lebanon Mts. were deformed and uplifted, and two major pull-apart basins, the Ghab Basin in NW Syria and the Hula Basin in northern Israel, developed.

Rate of strike-slip on the Amanos Fault (Karasu Valley, southern Turkey) constrained by K-Ar dating and geochemical analysis of Quaternary basalts

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The left-lateral Amanos Fault follows a ~200 km long and up to ~2 km high escarpment which bounds the eastern margin of the Amanos mountain range and the western margin of the Karasu Valley in southern Turkey, just east of the northeastern corner of the Mediterranean Sea. Regional kinematic models have reached diverse conclusions as to the role of this fault in accommodating relative motion between either the African and Arabian, Turkish and African, or Turkish and Arabian plates. Local studies have tried to estimate its slip rate by K-Ar dating Quaternary basalts that erupted within the Amanos Mountains, flowed across it into the Karasu Valley, and have since become offset. However, these studies have yielded a wide range of results, ranging from ~0.3 and ~15 mm a^{-1}, which do not allow the overall role and significance of this fault in accommodating crustal deformation to be determined. We have used the Cassignol K-Ar method to date 9 Quaternary basalt samples from the vicinity of the southern part of the Amanos Fault. These basalts exhibit a diverse chemistry, which we interpret as a consequence varying degrees of partial melting of their source combined with variable crustal contamination. This dating allows us to constrain the Quaternary slip rate on the Amanos fault to ~1.0 to ~1.6 mm a^{-1}. The dramatic discrepancies between past estimates of this slip rate are partly due to technical difficulties in K-Ar dating of young basalts by isotope dilution. In addition, previous studies at the key locality of Hacılar have unwittingly dated different, chemically distinct, flow units of different ages that are juxtaposed. This low slip rate indicates that, at present, the Amanos Fault takes up a small proportion of the relative motion between the African and Arabian plates, which transfers southward onto the Dead Sea Fault Zone. It also provides strong evidence against the long-standing view that its slip continues offshore to the southwest along a hypothetical left-lateral fault zone located south of Cyprus.

Neotectonic deformation at the junction of the Hellenic and Cyprus arcs (SE Greece - SW Turkey)

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For the eastern Mediterranean it is presently believed that a relationship exists between (1) the late Miocene collision of the African plate's Arabian promontory with Eurasia, (2) the ensuing westward extrusion of Anatolia into the Aegea, (3) the subsequent increasing curvature of the Hellenic Arc (HA), and (4) the onset of sinistral wrench tectonics along the eastern HA. This concept predicts an initial connection between the Hellenic and Cyprian subduction zones, which since the latest Miocene became separated due the sinistral wrench tectonics along the eastern HA. Combination and compilation of new and existing data from both sides of the Hellenic and Cyprus Arc (HCA) junction and from both on- and offshore domains provide structural evidence for such a "translation" of arc segments which until now is only poorly documented and of which the kinematics are inadequately understood.

At the time the southeastern segment of the HA started to act as a sinistral strike-slip zone, the low angle of plate convergence precluded active subduction along this part of the arc as is shown by deep intra-plate seismicity. Moreover, active subduction beneath the Cyprus Arc appears to be stalled with the arrival of Eratosthenes Seamount at the subduction zone. The kinematic difference or incompatibility of the two arc segments may explain the existence of complex strain patterns at the HCA junction.

In the context of the “translating” arcs theory we will address the role of several key features in the eastern Mediterranean: 1) If and how do the effects of sinistral strike-slip along the eastern segment of the HA penetrate into the Isparta angle. 2) Is the sequence of deformation in SW Turkey comparable to that of the Hellenic forearc? 3) What is the role of the Anaximander Mountains and how do they correlate with southwest Turkey and the southeastern Aegean domain.

Eventually we discuss several alternatives for the linkage between geodynamics and kinematics of the identified structural domains.

Neogene to Quaternary Volcanism and Strike-slip Faulting in the Gaziantep Plateau, Southeastern Turkey

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The Gaziantep plateau is an upland region northwest of the city of Gaziantep, within the Arabian platform in south-eastern Turkey. The characteristic sequence of Palaeogene and Early Miocene platform carbonates is locally covered by up to ~100 m thickness of young basalt, over an area of ~2000 km^2. Although this area has not previously been studied in detail, past investigators have variously claimed that this volcanism is either Miocene or Quaternary. Other studies have also suggested that this region is cut by an active left-lateral strike-slip fault segment, the Kırkpınar Fault, which links the Dead Sea and East Anatolian fault zones. Exposure in most of this area is very poor, as much of the land surface (whether in the basalt or the underlying sediments) is covered by a “pediment” of loose basalt blocks. However, new exposures formed during the construction of the O-52 Adana-Gaziantep motorway allow a start to be made in studying this region. The deeply weathered character of much of the basalt and the presence of lateritic palaeosols between flow units suggest strongly that this volcanic sequence is Miocene. This is supported by K-Ar dating to the Middle Miocene (~19-15 Ma) of samples from the plateau margin, which are chemically very similar to many flow units in its interior. This age means that this volcanism has no direct relationship to the present phase of active strike-slip faulting in the region, which began in the Pliocene at ~3 Ma. However, these basalts can be subdivided into northern and southern groups on the basis of major and trace element geochemical characteristics. Analysis of the geometry of the lateral variations in their thickness and geochemistry, and of the geomorphology, suggests that ~10 km of left-lateral slip on the Kırkpınar Fault post-dates the basalt eruption. We have no direct age-control evidence to constrain the timing or present-day rate of this slip, but are concerned that – given the position of this locality between established active fault segments and the historical record of poorly-located major earthquakes in the region – this rate may be substantial. The proximity of this structure to a major city thus represents a significant potential earthquake hazard, which warrants more thorough investigation in future.

Sedimentary and structural evidence for the Cenozoic development of the left-lateral Ecemiş Fault Zone, southern Turkey

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The Ecemiş Fault Fault Zone, with an estimated left-lateral displacement of 60 km, documents important strike-slip within Anatolia, prior to and during Plio-Quaternary tectonic escape along the well recognised right-lateral North Anatolian Fault Zone and the left-lateral East Anatolian Fault Zone. Although the Ecemiş Fault Zone has undegone considerable recent study our appoach has been to intregrate detailed structural (microtectonic), sedimentological and geomorphological analysis to provide a regionally integrated view of the fault zone's development through time.

A Mesozoic passive margin phase constructed the regional Tauride carbonate platforms until this was terminated by latest Cretaceous southward ophiolite emplacement (e.g. Pozantı-Karsantı ophiolites). Late Eocene final collision caused further thrusting and large-scale backthrusting along the north margin of the Bolkar Mtns. and adjacent areas. Regional orogenic exhumation in the Oligocene-Mid Miocene was associated with non-marine red-bed-type deposition along the future Ecemiş Fault Fault Zone and within neighbouring basins (Ulukışla and Karsantı). An elongate depocentre already existed in the vicinity of the Ecemiş Fault Zone during Oligo-Miocene time. Left-lateral stike slip was initiated by the Mid-Miocene when the Ecemiş fault system was probably orientated NE-SW. The fault zone later rotated anticlockwise, along with the rest of central Anatolia, to more NNE-SSW, accommodating less strike-slip and more extension during Plio-Quaternary time. Minor continuing left-lateral strike-slip is documented by stream offsets on major Plio-Quaternary alluvial fans shed from master fault scarps. The Ecemiş Fault Fault Zone is, thus, identified as one of several important strike-slip fault zones that accommodated early (Mid-Late Miocene or earlier) tectonic displacement of Anatolia but which became less important subsequently.

Reference: Jaffey, N. and Robertson, A.H.F. , 2001. New sedimentological and structural data from the Ecemis Fault Zone, southern Turkey: implications for its timing and offset and the Ceozoic tectonic escape of Anatolia. J. Geol. Soc. London, v. 158, p. 367-378.

Microplates (terranes) of Turkey and their types and the Importance of Strike-Slip-Faults in Building Geological Structures.

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A cross-section from north to south along Trabzon- Mardin line of Turkey shows the following tectonic units: Pontid unit, Erzincan suture, Munzur units, Bitlis metamorphites with Maden-Guleman ophiolites and South-East-Anatolian unit.

A Liassic to Uppermost Cretaceous reaching sedimentary pile cover a hercynian-folded basement. This sedimentary cover was an oceanic plateau during Malm-Lower Cretaceous time, being characteristic for the Pontid unit.

Erzincan suture is a remnant of a deep oceanic realm, characterized by Steinmann-trinity. The ingredients of this oceanic realm are thrusted upon northern (Pontid) and southern (Munzur) tectonic units.

An Upper Paleozoic-Mesozoik carbonaceous sedimentary pile, developed on an oceanic plateau, characterizes Munzur unit. The southern part of this unit is slightly metamorphized.

Bitlis metamorphites contains a suite from amphibolite to greenshist facies with local eklogite facies inclusions; encompassing Pre-Devonian to Upper Cretaceous rocks. Maden-Guleman ophiolites are thought to have been developed in a supra-subduction-zone during Late Cretaceous.

A continuous sedimentary pile, most as platform carbonates, reaching from Uppermost Proterozoic to the Cenozoic characterize South-East-Anatolian unit.

The Pontid-, Munzur- and South-East-Anatolian-units are continental blocks, whereas Erzincan suture is a remnants of an oceanic plates and Bitlis metamorphites are products of a geosynclinal basin over a hot astenosphere. Therefore, the continental blocks have survived the plate-tectonic consumptions (subductions) and retained their main aspects; whereas the oceanic lithospheres are conserved only as obducted, smeared small flakes in form of thrust sheets. In continental block-interactions, the northerly ones are always the overriding plates.

Turkey is a mosaic-structure built of many distinct terranes (microplates). Those terranes can be divided in three groups: 1- Terranes in form of oceanic plateaus (with continental lithosphere, like East-Pontides, Munzur and South-East-Anatolian unit); 2- Terranes in form of oceanic bottoms (with oceanic lithosphere, e.g. Erzincan suture); 3- Terranes in form of geosynclines (e.g. Bitlis-, Menderes-metamorphites, Karakaya Complex, etc.)

Most metamorphic belts show:

1) A nearly continuous sedimentation most reaching from Pre-Cambrian to Paleogene,
2) A polyphase metamorphism (both in Palaeozoic and Mesozoic)
3) A Polyphase deformation and,
4) are thrusted over adjacent terranes.

Therefore the metamorphism must have been developed in geosynclinal basins over hot astenospheres, controlled by strike-slip-faults, acting sometimes transpressive, sometimes transtensional.

Active Faults and Seismotectonics of Georgia and Adjacent Parts of East Anatolia

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The Caucasus and East Anatolia are situated within the Alpine-Himalayan orogenic belt and are distinguished by high level of seismic activity. The tectonic framework and character of seismicity of the region are conditioned by its position between the converging Arabian and Eurasian plates at a rate ~30 mm/y. Geological and geophysical data suggest that the region consists of a number of blocks separated from one another by deep seated faults with traces of both horizontal and vertical displacements. Three main directions of active faults are identified in the Caucasus: WNW-ESE (or W-E) coinciding with the trend of the orogenic belt ("Caucasian" strike), and two transversal NW-SE and NE-SW. The recent kinematics of these faults obtained on the ground of detail and regional structural analysis is compatible with the general submeridional compression of the region showing mainly dip-slip motions on W-E (WNW-ESE) thrusts and reverse faults, right-lateral strike-slip on NW-SE, and left-lateral strike-slip on NE-SW striking faults. The amount of horizontal displacement on these faults varies widely from a few km to tens of km. The most considerable displacements are observed on the "Main thrust of the Greater Caucasus" and Frontal flysch fault along which the northern blocks are overthrusting the southern ones at a distance of several tens of km. The overall horizontal shortening of the Greater Caucasus is estimated between 50 and 200-300 km. The present-day velocities of horizontal motions of individual blocks according to GPS measurements, are estimated to be 2-7 mm/y.

The rates of vertical movements, obtained by geological and geomorphic studies, indicate average uplift rates over the Quaternary time (ca. 2m.y.) up to 2 mm/y in the Greater Caucasus and 1.2 mm/y in the Lesser Caucasus. These figures are much less than those obtained by repeated geodetic levelling which indicate uplift rates up to 13 mm/y in the Greater Caucasus and 6 mm/y in the Lesser Caucasus.

Focal plane mechanisms for some well-defined earthquakes are in good accordance with the surface faults confirming genetic association between faulting and seismicity.

Compressional regime in East Anatolia resulted in two dominant directions of active faults NW-SE and NE-SW corresponding to two main transform faults of the region –North and East Anatolian faults. The latter is proposed to have its northerly extension in the Caucasus as a large NE-SW –striking left-lateral Borjomi-Kazbegi fault zone.

Sinistral strike-slip fault planes in Çameli Basin (Late Miocene-Late Pliocene, SW Anatolia): Evidence for the age of Fethiye-Burdur Fault Zone

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The Fethiye-Burdur Fault Zone (FBFZ) having 5-30 km width is laid between Fethiye and Burdur in SW Anatolia. The fault zone is accepted as sinistral strike-slip fault zone formed by en-echelon type faults. According to seismic records it is known that there had been some earthquakes (M=6-7) occured in 1914, 1915 and 1971. Historical records also mention two other important earthquake in 23 and 417 AC and the historical Cibyra town 2 km of Gölhisar had destroyed. These data indicate that the fault zone is seismically active and there is sinistral strike-slip movement in the region. On the other hand, it is still unclear that the faults responsible for recent earthquakes and tectonic factors controlling the Neogene units in the region are the same or not, neither the existence, nature and age of the FBFZ. It is also undetermined whether the Burdur, Tefenni and Çameli basin are controlled or not by this fault zone.

The faults which opened the Çameli Basin are gravitional faults. The basin contains terrestial clastics and lacustrine sediments which have age span from Vallesian to Gelasian. The infill of the basin is formed as a graben infill with extentional marginal faults. In addition the tilting toward the eastern marginal faults and the decrease of dips toward the top of the infill indicate an extentional regime in this basin.

Strike-slip fault planes which cut Çameli Basin infill are seen 17 km NNE of Gölhisar and they are not controlling the basin. The historical Cibyra town is located on the strike of this faults and measured 50 cm left lateral strike-slip movement. All this data show that the FBFZ exist with a strike-slip movement and seismic activity. The faults cut Upper Miocene-Uppermost Pliocene aged Çameli Basin, and they may had begun in Early Pleistocene or later, and the present FBFZ has no relation with the geological evolution of the Çameli Basin and possibly other basins such as Burdur and Tefenni as previously considered.

Neogene Deformational Phases from Slip lineation data, (North of Ankara, Turkey)

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A total of 761 slip lineation data are collected north of Ankara around Kazan, Ayaş, Çeltikçi, Peçenek and Beypazarı. The data are measured along the planes of faults that cut Neogene sequences. The data are processed and analysed using Angelier's direct inversion method.

Analysis produced 66 solutions that can be categorised into three tectonic phases. Accordingly, the first phase is an E-W compression. Large-scale folds and tear faults, particularly around Kazan basin, are products of this phase. The second phase is a N-S compression. Monoclines that concentrate around Beypazarı with a vergence from NNW to SSE are formed during this phase. The last phase is extensional, which is still operating in the region.

The order of these phases is identified from i) overprinting slickenlines, ii) different fold patterns, and iii) cross-cutting relationships of the structures observed in the field. The most definite age can be given to the second phase (N-S compression), which produced monoclines controlling deposition of 7.7 Ma old clastics (Kirmir formation).

The neotectonics of the Bolu Pull-Apart Basin in the Western Part of the Convex Northward North Anatolian Fault Zone

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Bolu plain in the northwest of Turkey reveals neotectonic features pointing to a pull-apart opening mechanism. The Almacık mountain in the west of the plain as a proportionally rigid block of a plate flake played role for bifurcating of the North Anatolian Fault during its propagating towards the east. The stress field due to this, caused to the forming of the oblique-slip normal faults with a right-lateral strike-slip component in the north of the purely strike-slip master strand of the North Anatolian Fault Zone. The opening of the Bolu plain by these faults has been lasting possibly since Late Pliocene as a pull-apart basin in spite of the general transpressional stress field of the zone due to the northward convex shape of it. In the mid parts of the Bolu plain there are some dip-slip normal faults in the fluvial Quaternary sediments pointing to the stretching of the base of the plain in east-west direction. The 12 November 1999 earthquake occurred by the refracturing of the Gölyaka-Kaynaşlı segment affected the Bolu plain by forming of a highly strained zone in east-west direction in the mid of it.

Geology and morphotectonics of the northern part of the Gulf of Saros, NW Turkey

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The study area is located on the northern side of Gulf of Saros, northwestern Turkey, which is a young depression opened on the North Anatolian Fault. At the visible base of the region is a low grade metamorphic assemblage consisting of phyllites and slates. A Middle Eocene reefal carbonate succession is unconformably overlie this metamorphic assemblage. This unit deposited on the southern shoulder of the Thrace sedimentary basin and it grades up and basinward into basin clastics. The Oligocene sediments of the basin are represented by deltaic sediments and flysch-type sediments with volcanic and pyroclastic interbeds.

The Miocene sediments covering most of the northern part of the Gulf of Saros are represented by interfingering terrestrial and marine clastics and carbonates. These sediments fill an half-graben of Miocene age.

Since the Pliocene onwards, the area was shaped by North Anatolian Fault. To the south of the study area the Gulf of Saros opened while the Miocene sediments generally tilted toward the north by the effects of strike-slip faults.

The goal of this study is to describe the stratigraphy, structure and morphology of the northern part of the Gulf of Saros. In addition to the detailed field studies, remote-sensing and GIS (Geographical Information System) methods were used. The morphology of the region was investigated by the analyzing of the LANDSAT TM images and digital elevation model (DEM) of the region. Remote-sensing, DEM and field data were combined by using GIS programs.

Monoclines of Ankara-Beypazarı area, Turkey

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Monoclines developed between Ankara and Beypazarı are one the most distinguishing Neotectonic structural features of the region. Ten of these monoclines with considerable large extensions are mapped and analysed. These monoclines are named as Beypazarı, Zaviye, Çakıloba, Sarıağıl, Boyalı, Ayaş, Yenikent, Çeltikçi, Elvan and Killik monoclines. They are all developed within Middle Neogene or older sequences. They trend in N30-50E direction for lengths ranging from 1 to more than 50 km. Width and the vertical difference between the upper and lower hinges of the monoclines is between 200 m to 3 km and 50 to 500 m, respectively. Strike-slip faults are common structures in the vicinity of the monoclines. Slip lineation data associated with the faults indicate that the faults had a reverse slip-component. Davutoğlan fault is a good example of such faults. The monoclines are formed during a N-S compressional phase. All monoclines, except Ayaş and Çeltikçi monoclines, indicate a vergence from NW to SE. Extensive clastic deposition (Kirmir Formation) occurred at the lower hinge of the monoclines and these clastics are dated to be 7.7 Ma. Kirmir Formation is composed of typical “flank type deposit” accumulated in front of the monoclines. Age of the monoclines is, therefore, contemporaneous or slightly younger than this age. “Uplifted regions” which are commonly observed in the area are products of vertical movements due to this N-S compression that gained their final shape during post compressional “extensional” phase. Beypazarı, Ayaş, Çeltikçi and Elvan uplifts are examples of such structures, which trend in NE-SW direction.

Paleo-stress analysis of Tertiary post-collisional structures in the Western Pontides: Northern Turkey

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Western Black Sea oceanic basin opened as a back arc basin of northward subducting Intra-Pontide Ocean. Basement rocks, regarding to this opening are represented by Lower Cretaceous and older units. The first arc magmatism related with this subduction started during the Middle Turonian. Coeval with this magmatism, back-arc extension affected the region and caused to develop horst-graben topography. This extensional period resulted the break-up of continental crust and the oceanic spreading in the Western Black Sea Basin during the Late Santonian. Shortly after this collision, during the Late Campanian-Early Maastrichtian, Sakarya Continent and Pontides collided and arc magmatism on the Pontides came to an end. Following this collision, the Western Pontides imbricated, thickened, and gained a mainly north-vergent foreland fold and thrust belt character since Late Eocene-Oligocene. In this paper we describe main structural features of this fold and thrust belt. The data were obtained from the area between Cide (Kastamonu) and Kurucaşile (Bartın) in Northern Turkey, along the Black Sea coast.

Measurements from the structural features of this fold and thrust belt reveal that the vergence of this system was NNW in the west, N in the central part, and NNE in the east. The paleo-stress directions calculated from thrust and reverse faults are $156.6^0/4.6^0$ for σ_1, $66.1^0/6.4^0$ for σ_2, and $261.9^0/83.2^0$ for σ_3. The nature of the imbrication indicates that it was a northward prograding system connected to a floor thrust (detachment) fault at the bottom.

Recent change in stress regime around Niksar Basin, Eastern part of the Central North Anatolian Fault Zone, Turkey

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The North Anatolian Fault Zone (NAFZ), major dextral strike-slip fault, runs about 1400 km long from Karlıova in the east to the Saros Gulf in northern Aegean domain. This major fault is divided into three segments: N110° eastern part, N75° western part and central part. The central part, connecting the eastern and western parts of NAFZ, forms northward convex. The Niksar basin, located in the eastern part of central NAFZ, is found between two great earthquake ruptures 1939 and 1942 forming the southern and northern boundary respectively. We investigated Late Cenozoic stress states determined by inversion of slip vectors measured on fault planes of various scale affecting the Mesozoic basement, Cenozoic sediments as well as the Plio-Quaternary deposits. Fault kinematic analysis indicates a dominant strike-slip stress regime. The inversion and chronology between striations permit to distinct two strike-slip stress states. The older strike-slip stress regime is characterized by a NW-trending (N348°) maximum horizontal stress axis (σ_1) and NE-trending (N78°) minimum horizontal stress axis (σ_3) with Rm=0.68 indicating transpressional stress regime. The younger strike-slip stress regime is characterized by a NW-trending (N343°) σ_1 axis and NE-trending (N253°) σ_3 axis and a mean Rm=0.17 that point out a transtensional character for this regime. This regional stress regime induce locally normal faulting stress state, with a consistent NE-trending σ_3 axis. Both regional strike-slip stress states, having consistent NW- and NE-trending σ_1 and σ_3 axes respectively but significantly different mean R values, induce a dextral movement along major NAFZ, which accommodates the Anatolian extrusion with sinistral East Anatolian Fault Zone. The change in regional strike-slip regime from transpressional to transtensional occurred probably in Quaternary time, related to the northward motion Arabian/African plates in respect to Anatolian block.

Structural control on the southward fore-thrusting and northward back-thrusting in the Central Anatolian thrust belt (Turkey)

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The Anatolian platelet includes distinct continental elements gathered during the convergence and collision of the Eurasian and African/Arabian plates since the late Cretaceous. The Central Anatolian thrust belt is bounded to the north, by the İzmir-Ankara-Erzincan Suture Zone along the northern margin of the Kırşehir basement, to the south, by the Inner Tauride Suture Zone separating the Kırşehir block and Ophiolites from the Taurides. Eastwards, all these major tectonic lines are connected to the North Anatolian Fault Zone. The Sivas basin corresponds to the main part of the Central Anatolian thrust belt. The fold and thrust system fits with the kinematics of a southward propagation of thrusts controlled by master décollement horizons following the Oligocene gypsum and serpentinites related to the Ophiolites. From East to West, the fold and thrust belt displays two distinct styles and evolutions: The eastern domain includes mainly hinterland dipping thrust sheets with an out of sequence but conform evolution. The western domain shows both foreland and hinterland dipping sheets and superimposed thrusts and back-thrusts. The overprinting of northward directed thrusts along the western and northern boundaries of the fold-and-thrust belt is reconciled with the internal southward propagation in a scheme involving the Kırşehir basement as a backstop during the accretion of the Sivas basin in Late Neogene. The lateral transfer zone necessary to account for the juxtaposition of different geometries, styles and rates of shortening occurs along a branch line containing the eastern tips of the Kırşehir and Tokat basements.

Geology of the Namaras-Eğrigöl-Seyiricek (SW Hadim-Konya/Turkey)

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In this study, four structural units, which tectonically related to each other and represents different basins and structural characteristics, have been differentiated within the area between Bozkır-Hadim and Gündoğmuş towns at the western part of the Central Taurus. These structural units are "Hadim nappe" of Beyşehir-Hoyran-Hadim nappes, "Çataltepe nappe" of Antalya nappes, "Anamas-Akseki autochthonous" and "Eğrigöl nappe".

Within the Anamas-Akseki autochthonous, the Liassic-Dogger Kurucaova formation, Malm Akkuyu formation, Cretaceous Akseki limestone, Upper Cretaceous Seyrandağı limestone, Upper Paleocene-Eocene Bakalasay and Middle Eocene Çaşıryayla formation have been distinguished.

In the region, Upper Triassic Kasımlar formation and Jurassic-Cretaceous Kayabükü formation of Çataltepe nappe; Middle-Upper Devonian "Gölboğazı formation", Carboniferous "Yarıcak formation" and Permian "Çekiçdağıdağı formation" of Hadim nappe crop out. The Eğrigöl nappe, which is firstly identified and named in this study, includes exposures of Upper Permian Karagöztepe formation, Middle-Upper Triassic Kürtleryaylası formation, Liassic Boztepe formation, Jurassic Biberler formation and Paleocene/Eocene Söbüçimen formation.

In the region, the Quaternary age morains crop out widely and overlain these structural units with an angular unconformity. The alluviums, as the youngest sediments, cover the oldest units with angular unconformitiy in the region.

During Late Cretaceous-Lutetian time interval due to development of two-stage north-south compressional tectonic regime, the Çataltepe nappe emplaced over the Anamas-Akseki autochtone from south during the late Cretaceous-Paleocene; related to this continued compression, Hadim and Eğrigöl nappes thrusted over autochtone from north during Lutetian. With respect to the data obtained from this study, the region undergone generally northeast-southwest directed compressional forces and consequently, the northwest-southeast trending thrusts and folds, northwest-southeast and east-west trending normal faults were developed.

Late Cenozoic Stress regime acting between Karataş and Osmaniye, Southeastern part of Adana Basin, SE Turkey

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The study area, lies between Karataş (Adana) and Osmaniye, is characterized by Misis structural high where the Paleo- and Neo-tectonic features are observed. The structural elements such as Missis-Ceyhan, Karataş-Yumurtalık-Osmaniye faults, which limit the Neogene Adana basin to the southeast, are appear to be parallel to the major sinistral East Anatolian Fault Zone (EAFZ). The structural patterns and distribution of seismicity indicate that this region has been affected by these active faults, mainly strike-slip faulting character. The active faults seem to represent the major EAFZ from Kahramanmaraş southwestward to Karataş. Both the sinistral EAFZ and dextral North Anatolian Fault Zone contribute to the westward extrusion of Anatolia as consequence of the northward drift of African and Arabian plates. The stress regimes determined by inversion of slip-vector measured on fault planes affecting the Mesozoic bedrocks and Tertiary sediments as well as Plio-Quaternary deposits. The fault kinematic results indicate a dominant strike-slip faulting regime for this deformation zone. The dominant strike-slip faulting stress regime is characterized by a NW-trending (N348°) maximum horizontal stress axis (σ_1) and a NE-trending (N258°) minimum horizontal stress axis (σ_3). However, the fault kinematic analysis show two others reverse and normal faulting stress tensor. The reverse faulting stress regime with a NW-trending σ_1 axis, contemporaneous to Missis structural high, is consistent to a NW-trending maximum horizontal stress axis (σ_1) of dominant strike-slip stress regime. So, the normal faulting stress regime with a NE-trending σ_3 axis is consistent with a NE-trending minimum horizontal stress axis of dominant strike-slip faulting stress regime. Thus, the normal faulting probably could be related to formation of Adana/Cilician basin.

The stress regimes, i.e. dominant regional strike-slip faulting as well as local significant reverse and normal faulting regimes induce a left-lateral displacement along NE-SW major active faults. All state of stress regimes acting in study region are related to the tectonic configuration of the African-Arabian plates and Anatolian block in eastern Mediterranean.

Balanced cross-section across Kartli foreland thrust and fold belt: Implications for the timing and kinematics modeling (South-East Georgia)

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Kartli foreland is located between Achara-Trialeti and Greater Caucasus thrust and fold belts. We present balanced cross-section across Kartli foreland thrust and fold belt along the r. Aragvi. Balanced cross-section has been constrained by surface geological, seismic reflection profile and oil well data. Section balancing of seismic reflection profile, together with forward kinematics modeling, was used to develop a tectonic model for the evolution of the Kartli foreland basin. Section balancing shows that synorogenic stratigraphic series involved in thrusting and consists of Sarmatian shallow marine and Meotian-Pontian thick continental sediments. The Meotian-Pontian sediments were deposited Kartli piggyback-basin and are involved in thrusting. The timing of deformation is post Sarmatian, probably late Miocene-Pliocene. North and central part of Kartli foreland basin are deformed by Greater Caucasus south-vergent thrust structures. Thrust front is linked by tip-line Bitsminda anticline and is fault-propagation fold. Southern part of Kartli foreland basin represent of Tertiary strata that have been deformed and uplifted by passive back thrusting at the triangle zone (structural boundary between Achara-Trialeti and southern part of Kartli foreland Basin). Deformation of these structures is related north-vergent duplexes. The duplex sequence consists of Oligocene-Lower Miocene strata.

PLUTONISM AND CRYSTALLINE COMPLEX

Genesis of collision-related plutonic rocks in the central Anatolian massif (Turkey)

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Central Anatolia exhibits good examples of calc-alkaline and alkaline magmatism of similar age in a collision-related tectonic setting (continent-island arc collision). In the Central Anatolia region, post-collisional plutonic rocks (around 79.5 to 66.6 Ma) intrude Palaeozoic-Mesozoic metamorphic rocks overthrust by Upper Cretaceous ophiolitic units to make up the Central Anatolian Massif. In the Massif, three different intrusive rock types are recognised based on their geochemical characteristics: (i) calc-alkaline (Behrekdag, Cefalikdag, Celebi-BCC); (ii) transitional (Baranadag-B); and (ii) alkaline (Hamit-H). The BCC and B plutonic rocks are metaluminous, I-Type ranging from monzodiorite to granite. The H plutonic rocks are metaluminous to peralkaline, predominantly A-Type ranging from nepheline monzosyenite to quartz syenite. All intrusive rocks show enrichment in LILE and LREE relative to HFSE and have high $^{87}Sr/^{86}Sr$ and low $^{143}Nd/^{144}Nd$ ratios. These characteristics indicate an enriched mantle source region(s) carrying a subduction component inherited from pre-collision subduction events. Rb, Nb, Y versus SiO_2 diagrams and the tectonic discrimination diagram of Rb and the (Y+Nb) reflect that the BCC, B and H plutonic rocks have been affected by crustal assimilation combined with fractional crystallisation processes. Coexistence of calc-alkaline and alkaline magmatism in the Central Anatolian Massif has been attributed to mantle source heterogeneity before collision. Either thermal perturbation of the metasomatised lithosphere by delamination of the thermal boundary layer (TBL) or removal of a subducted plate (slab breakoff) are the likely mechanisms for the initiation of the post-collisional magmatism in the Massif.

Nature and Distribution of Felsic Plutons in Central Anatolian Crystalline Complex : Time–Space Relations

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The felsic plutons comprising an essential component of the Central Anatolian Crystalline Complex (CACC) can be differentiated into three major groups on the basis of their field aspects, mineralogical composition and geochemical features: granitic, monzonitic and syenitic intrusions.

Granitic intrusions, represented by Ağaçören, Çelebi, Behrekdağ, Sulakyurt and Yozgat plutons, are essentially exposed along the western and northern margins of the CACC. These intrusions are associated with mafic intrusions, and are characterized by the abundance of mafic microgranular enclaves (MME) ranging up to meters in size and comprising up to 25 % of the whole pluton. Monzonitic intrusions, represented by Terlemez, Saraycık, Cefalık, Baranadağ, Fakılı and Şefaatli plutons, are exposed towards the inner parts of CACC. The MME are low in abundance (less than 10 % of the whole pluton) and smaller in size than those observed in granitic intrusions. Syenitic intrusions are exposed in the innermost part of the CACC, with İdişdağı, Bayındır, Buzlukdağ and Akçakent plutons representing the typical examples. Syenitic intrusions are almost totally devoid of MME and are divided into two as silica-saturated and silica-undersaturated types, the latter occupying the central parts of the Bayındır, Akçakent and Buzlukdağ plutons.

Geochemically, granitic intrusions are calc-alkaline, monzonitic intrusions are calc-alkaline to shoshonitic and syenitic intrusions are alkaline in nature. On the trace element discrimination diagrams both granitic and monzonitic intrusions plot in the *volcanic-arc granite (VAG) and syn-collisional granite (Syn-COLG)* fields, whereas the syenitic intrusions in *within plate granite (WPG)* field, which led several researchers to accept calc-alkaline granites/monzonites as syn- to post-collisional, and the alkaline syenites as post-collisonal/extensional intrusions. Based on the previously reported radiometric age data which reveal a progressive decrease in age from granitic through monzonitic to syenitic intrusions, there appears a transition in time and space from collision-related calc-alkaline at the margins to extension-related alkaline magmatism at the inner parts of CACC. Given the spatial distribution of the syenitic intrusions, and an explicit positive aeromagnetic anomaly along these units, it can be tentatively suggested that the extension in CACC might have taken place along an axis curved from Akçakent at the NE, through Bayındır at the SW, to İdişdağı at the SE, although this has to be confirmed by further studies.

Post-collisional magmatism on the northern margin of Taurides and its geologic implication: Petrology of Yahyalı-Karamadazı granitoid

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The Karamadazı Granitoid (Yahyalı-Kayseri) is a typical example to bimodal magmatism on the northern margin of the Eastern Tauride Belt. Karamadazı Granitoid intrudes the Paleozoic-Mesozoic Yahyalı Metamorphics and is unconformably overlain by Upper Maastrichtian clastics. It consists of granodiorite-quartz diorite as the main intrusive phase, and includes leucogranites and aplitic dykes at the marginal parts. Samples from the Karamadazı Granitoid are calcalkaline and calcic in character. Granodiorites are mainly metaluminous, whereas leucogranites and aplites are weakly peraluminous in nature. Plots of major element oxides against SiO_2 indicate a poor fractionation trend for granodiorites. Leucogranites represent highly fractionated end members.

Karamadazı Granitoid displays I-type characteristics based on geochemical and mineralogical compositions. LIL elements are enriched compared to HFS elements in all samples and spider diagram patterns are similar to those of the upper crustal rocks. The geochemical data also imply that the Karamadazı Granitoid is composed of two distinct magmas derived from different sources and undergone limited differentiation. Whatever the sources are, the magmas are closely interacted with the upper crust. On tectonomagmatic discrimination diagrams, granodiorites plot in the arc region, while leucogranites plot in the triple-junction of the arc, syn-collisional and within plate fields and thus can be classified as post-collisional granitoids.

Geochemical comparison of Karamadazı Granitoid with several H-type post-collisional granitoids from northern Tauride margin (Horoz Granitoid) and central Anatolia (Yozgat, Ekecikdağ, and Terlemez granitoids) clearly exhibits similarities with these granitoids. These suggest that the granitoids are comparable not only in age, and formation and emplacement processes, but also in tectonic processes leading to the formation of the granitoids.

Petrogentic model for the origin and evolution of Chenar granitoid stock, NW of Kerman/Iran: Evidence for subduction related magmatism

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The lower to middle Miocene Chenar granitoid stock , apart of Central Iranian volcanic belt, is intruded into Eocene volcano-sedimentary complex in northwestern part of Kerman in south Central Iran. The contact between these two rock units is marked by hornblende hornfels facies and granitic apophyses. The granitoid rocks are formed in the epizone at subsolvous condition (i. e., under 3.8-4% water content, water pressure of 5.5 kbars at 780-800 ^{o} C and estimated water activity of 0.4 to 0.45). The granitoid rocks show enrichment in LILEs such as Rb, Ba, K, Ce and depletion in HFSEs such as Y, Nb and Zr which may point to subduction zone enrichment and/or crustal contamination. Geochemical data, various trace element discriminant diagrams, enhanced Y/Nb and Ce/Nb ratios, and ocean ridge granite normalized multi-element diagrams indicate that the Chenar granitic rocks have characteristics of metaluminous to slightly peraluminous, high K, calc-alkaline, I-Cordolarian type garnite of volcanic arc settings and is formed in an active continental margin environment prior to collision of Afro-Arabian plate with Central Iran and may represent part of Andean-type magmatic arc formed in response to subduction of Neotethys oceanic crust beneath Central Iran, unrelated to rift settings. These rocks are probably formed as a result of partial melting of the subducted oceanic lithosphere and its overlying mantle in a subduction zone at pressure of 16-20 kbars equivalent to 43-54 kms, where the melting of protolith occurred either in the absence or in relatively low water environment.

Genesis of Igneous Enclaves in the Central Anatolian Plutonics, Turkey

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Post-collisional plutonic rocks (around 79.5 to 66.6 Ma) intrude Palaeozoic-Mesozoic metamorphic rocks overthrust by Upper Cretaceous ophiolitic units to make up the Central Anatolian Massif. Igneous enclaves are widespread in these plutonic rocks in the Massif. Two types of igneous enclave have been recognised in the Behrekdag, Cefalikdag, Celebi (BCC) plutonic rocks in Central Anatolia: (i) fine-grained (Type-I); and (ii) medium-grained to porphyritic with feldspar megacrysts (Type-II). Most abundant are Type-I enclaves with quartz dioritic to quartz monzodioritic compositions (SiO_2=55 to 66 wt.%) and fine-grained textures indicating chilling against the host rocks. Less common are Type-II enclaves with quartz dioritic to gabbro compositions (SiO_2=42 to 59 wt.%) and cumulate to porphyritic textures reflecting accumulation of early precipitating phases. Igneous enclaves have mineral phases similar to that of the host rocks but with different mineral proportions. Origin and evolution of enclaves are strongly linked to those of their host rocks. For example, mafic to intermediate Type-I enclaves (originated from magma mixing/mingling) in the BCC plutonic rocks indicate existence of some interaction between silicic magmas and mantle-derived melts. Their presence could imply that the host plutonic rocks have undergone hybridisition to a greater or lesser extent. On the other hand, mafic Type-II enclaves (formed as cumulates of early crystallised minerals) give an information about the early crystallised minerals in the parental magma of the plutonic rocks.

Gabbro Types in the Central Anatolian Crystalline Complex: Field Aspects, Petrographic Features and Geochemistry

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Gabbro-granite association is characteristic for most of the plutons in the Central Anatolian Crystalline Complex (CACC) although the nature of gabbros has long been a matter of debate among geologists. Field aspects, petrographic features and geochemical characteristics of various gabbro exposures investigated in this study differentiate these gabbros into two main groups. The first group is exemplified by relatively larger exposures associated with the outer-western belt granitoids (e.g. Ağaçören, Behrekdağ), whereas the second group is exposed within the unit shown as "Mesozoic Ofiolitic Series" in regional geologic maps and is spatially associated with the inner-western belt granitoids (Saraycık-Dedeli, Sarıkaraman-Terlemez) of the CACC. The occurrence of both groups, however, is common for a number of plutons and is especially typical for the Akçakent pluton and Yozgat batholith at the north.

Although the contact of gabbros with the granitic intrusions is commonly concealed by soil cover in the field, where observed, it is sinuous in shape and transitional in nature for the first group, whereas it is sharp for the second group where the gabbro bodies are kept as roof-pendants in granitic intrusions. While irregular fractures are characteristic for the second group, the first group of gabbros show no sign of deformation.

Subophitic/ophitic texture is typical for the first group gabbros, whereas the second group displays holocrystalline-granular texture. In the first group, amphibole is the dominant mafic component and locally contains pyroxene relicts at the core. In the second group, pyroxene is the dominant mafic mineral and amphibole is observed as the product of (secondary) uralitization of pyroxene. The occurrence of biotite minerals at the contact with granite intrusions is a common feature of the first group, whereas no biotite mineral is observed in the second group.

Whole-rock geochemistry reveals that the first group gabbros are transitional in nature from calc-alkaline to tholeiitic, while the second group are all tholeiitic gabbros. As investigated for the individual plutons, Harker diagrams yield magmatic differentiation trends for the first group, but no trend can be identified for the second group. Flat REE patterns and HFSE depletion relative to N-MORB are features common to both groups, although the first group also displays LILE enrichment relative to HFSE.

The Co-Existence of the Crustal Thickening and Thinning Related Plutons in the Middle Taurus Mountains, Turkey

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There are some intrusive rocks intruding the Bolkardağ unit, Aladağ unit, Niğde massif and units of the Ulukışla-Çamardı basin in the Middle Taurus mountains, S Turkey. These intrusives have been emplaced within different structural levels in the crust showing a great diversity in mineralogical-petrographical/geochemical compositions and genetical relations. They can be subdivided into two main groups such as (1) crustal thickening related plutons with a prevailing crustal contribution, and (2) crustal thinning-related intrusions with an exclusively upper mantle origin on the basis of geological setting and mineralogical-geochemical characteristics. The crustal thickening related plutons, consisting of the Horoz, Karamadazı and Celaller plutons, always associated with the crustal metasediments of the Bolkardağ, Aladağ and Niğde massif. They are generally considered to be of Uppermost Cretaceous-Paleocene in age, however, there is no any absolute age dating record. These intrusions can also be subgrouped as (1) pure crustal-derived peraluminous, S-type, leucogranitic plutons i.e. Celaller pluton and light rocks of Karamadazı pluton, and (2) crust+UMM (underplating mafic magma) mixed, calcalkaline, metaluminous, I-type intrusive rocks comprising of the Horoz pluton and dark rocks of Karamadazı pluton. As for the crustal thinning related intrusive rocks, namely the Uçurumtepe monzonite, Yağlıtaş diorite and Elmalı syenite porphyry, they are clearly exposed to cut the volcano-sedimentary rocks of the rifting-related Ulukışla-Çamardı basin of Uppermost Cretaceous-Tertiary in age. All these three units show an alkaline, metaluminous, A-type mineralogy and geochemistry. The Elmalı syenite porphyry seems to be a highly-evolved derivatives of the Uçurumtepe monzonite magma source on the basis of mineralogical-geochemical data. The crustal-thickening plutons are thought to be derived from anatexitic melt generated by the partial melting of supracrustal rocks presumably constituting the deeper parts of Bolkardağ unit or Niğde massif in a compressional tectonic regime. As to the crustal-thinning related intrusives units, they could have been derived from exclusively mantle-derived alkaline magmas generated by adiabatic decompressional partial melting of upper mantle material under the tensional tectonic regime which could follow the crustal thickening.

Petrology and Geodynamics of the Alkaline-Transalkaline Igneous Rocks Outcropping in the Northern and Southern Parts of the North Anatolian Fault Zone, Eastern Pontides, Turkey

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Some alkaline intrusions, intruding the alkaline Middle Eocene volcano-sedimentary units, are exposed in both of the northern and southern parts of the North Anatolian Fault Zone (NAFZ) in the Bektaşyayla-Çambaşı (south of Ordu and Giresun), and Kösedağ (Suşehri, NE Sivas) regions, respectively, in the Eastern Pontides, Turkey. The rocks of Bektaşyayla-Çambaşı region have also been subdivided into two subgroups such as alkaline and transalkaline which are composed of several small and discrete plutons, whereas the Kösedağ region rocks, constituting the huge Kösedağ batholith, represent alkaline character in composition. The alkaline and transalkaline subgroups of the Bektaşyayla-Çambaşı region comprises, from bottom to top, the Abdestsuyu Monzonite (M), Bektaşyayla Quartz Monzonite (QM), Çambaşı Quartz Syenite (QS), and the Eğrikaya Quartz Monzodiorite (QMD), Kayabaşı Quartz Monzonite (QM), respectively. The major rock types of the Kösedağ batholith, made up of solely alkaline rocks, consist essentially of syenites and quartz syenites. Mineralogical-petrographical and wholerock major and trace element geochemistry studies reveal that the alkaline intrusives in the Bektaşyayla-Çambaşı and Kösedağ regions and even most probably their wall-rocks of Middle Eocene alkaline volcanics can be genetically related to an initial alkaline magma source whose composition might have been diversified under the influences of some solidification processes like crystal-liquid fractionation, assimilation and magma mixing. Such a diversification is thought to yield some alkaline and transalkaline plutons formed in different levels of crust in the Bektaşyayla-Çambaşı region, but a huge batholith in the Kösedağ region. The units of alkaline subgroup of Bektaşyayla-Çambaşı region constitute a well-defined association representing a solidification sequence from Abdestuyu M through Bektaşyayla QM to Çambaşı QS units. On the other hand, the Eğrikaya QMD unit of the transalkaline subgroup differs from both of the Kayabaşı QM and the units of alkaline subgroup with an enrichment in the Na and Nb contents which is assumed to be sourced by assimilation of subalkaline wall rocks or mixing with a co-eval subalkaline magma source. As to the Kösedağ batholith, the solidification sequence follows syenite through quartz syenite, constituting the marginal and central parts of the batholith, respectively. The initial alkaline magma can be derived from the adiabatic decompressional melting of the upwelling mantle material under the tensional regime due presumably to crustal attenuation which might be occurred in both of the northern and southern zones of the Ankara-Erzincan suture zone following the Anatolide-Pontide collision that forming a single microplate or microcontinent at least during Eocene time. Some parts of this suture zone, i.e. at least the parts between Bektaşyayla-Çambaşı and Kösedağ regions, could have gained a dextral strike-slip character to form the NAFZ after the evolving of these alkaline rocks in the region. Such a geodynamic and tectono-magmatic evolution model seems to be appropriate to the recent geological and geochemical data for the explanation of the alkaline rocks located in both of the north and south of the NAFZ in an area between the Bektaşyayla-Çambaşı and Kösedağ regions in the eastern Pontides of Turkey.

Some Major, Trace and REE Diffusional Transfer from the Felsic Host Magma to Mafic Microgranular Enclaves in the Tamdere quartz monzonite, South of Dereli/Giresun, Eastern Pontides, Turkey

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The quartz monzonitic rocks, so-called Late Cretaceous-Early Tertiary Tamdere Quartz Monzonite constituting the part of Eastern Pontide plutonism, includes some spectacular mafic microgranular enclaves (MME) ranging from spheroidal to ellipsoidal in shape, and from a few centimeters to decimeters in size, respectively. The MMEs are composed of diorite, monzodiorite and quartz diorite, whereas the felsic host rocks comprise mainly quartz monzonite, granodiorite and scarcely monzogranite types of rocks on the basis of both mineralogical and chemical compositions. The most commonest texture of felsic host rocks is the equigranular texture dominated by feldspar, mafic constituents and visible quartz even in hand specimen that differs from that of MME which is characterized by the microgranular texture dominated by small lath-shaped plagioclase and acicular prizmatic amphiboles. The MMEs also reveal some special types of microscopic textures such as acicular apatite, hollow amphiboles, blade biotites, poicilitic large feldspars including a lot of mafic inclusions like early formed pyroxene, amphibole and biotites.

The major, trace and REE analyses apparently remark the element exchangements between MMEs and felsic host rocks due probably to thermal, mechanical and compositional interactions between coeval felsic host magma and mafic magma which is found as the blobs in the felsic one. The most recognizable major element transfer from felsic host magma to mafic magma blob is that of alkalis such as Na and K among which the latter one is also associated with a considerable enrichment in the content of Rb of LILEs. Similar to LILEs, some HFSEs such as Nb, Y, Zr and Th have also been transferred from felsic host magma to MMEs that shifted their compositions towards the felsic host rocks. Apart from these major and trace elements, the most impressive element transfer from felsic host magma to mafic one is observed in the REE contents. Such a transfer of REEs have evidently increased the LREE contents of MMEs. All these enrichments in the alkalis, LILEs, HFSEs and also REEs should be realized by diffusional processes during the solidification of these coeval felsic and mafic magma sources among which the first and latter behaved as the newtonian and visco-plastic types of behaviours by means of viscosity. In such an interaction, the small MME has become as a closed system immediately due to rapid cooling relative to big one that makes the big MME to be more accommodated these types of elements by diffusion from the Newtonian felsic host magma. This has conluded the big MMEs to be enriched more by these elements mentioned above than the small ones.

Petrogenesis of the Composite Kaçkar Batholith Along a North-South Geotraverse Between Ardeşen (Rize) and İspir (Erzurum) Towns, Eastern Black Sea Region, Turkey

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The Composite Kaçkar batholith, constituting the main axis of famously known NE-SW trending Kaçkar mountains with some peaks attaining up to 3.947 m in altitude, and some exceptional mountain lakes and icy snowfields taking place in some locations possessing elevations more than 3.000 m which makes the region to be an international mountaineering area in the Eastern Black Sea region of Turkey, consists of various intrusive rock units derived from at least five different magma surges generated different geodynamic environments and structural levels ranging from Late Cretaceous/Early Tertiary to Late Eocene and most probably to Neogene (?) in age. It crops out as an elliptic-shaped batholith covering more than thousands of kilometers of squares, and intrudes the Cretacoeus and Middle Eocene volcano-sedimentary units. The five different igneous associations, comprising the composite kaçkar batholith, consists of, from bottom to top, (1) I-type, CALK, metaluminous, hybride, arc-related (VAG) quartz dioritic/monzodioritic and granodioritic associaton (Halkalıtaş Quartz Diorite/Monzodiorite and Marselevat Granodiorite); (2) S-type, peraluminous, syn-collisional (syn-COLG), leucogranitic association (Asniyor Leucogranite); (3) I-type, high-K CALK, hybrid-late orogenic, post-collisional (post-COLG) monzogranitic association and its highly-evolved derivative microgranites (Ayder K-feldspar Megacrystalline Monzogranite, Sırtyayla Monzogranite and Sasmistal Microgranite); (4) A-type, alkaline, post-collisional (post-COLG), within-plate (WPG) monzonitic-quartz monzonitic association (Güllübağ Monzonite/Quartz Monzonite), and (5) M-type, low-K tholeiitic, within-plate (WPG) gabbroic association (Ardeşen Gabbro and İsina Diabase). Regional geological setting and the space and time relations of these intrusive rock units in the composite Kaçkar batholith reveal a close connection with the evolution of the northern branch of neotethyan realm with a nortward subduction beneath the Eurasian continent during Late Cretaceous time. Such a subduction zone would create the Halkalıtaş Quartz Diorite/Monzodiorite and Marselevat Granodiorite as the deep-seated equivalent of the well-known Esatern Black Sea arc magmatism. The Asniyor Leucogranite, intruding the arc related intrusives, seems to be derived from a minimum-melt composition magma which could be generated as a syn-collisional magma during the crustal thickening due to Anatolide-Pontide collision. The high-K, calcalkaline and typically K-feldspar megacrystalline monzogranitic association represents the characteristics of a late-orogenic hybride magma which can be formed by mixing and mingling types of interaction between co-eval crustal-derived felsic magma and underplating mafic magma in a post-collisional environment which would precede the lithospheric delamination following crustal thickening due to collision. The Güllübağ Monzonite, intruding the Middle Eocene rocks, is considered to be derived from an alkaline magma which could be generated by adiabatic decompressional fractional melting of upper mantle material with a very small partial melting degree, i.e. less than 3-5 % under the tensional regime due to lithospheric attanuation. The youngest intrusives, low-K tholeiitic Ardeşen Gabbro and İsina Diabase are thought to be the representatives of a mantle-derived M-type mafic magma coming directly from upper mantle through deep tensional faults cross-cutting all the crust.

Extensive hydrothermal rehydration of high-grade gneisses during exhumation, Pulur Massif, Eastern Pontides, NE Turkey

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Hercynian high-grade gneisses of the Pulur massif (Eastern Pontides) are characterized by an extensive hydrothermal rehydration which occurred mainly under subgreenschist (prehnite-pumpelltite- & pumpellite-actinolite-facies) and subordinately in greenschist facies conditions. Younger intrusions in the massif (Liassic gabbro-cumulate-complex and Eocene granodiorite) also show a hydrothermal overprint of mainly subgreenschist facies. Although no unequivocal increase in the degree of the rehydration of the high-grade gneisses towards these intrusions could be determined, this case implies that the hydrothermal overprint of the gneisses might have been related to the hydrothermal phases of one of those intrusions. In this study, we aim at characterizing this hydrothermal rehydration of the high-grade gneisses by means of phase petrology and geochronology in order to determine the possible relation to the intrusions.

Following hydrothermal minerals are found: Chl, ms/phe, qtz, ±mrg, ±pg, dsp, ±crn, ±kln, py, ccp, ±ab, ±ep and ant in Al-rich metapelites; ab, ep, ms/phe, chl, pmp, prh, ttn, ±ant, qtz, cal and ±kfs in relatively Al-poor gneisses; ep, ab, ±pmp, ±prh, ±qtz, chl, ttn, ±act and cal in amphibolites. Formation of the hydrothermal minerals was controlled mainly by the primary mineralogy of the rocks: Dsp and crn are confined to the former spl and cln to the former sill. Hydrothermal mineral assemblages are characterized by overall absence of zeolites (e.g. wairakite). Hydrothermal minerals forms pseudomorphs after primary phases and preserve their primary outlines, and the phyllosilicates in the matrix of the rocks show no preferred orientation, indicating that the rocks were not subjected to any ductile deformation during and after the hydrothermal event.

Disequilibrium among the hydrothermal minerals is widespread und equilibrium domains is usually very small. Using thermodynamic considerations and various phase equilibria, the temperatures were constrained to between 230-380 °C and pressures to between 0.1 and 0.45 Gpa. The mineral assemblages were formed in rather CO_2-deficient and H_2O-rich fluids. Spatial distribution of the hydrothermal minerals in a particular bulk composition does not allow recognition of any temperature gradients.

Dating of the hydrothermally formed, coarse grained (∅ ≥ 250 μm) muscovites in $^{40}Ar/^{39}Ar$ system by total fusion yielded very consistent ages of 310 ± 3.1, 313.2 ± 1.5 and 315.6 ± 0.5 Ma (1□). These ages indicate that the rehydration occurred in the upper crust during the exhumation of the high-grade rocks, and is not related to any hydrothermal phase of the late intrusions.

Metamorphic history of the southern Menderes Massif

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The petrology and structural geology of the southern Menderes Massif suggest that this part of the massif was metamorphosed during the emplacement of mid-crustal, north-verging thrust sheets. We present the results of an extensive study of the thermal history recorded by schists of the southern margin of the southern Menderes Massif. Metamorphic temperatures have been calculated from garnet-biotite equilibria for 21 metasedimentary samples from 15 different outcrops in a region extending from Lake Bafa in the west to the Yatagan area in the east. In addition, we have studied a total of 68 samples from 48 different field sites for petrographic constraints on metamorphic conditions.

The metasedimentary rocks of the southern Menderes Massif comprise a tilted sequence of semi-pelitic, siliceous, and calcareous units that structurally overlie a highly deformed orthogneiss (augen gneiss). Metamorphic grade increases from south (structurally highest) to north (structurally lowest). In the south, greenschist facies phyllite beneath slightly recrystallized carbonate rocks contains chlorite + white mica. The garnet isograd marks the first appearance of garnet in aluminous schists, and garnet + biotite is the stable assemblage up to the contact with the gneiss. Some aluminous layers contain chloritoid, but the stability field of staurolite was not attained during metamorphism, indicating that temperatures did not exceed 560 C.

In garnet-bearing schists, the most common assemblages are Fe-garnet + muscovite ± chlorite ± albite ± graphite, garnet + biotite + muscovite + quartz ± chlorite ± albite, and garnet + muscovite + Fe-chloritoid + chlorite ± albite ± graphite. In some rocks, rutile has partially pseudomorphed ilmenite, perhaps owing to the prograde reaction chloritoid + ilmenite + quartz = garnet + rutile + H2O.

Overall, metamorphic grade is relatively low throughout the southern Menderes Massif. Thermometry results from sites located along strike across the region are consistent with each other and indicate low temperatures for the southernmost garnet-bearing rocks (~ 450 °C), 500 °C for the chloritoid-bearing rocks, and higher temperatures to the north (up to ~ 550 °C near the contact with the orthogneiss). There are no detectable discontinuities in metamorphic temperature from north to south. Pressure is not well constrained; barometric results yield P ~ 8 kbar, but mineral assemblages and structural constraints suggest low to moderate pressure (¾ 5 kbar). The mineral textures and compositional patterns of the major metamorphic minerals appear to have formed during a single thermal event, with regional metamorphism driven by folding and stacking of thrust sheets. Structural features observed in outcrop and thin section indicate that the deformation history evolved from contraction (top-to-N, syn-kinematic with garnet growth) to extension (top-to-S, producing shear bands that truncate the earlier foliation and that post-date garnet growth).

Ductile-brittle transition in Salihli granitoid below the Karadut detachment surface, Menderes massif, Western Turkey

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Exposed along the southern margin of the Alaşehir (Gediz) Graben in Western Turkey, the Karadut detachment surface separates brittlely deformed Cenozoic volcanic and sedimentary rocks on its hanging wall from the mylonitic, ductilely and brittlely deformed metamorphic and igneous rocks on its footwall. This investigation is aimed at describing and interpreting structural features related to the ductile-brittle transition along a granitoid rock body within the footwall of the detachment.

Granitoid outside the shear zone texturally is usually equigranular granodiorite and largely composed of quartz, feldspars and biotite. It is progressively overprinted by mylonitic rocks indicative of a ductile deformation and cataclastic foliation manifesting a brittle deformation. The extend and degree of deformation increases northward, or structurally upward. The ductile deformation produced protomylonite, mylonite and ultramylonite. Mylonitic foliation and lineation are defined by the preferred crystallographic orientation of biotite, dimensional alignment of quartz ribbons and the direction of extension of fractured feldspar porphyroclasts. Quartz and biotite are predominantly recrystallized, whereas plagioclase and K-feldspar are only partly recrystallized. The most common kinematic indicators, meso- and microstructures, are S-C and –C' fabric, biotite-fish, asymmetric enclaves, asymmetric porphyroclasts, oblique quartz grain-shape foliation, fractured and displacement grains, indicating top-to-the N-NE sense shear.

The structural features that indicate brittle deformation include cataclasites, alteration and mesoscopic extensional faults. Cataclasites (breccia, microbreccia, cataclasite) are easily distinguishable from the their mylonitic protolith based on their color and textural features. They show foliation defined by surface of discrete shearing. Cataclasites are generally brownish-green in color and consist of angular to subrounded clasts of rock and mineral and fine-grained matrix.

We have observed a general upward gradual change from the undeformed isotropic granodiorite to the deformed granodiorite with mylonitic foliation which, in turn, grades into the deformed granodiorite containing mylonites and cataclasites. This suggests that Tertiary extension resulted ductile deformation at depth and as the crust isostatically adjusted to the removal of the rocks in the hanging wall of the detachment surface, the ductilely deformed granitoids were brought to shallower depths and were brittlely deformed. The exhumation history along the detachment surface, however, remains to be studied in detail.

First tectono-metamorphic data in the metasediments of the Lycian thrust sheets: Implications for the emplacement of the Lycian nappes in Southwest Turkey.

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In the southwestern part of Turkey, the Lycian nappe complex overlies an extensive autochtonous basement, composed of the Menderes massif and the Bey Dag platform. This nappe complex consists of metasediments, a mélange unit and an ophiolitic sequence from base to top.

Fresh Fe-Mg-carpholite occurrence in the metasediments points out a high pressure-low temperature metamorphic event. We describe the distribution of carpholite and its breakdown products, such as pyrophyllite and chloritoid on the Bodrum peninsula, south of the Menderes crystalline massif as well as in klippen of Lycian nappes on the top of the Menderes Massif. The distribution of Fe-Mg-carpholite and its relics shows that the low-grade high-pressure metamorphism affected a widespread area in the lower units of the Lycian nappes.

On the Bodrum peninsula, ductile deformation analysis in HP-LT metasediments of the Lycian thrust sheets indicates shear senses top-to-the-northeast to top-to-the-east. This deformation is mainly contemporaneous with the retrogression of high pressure-low temperature parageneses and therefore corresponds to the exhumation of these low-grade high-pressure rocks. At the top of the Menderes massif cover series, close to the contact with the Lycian nappes, similar eastward displacements are observed and trajectories of the stretching lineations are continuous from the Lycian nappes to the Menderes massif across the contact. These observed movements are incompatible with the southward transport of the Lycian nappes over the Menderes massif and a later tectonic event, in relation to the exhumation of the Menderes massif is discussed.

Age and metamorphic conditions of low-grade metamorphism in the Pulur Massif, NE-Turkey

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Eastern Pontides, NE Turkey, have a very complex pre-Liassic basement, consisting of different-tectonometamorphic units, Permocarboneous nonmetamorphic sediments and granites. These basement units are exposed as small inliers under the Mesozoic and Cenozoic sedimentary and volcanic rocks. The low-grade metamorphic rocks are usually regarded as accretionary products of an ancient ocean known as Paleo-Tethys, which once existed between the northern continent, *Eurasia*, and the southern continent, *Gondwana*. This contribution deals with one of the exposures of these low-grade metamorphic rocks (Doğankavak unit) in the Pulur area where they are exposed in form of three tectonic windows under the Carboniferous high-grade metamorphic rocks.

The Doğankavak unit consists basically of an alternation of metabasics (greenscists and ab-ep-amphibolites) and phyllites. Subordinately marbles, calcphyllites, quartzofeldspatic schists and metacherts are found in this sequence. This overall lithology is similar to that of the other low-grade metamorphic areas in the Pontides such as Ağvanis, Tokat and Nilüfer unit of the Karakaya-Complex. However, no obviously tectonic blocks and serpentinite slivers are presently known in the massif, what is typical for most accretion complexes.

The rocks were metamorphosed under conditions of greenschist- and albite-epidote-amphibolite-facies conditions separated by hbl-in isograde in metabasites from each other. The metabasics in the greenschist facies field include act + ab + chl + ep + qtz ± ms/phe ± cal ± mag, while those in the albite-epidote-amphibolite facies are characterized by the assemblage of hbl ± act + ep + ab + qtz ± ms/phe ± cal ± mag. The associated phyllites are generally made up of the assemblage of ab + phe/mu + qtz + chl and cal. In the albite-epidote-amphibolite facies part, garnet bearing assemblages with or without biotite occur. Phase-petrologic considerations in concert with oxygen isotopic geothermometry indicate that the rocks in the epidote-albite-amphibolite facies are equilibrated at 425 ± 25 ºC and 0.6 - 0.9 GPa. These conditions reflect a relatively pressure dominated metamorphism. No relics of a former high pressure metamorphism (eclogite or blueschist facies) were found.

Rb-Sr hbl- and mu/phe whole rock dating yielded ages of 264.4 ± 3.4 and 260.3 ± 2.8 Ma, respectively, which are also verified by mu/phe total fusion $^{40}Ar/^{39}Ar$ dating (258.9 ± 4.4 Ma, 2σ). These ages obviously substantiate that the low-grade metamorphism occurred in Perm, and cast doubt upon the generally assumed late Triassic ages of metamorphism for the low-grade units (Karakaya complex) in the Pontides.

The geological and petrographical characteristics of the magmatic rocks and their contact zones in the Hacımahmutuşağı (Ortaköy-Aksaray) area, Central Anatolian Crystalline Complex, Turkey

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The Hacımahmutuşağı area is located on the north of Aksaray city (Turkey), where field relations of different rock units of the Central Anatolian Crystalline Complex (CACC) are clearly observed.

The basal unit in the Hacımahmutuşağı area comprises the Gümüşler Gneisses and the Aşıgediği Marble of the Central Anatolian Metamorphics (CAM). The pegmatitic and micro gabbros (Dede Tepe Gabbro) of the Central Anatolian Ophiolites (CAO) overthrust the metamorphic rocks. The contact zone between the gabbros of the CAO and the marbles of the CAM is represented by a sharp shear plane and there is no indication for a contact metamorphic overprint in the adjacent marbles. The Borucu Granodiorite-Monzogranite, Kalebalta Leucogranite and aplitic micro-granite of the Central Anatolian Granitoids (CAG) intrude both the metamorphic and the ophiolitic rocks, and metamorphic rocks occur locally as roof pendents in the granitoids.

In the contact metamorphic zone cordierite occurs as the main contact metamorphic phase within the gneisses. The marbles in the contact zone include wollastonite, vesuvianite, tremolite and diopside. The gabbroic rocks at the contact with the granitoids are characterized by replacement of primary hornblends by actinolite and chlorite and formation of secondary biotite.

The field and petrographic data indicate that the intrusion of Central Anatolian Granitoids in the Hacımahmutuşağı area postdates the tectonic emplacement of the ophiolitic rocks onto the metamorphic rocks of the CACC.

Geochemistry and Geochronology of west-northwestern part of Behrek Batholite, Central Anatolia

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The investigated area is located in Central Anatolian Crystalline Complex. The plutonic rocks are divided into 3 different lithodem units in this area. These are Behrek Quartz Monzonite, Büyüköz Biotite Monzogranite and Hacıyusuflu Monzogranite. All of these units are unconformably overlain by The Bıyıkkebir Limestone which yields Bartonian age.

These rocks represent subalkaline character and some good evidences of the fractional crystallisation (FC) and magma mingling/mixing processes by means of field, mineralogical-petrographical and geochemical characteristics.

Mafic mineral assamblages of Behrek Quartz Monzonite are amphibole (hornblende+hastingsite), clinopyroxene (augite) and biotite. While the Büyüköz Biotite Monzogranite include biotite, amphibole (hornblende+hastingsite) and clinopyroxene (augite); the Hacıyusuflu Monzogranite consist of hornblende+biotite mafic mineral assamblage.

Some K/Ar absolute age determinations have been carried out on some minerals such as hornblende, biotite and K-feldspars extracted from 9 wholerock samples from Behrek Quartz Monzonite. Hornblende K/Ar ages represent some cooling ages renging from 80 Ma to 67,8 Ma. Biotite cooling age yields an age of 70,3 Ma. As for the K-feldspar K/Ar ages, they range from 65,5 Ma to 57,5 Ma.

According to these data, it can be proposed that these units have been formed by fractional crystallisation (FC) from a single magma source.

Petrology of Oymaağaç (Beypazarı-Ankara) Granodiorite

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The study area is exposed to the north west of Central Anatolia and mainly is composed of granodiorite and young sedimentary cover units. Quartz, K-feldspar, plagioclase and amphibole mineral assemblages represent the granodiorite. However, the granodiorite is further differentiated into three subgroups according to the proportion of amphibole in the rock unit. This discrimination has done on the bases of field aspects and modal mineralogical composition under the microscope. The first group crops out at the margin of the intrusive body and the amphibol contents reach up to 35%. The second group has transitional contact with first group and the amphibole contents reach up 20%. The other group is exposed at the core of the intrusive body which characterized by quartz enrichment and the amphibole contents are less than 10 %. All the subgroups are cut by alkali feldspar granit in the form of aplitic dyke along the direction of NW. Mafic magmatic enclaves are observed in Oymaağaç granodiorite in the composition of diorite and monzodiorite. The enclaves are changing in size from 1 cm upto 20 cm and there abundanceses decrease from the marginal unit towards the core of the intrusion.

All the subgroups of Oymaağaç granodiorite are calkalkaline in composition and the geochemical trends on the variation diagrams of all sub groups suggest a fractional crystallization from same products. ORG normalized elemental patterns of all these three groups have enriched in LILE (K, Rb, Ba and Th) relatively to a depletion in some HFSE (Zr, Hf, Sm, Y and Yb) and they exhibit calkalkaline pattern. The slight enrichment in LREE relatively to a flat HREE patterns are the characteristc features of Oymaağaç granodiorite. All sub groups of the granodiorite plot on the collisional related granites on the trace element tectonic discrimination diagrams.

Petrographical and geochemical characteristics of the Güre (Giresun) granitoid, Eastern Pontides, NE Turkey

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The Eastern Pontides is characterised by widespread intrusions of varying age and compositions in both northern and southern zones. These intrusions intruded broadly in Jurassic, Cretaceous, Palaeocene and Eocene time intervals, all of which show general characteristics of arc granites, and mainly located inland away from the Black Sea Coast. However the Güre granitoid studied is situated at 3 km west of Giresun city, very near (about 150 meters) to the Black Sea Coast. The Güre granitoid extends NE-SW direction with 3 km length and 1 km width oval shape outcrop. The granitoid intruded into Lower Cretaceous aged basaltic rocks and Upper Cretaceous aged dasitic rocks. The contact with country rocks is sharp with common epidote, clay and rare pyrite occurrences. General field characteristics of the stock correspond epizone granitoids.

The Güre granitoid contain quartz (17-52%), orthoclase (1-18%), plagioclase (38-58), hornblend (0-37%), biotite (0-6%), accessory apatite and sphene, and secondary chlorite, epidote, actinolite-tremolite and calcite. Generally, ferromagnesian mineral content decrease towards northern part of the granitoid. Likewise biotite content increases to the north whereas hornblend content increases to the south. The stock exhibits mainly medium to fine grained, rarely porphyric and graphic textures. Based on modal mineralogy, the granitoid is granodiorite and tonalite in composition which is also consistent with chemical classification. Geochemically, the granitoid shows I-type, calc-alkaline characteristics with metaluminous-peraluminous (A/CNK=0.9-1.1) transitional features. In addition it plotted in ALCAF field of characteristic mineral diagram, showing light coloured subalkaline (SALKL) trend. On magma tectonic discrimination diagrams, it plotted syn-collision granitoid field. Compared with same aged other granitoids of the eastern Pontides, the Güre granitoid is very interesting in terms of their position and geochemical features. The investigated granitoid may represent either late phase differentiate of mafic parent magma or influence of mature arc crust, probably corresponding beginning of an early collision time in the region.

Petrographical and geochemical characteristics of the Deredam (Gölköy-Ordu) granitoid, NE Turkey

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In the eastern Pontides many intrusions also emplaced in an age spectrum ranging from Permo-Carboniferous to Eocene times. Palaeozoic aged Gümüşhane Granitoid intruded into Pulur metamorphics whereas Jurassic-Cretaceous-Palaeocene aged granitoids emplaced into volcanic and/or volcaniclastic units. In the Gölköy (Ordu) area studied, Late Cretaceous aged lithologies have widespread occurrences whereas pre-late Cretaceous sericitic schists are the oldest unit. Sericite schists are overlain by a volcanic rocks consisting of andesite, basalt and their pyroclastics, and followed by young trachyandesites. These rocks are cut by the Deredam granitoid having irregular intrusion outlines that crop out largely in the valleys. Entire sequence is unconformably overlain by Maastrichtiyen limestones deposited as two distinct facies in two different areas.

The granitoid is observed as large stock with apophysis and dykes. The granitoid are monzonite and siyenite in composition. Monzonites contain oligoclase-andesine (36-55%), orthoclase (34-49%), hornblend (5-8%), augite and biotite with medium grained and monzonitic textures. Siyenites consist of orthoclase (52-63%), oligoclase (17-31%), microcline, quartz (3-6%), biotite (2-10%). Based on field observations, petrographic and geochemical investigations, monzonite emplacement was found to predate siyenite emplacement in the area. Geochemically, a possible fractional crystallisation can explain the observed trend from monzonitic to microsiyenites. Hornblend and biotite appear to be predominant mafic minerals in monzonites whereas, biotite is the most abundant mafic phase in siyenites indicating I-type character of the granitoids. Siyenites outcropping in the field include quartz siyenite, siyenite, and monzosiyenite. Monzonites appear to have relatively more uniform composition. Furthermore, geochemical data suggest evidences of crustal contamination and originated from hybrid parental magma.

Upper Cretaceous granitoids: Geochemical implications for the temporal variations in the evolution of the arc magmatism in the Yusufeli (Artvin) area, NE-Turkey

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Eastern Pontides has a very complex pre-Liassic basement and Liassic to Eocene volcanic, sedimentary and volcano-sedimentary units were cut by Upper Cretaceous granitoids. But, three granitoids in the area studied are constrained by Liassic units. They are seen in small areas of 1 to 3 square kilometer and were named as Sumbated quartz monzodiorite (SQM), Keçikaya Tepe granitoid (KTG) and Dutlupınar granodiorite (DG). The SQM and KTG compositionally range from quartz diorite to granite displaying medium-K calc-alkaline, whereas DG from tonalite to granodiorite exibiting low-K trondhjemitic trend.

Total ferromagnesian content (FC = $Fe_2O_3^T$ + MgO + TiO_2) and differantiation index (DI = q + or + ab + ne + lc + kp) give information about the differantiation degrees of the granitoids. SQM with high total FC (15-10 %) and low DI (46-59) values has the least fractionated body. Those values (FC =10-3 % ; DI = 61-89), and all the major and trace element contents of the KTG follow the same values of the SQM. Therefore, both of them produce compositionally a broad range together (SiO_2 = 55-73 %) suggest that they were evolved from the same parental magma. On the other hand, FC (5-3 %), DI (71-83), and major and trace element contents of the DG have a narrow interval (SiO_2 = 71-74 %) and coincide with the most differantiated values of the KTG. Besides, it follows different differantiation path from the others particularly in terms of K_2O, total alkali and Rb contents. This difference appear more obvious on K - Na - Ca and normative Q - Ab - Or diagrams heve been used for discrimination of calc - alkaline and trondhjemitic suites of arc volcanism. Na and normative Q enrichments of the DG are resemble Archean tonalites, trondhjemites and dacites (TTD) in differantiation believed to be derived from partial melting of metamorphosed basalt. On the contrary, SQM and KTG show K and normative Or enrichments and conform to typical calc - alkaline trend indicating partial melting of metasomatized mantle peridotites.

As a result, a distinct difference between the differantiation paths and other geochemical features of the granitoids may attribute various petrogenetic processes in the evolution of their parental magmas. High SiO_2 contents and low-K trondhjemitic trend of DG rocks indicate that parental magma were derived rising diapirs from mantle and then subjected to partial melting at shallower depth under hydrous conditions, generating silica-oversaturated magma. In contrast, high K_2O contens, positive Eu anomalies and medium-K calc-alkaline trend of SQM samples imply that fluids and melts arised from deeper fertilised mantle peridotite.

Mineralogy, Mineral Chemistry and Geochemistry in Saraftepe Sill from south Trabzon, NE Turkey: Constrains on their genesis and evolution

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Saraftepe Sill which take place in the south of the Trabzon area of the eastern Black Sea region is located in the northern of the eastern Pontide Tectonic Unit in terms of the tectonic scheme of Anatolia. The sill, which has approximately 30 m. thick and approximately 750 m. long and massive in appearance, is concordant with Upper Cretaceous (Campanian) volcano sedimentary series that consists mainly of andesitic and basaltic pyroclastics interbedded with reddish micritic limestones. Although Saraftepe Sill occurs in a Upper Cretaceous aged volcano sedimentary series, mineralogical, mineral chemistry and geochemical features are so different from them. Moreover, radiometric K/Ar dating on biotites in the sill has yielded K/Ar age of 3.2 ± 2.3 Ma.

Saraftepe Sill is tephrite-phonolitic tephrite and alkaline to shoshonitic character. It shows common porphyric and glomeraporphyritic textures and consist of abundantly oscillatory and sector zoned Ti-Al diopside, Mg-rich biotite, plagioclase (Ca-K albite to K-andesine), K-feldspar (sanidine to K-sanidine), analcite, ulvöspinel, apatite, ± calcic amphibole. Zeolite, calcite and clay are present as secondary minerals in matrix. The samples have very high abundances of LILE (Sr, Rb, Ba, Th) and LREE (La, Ce, Pr) as would be expected from their high K contents. Mineralogical characteristics, trace element abundances and REE patterns reveal that presence of at least three different magmatic differentiation levels. Between minimum and maximum level of the Sill have quite fractionated REE patterns with (La/Lu)N= 54 to 82. In general, LILE/HFSE and LREE/HREE ratios are very high relative to E-type MORB and Ba/Zr (6.8-8.4) and Ba/La (10.8-16.1) ratios are similar or slightly high to those of OIB, but lower than those of island arc basaltic rocks. The REE patterns are similar to the patterns of incompatible elements.

All data obtained from Saraftepe Sill are concordant with previous limited in number of the investigations both geocronological and mineral-rock chemistry studies in Neogene alkaline volcanism of the eastern Black Sea coast.

K-Feldspar Megacryst Compositions from Kaçkar and İkizdere Batholith: Evidences to Generation Model of Granitoid Rocks

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K-feldspar megacrysts are common in alkaline, calc-alkaline plutons and their enclaves. Their crystal habits and zoning growths in some elements represent magmatic records of magmas generating them. So, texture, size, zoning, distribution and chemical composition of the megacrysts are important for magma genesis.

Kackar and Ikizdere Batholithe have pink colored K-feldspar megacrsyts. Their crystal sizes range from 1 to 4 cm. Crystal inclusion sizes are small (<1 mm). Macroscopically, zoning is not observed in megacrysts. The megacrysts contain plagioclase (Ab_{75} An_{24} Or_1), amphibole (magnesiohornblende), biotite (iron-rich phlogopite) and iron-titanium oxide (magnetite and ilmenite) inclusions being euhedral to subhedral.

The K-feldspar megacryst composition range from Or_{95} Ab_5 An_0 to Or_{82} Ab_{17} An_1. The Ba contents of megacrysts increase from core to rim. The mafic and felsic crystal inclusion compositions are similar to that of host rocks.

These chemical and textural features are typical of K-feldspar megacrysts that grew as phenocrysts in these plutons. The overgrown of K-feldspar relative to the other minerals in same system may be related with temperature, pressure and compositional fluctuation in magma chamber. Mafic magma injections (magma mixing) and crustal contamination (?) may result in temperature, pressure and compositional flutuation in felsic magma chamber. While the mafic injection can decompose some precipitated K-feldspar megacrysts with small nucleus, the others remain in felsic system. The K-feldspar nucleus remaning is overgrown by rapid diffusion of K, Na, Ba, and Rb elements in liquid phase during the later stages of crystallization of the host magma.

As a result, K-feldspar megacrsts in Kackar and Ikizdere Batholits can be interpreted as a product of magma hybridisation caused by magma mixing.

Comparison of enclave and their host rocks mineral chemistry: Evidences for the genesis and evolution of granitoid rocks, Dolek and Sarıcicek Plutons (NE Turkey)

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Many granitoid intrusions contain more or less mafic microgranular enclaves. Magmatic enclaves are probably dominant in most calc-alkaline, I-type granitoids. There are many different ways and different sources for originating of enclaves. So, enclaves and their textural and chemical relationships may convey important information for enclave evolution and magma processes.

Enclaves and their host rocks of Dolek and Sarıcicek plutons are calc-alkaline, metaluminous, and have I-type magmatic character. Monzodioritic, quartz monzodioritic, quartz dioritic and dioritic enclaves occur in the Dolek and sarıcicek plutons classified modally as granite, granodiorite, quartz syenite, alkali feldspar granite, quartz monzonite, monzodiorite, quartz monzodiorite and quartz diorite. Plagioclase, k-feldspar, quartz, amphibole, pyroxene, biotite, magnetite and ilmenite are magmatic phase in both enclaves and host rocks. The sizes of enclaves is small and range from 2 mm to 15 mm in diameter. Their morphology is commonly elipsoidal and ovoid shaped being evidences blobs of mafic magma into the felsic magma.

Amphiboles of enclaves and their host rocks are magnesiohornblende and actinolite mainly having pargasitic and edenitic substition mechanism. Biotites are iron rich. Pyroxene is augitic and diopsidic. Plagioclase megacrysts of enclaves being similar composition with those of host rocks, especially at an early stage in their crystallization, indicate that the megacrysts must not be foreign to the enclaves. Granophiric alkali feldspar is evidence low temperature and pressure. Mg/Mg+Fe values for amphibole, biotites and pyroxene in enclaves are similar to that of host rocks. Crystallization temperatures-pressures and oxygen fugacity values are similar.

Textural and chemical similarities of enclaves and their host rocks indicate that magma mixing and mingling processes, possibly involving mantle and crustal-derived and-members, may have played main roles in the genesis of the enclaves and granitoid rocks. Thermal and chemical exchange may be effective magma mixing processes in generation of these plutons, but mechanical exchange is not due to that the interaction of mafic and felsic members occur at very early stage of crystallization in the plutons.

Petrography and Geochemical Features of Mafic Microgranular Enclaves in the Sarıhan Granitoid, NE Turkey.

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The Eastern Pontides (NE Turkey) is characterised by widespread acidic intrusions of varying age in both northern and southern zones. These intrusions intruded in Palaeozoic, Cretaceous and Eocene time intervals, all of which show general characteristics of calc-alkaline arc granites. Palaeozoic intrusions, which are mainly granite and monzogranite, do not contain mafic microgranular enclaves (MMEs) whereas Upper Cretaceous and Eocene intrusions, which are generally granodiorite and diorite in composition, consists of abundant MMEs. In this study, MMEs of Upper Cretaceous aged Sarıhan granitoid in the southern zone of eastern Pontides were investigated in terms of petrography, geochemistry and petrogenesis.

The Sarıhan intrusion is made up from quartz-monzodiorite (60%), granodiorite (35%) and quartz-diorite (5%), showing very similar petrographical features. MMEs have very sharp contacts with host granitoid, and oval shaped with 3-5 cm in diameter. There is biotite enrichment and some large K-feldspar crystals around contact of enclaves, indicating magma mingling processes. MMEs are diorite and quartz diorite in composition, and much fine-grained and dark coloured compared to the Sarıhan granitoid. Petrochemically, MMEs have 59-60% SiO_2, 4-7% MgO, 3-6% Na_2O and 1-3% K_2O contents. They are calcalkaline, metalumineous with A/CNK=0.7-0.8, and show characteristics of CAFEMIC granitoids. In SiO_2 versus some element variation plots, Fe_2O_3, MgO, TiO_2, K_2O and Zr show negative whereas Al_2O_3, Th and Nb positive correlation, all of which may be indicate plagioclase and hornblend fractionation. On tectono-magmatic discrimination diagrams, they fall in volcanic arc and post-collision uplift fields. All these geochemical features are quite similar to host granitoid. Continental crust-normalised trace element patterns show Th, Pb, Ba, La, Sr, Rb, Nb enrichment and Cr, Ni and Ce depletion, reflecting characteristics of post-collision granitoids.

Although general geochemical characteristics of MMEs are resemble the Sarıhan granitoid, MMEs are more basic and fine-grained. These features support that MMEs are magmatic in origin. Oval but not elongated shapes of MMEs suggest that there was no much internal flow within parental magma during emplacement. MMEs occurred as a result of mingling between mafic (dioritic) and felsic (granitic) magmas during Newtonian and visco-plastic stage. Conclusively, they formed by mingling and mechanical transfer of two masses, resulting in development of large-K feldspars.

The $^{40}Ar/Ar^{39}$ age of Ductile Extension and Granitoid Intrusions in the Northern Menderes Massif, Western Turkey

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Although metamorphic core complex origin of the Menderes massif has been generally accepted by the students of the Aegean extensional tectonics, the timing of extensional events in the massif remains poorly understood. In recent years, we have conducted field-oriented geological work in the northern part of the Menderes massif where a low angle normal fault, the Simav detachment fault, separates the non-mylonitic and mylonitic core rocks in its footwall from brittly deformed cover rocks of the hanging wall. Strongly mylonitized gneisses and marbles of the footwall have been intruded by granitoids.Kinematic indicators developed during cooling and uplift of the footwall indicate top-to-N-NE shear sense.

$^{40}Ar/^{39}Ar$ data indicate that mylonitic deformation formed at 22.86±0.47 Ma, while the cooling age of the granitoid is 20.19±0.28 Ma. The intrusion and cooling of granitoid occurred between ~22-20 Ma. These ages suggest that extensional deformation began in the northern Menderes massif in Early Miocene.

Our age data also suggest that initiation of extensional events in the whole massif is not same considering the age of an extensional shear zone was reported as syn-or-pre Eocene in the southern part of the Menderes massif. In the central part of the massif, however, the initiation of the extension was reported as Early Miocene.

Structural and petrographic features of metamorphic rocks in the south of Simav, Western Turkey

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In this study, the geological setting, structural and petrographic characteristic of the metamorphic rocks exposed to the south of Simav (Kütahya) whose ages extends from Proterozoic(?) to Cretaceous was investigated.

The studied area is mainly made up of Proterozoic-Paleozoic (?) migmatites of Kalkan formation. These rocks are overlain by protomylonites, migmatites and ultramylonites representing the Simav mylonites which was formed as a result of extensional tectonic during Tertiary. Balıkbaşı formation and its transitional low-grade schist facies of the Paleozoic Sarıcasu formation. In tectonic contact with this formation, meta-sandstones of Jurassic Kırkbudak formation and its transitional crystalline limestone facies of Jurassic-Cretaceous Budağan formation are taking place.

Studies of the metamorphic rocks exposed in the investigated area revealed that the migmatites of Kalkan formation and the low grade schists of Sarıcasu formation were separated by the protomiylonites, mylonites and ultramylonites belonging to the Simav mylonites. The rocks of Simav mylonites were developed the along the detachment fault during the extensional period post-dating the crustal thickening of Menderes massif during Paleocene-Eocene which had resulted in separating migmatitic rocks from the low grade schist. This fault is known as Simav detachment fault.

The kinematic indicators developed in relation to the ductile deformation of Simav mylonites are the followings: asymmetric feldspar porphyroclast, mica fish, S-C fabrics and the oblique microscopic structures. According to the microscopic structures, it has been established that the movements in shear zone is top to north.

The brittle deformation in the studied area is represented by the structural element, developed in the form of faults. These faults being to high-angled normal type character, bisects all units in the investigated area. The Simav fault and Kıbletaşı faults have normal faults characteristic.

Characteristics and age of the metamorphic sole rocks in the serpentinite of the Beysehir Ophiolites

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The ophiolite related metamorphic rocks of the Beysehir ophiolite crop out in the West of Gencek and in the South of Durak (South of Beysehir Lake) in the Central Taurus Belt. They appear as small outcrops.

The amphibolitic rocks are tectonically bounded by the serpentinites and the Wild flysch. According to Niggli parameters, these amphibolitic rocks present an ortho or igneous origin. The protholite of these rocks are probably alkali basalts, gabbros and some ultramafic cumulates, such as pyroxenite. In this respect, the amphibolitic rocks of the Beysehir ophiolite, developed at the base of an hot oceanic crust.

The amphibolites of the Beysehir ophiolite are divided into four groups. In the first group, the amphibolites are composed of amphibole + garnet + plagioclase ± epidote (as secondary mineral production) ± opaque such as ilmenite ± accessory minerals such as sphene and apatite. In the second group they are composed of amphiboles + pyroxene + plagioclase ± epidote ± accessory minerals such as sphene, apatite ± chlorite, calcite (as secondary mineral production). In the third group they are composed of amphibole ± opaque ± accessory minerals. In the fourth group, they are composed of amphibole + plagioclase ± epidote ± biotite and muscovite ± opaque ± accessory minerals.These metamorphic rocks mainly show granoblastic, granonematoblastic, porphyroblastic or poikioblastic textures.

The amphibolites shows an alkaline to subalkaline character. However, Primitive mantle normalized incompatible trace element diagram for the amphibolites show close similaritiy with typical ocean island basalt (OIB) pattern. The Rock/Chondrite normalized REE diagram of the amphibolites also confirm their OIB signature. Tectonomagmatic discrimination diagrams based on the immobile trace elements suggest mostly within plate alkali basalt (WPB) environment.

According to preliminary K/Ar age determinations based on hornblende minerals, the metamorphic sole rocks crystallized during the Upper Cretaceous (~ 88Ma).

Geology of the Kopuzsuyu metamorphics in The Eastern Pontides (Bayburt, NE Turkey)

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Eastern Pontides have a complex pre-Liassic basement consisting of at least two distinct tectonometamorphic units, permocarboniferous sediments and magmatics (granitoids and dacites). These basement units are widely exposed throughout Eastern Pontides often as isolated outcrops separated by large areas of younger cover, mainly in Pulur, Ağvanis, Artvin, Gümüşhane and Köse areas. Partial preservation of the overall tectonostratigraphy causes problems of the regional correlation. Basically two different tectonometamorphic units occur in the Pulur Massif: 1) A low-grade (greenschist to albite-epidote-amphibolite facies) tectonometamorphic unit (***Doğankavak)*** with metamorphism ages of 260-265 Ma (Rb-Sr muscovite & hornblende – whole rock, $^{40}Ar/^{39}Ar$ muscovite), and 2) a high-grade (amphibolite to granulite facies) tectonometamorphic unit (***Cenci***) with metamorphism ages of 320-330 Ma (Sm-Nd garnet-whole rock & U-Pb monazite), exhumed by the end of Upper Carboniferous. These two tectonometamorphic units were accreted before the Liassic transgression, so that the low-grade rocks occur in form of tectonic windows under the high-grade ones. Within the framework of a project aiming at elucidating the interrelationship among these different basement units, the Kopuzsuyu metamorphics – the northeastern extension of the Pulur Massif (4 km to the northeast from the northeastern end of the Pulur Massif, Bayburt) – were investigated in terms of lithology and metamorphism.

The Kopuzsuyu metamorphics occur in a small area of approximately 4 km^2, and are thrust over Malm-early Cretaceous limestones to the north, while they are transgresively overlain by a Liassic volcanosedimentary series to the south. The metamorphics consist of phyllite, quartzphyllite, quartzite, calcphyllite, marbles and muscovite-gneisses. Quartzite veins 2-20 cm in thickness and a strongly altered volcanics frequently crosscut this sequence. The mineral assemblages in phyllites (qtz + mu/phe + ab + chl + cal) and calcphyllites (cal + qtz + chl + mu/phe + ab) are indicative of very low-grade and low-grade metamorphism conditions. Absence of metabasics hampers further constraining of the metamorphic grade. The muscovite-gneisses are exposed towards the southwestern end of the Kopuzsuyu area, and its contact with the other rock types could not be observed due to poor exposures. The muscovite-gneisses are made up of quartz, plagioclase, muscovite, chlorite and minor K-feldspar. Besides, a mineral (cordierite??) totally pseudomorphosed by a shimmer aggregate is also present. The muscovite gneisses show a mylonitic texture characterized by asymmetric feldspar porphyroclasts in dynamically recrystallized quartz grains. Presence of pseudomorphs suggests that the muscovite gneisses might have had a pre-low-grade metamorphic history.

Lithology of the Kopuzsuyu metamorphics is similar to that of the low-grade metamorphics of Doğankavak unit apart from the absence of metabasics. No fossils have been found in this predominantly metasedimentary sequence. There is, therefore, no age information for the protoliths. As for metamorphism age, an early Permian age (260-265 Ma) is assigned to the Kopuzsuyu metamorphics, on the basis of analogy to the Doğankavak unit. Despite the analogy, radiometric dating is necessary to constrain the metamorphism age.

Development of mylonitic fabrics in granites at west of Isfahan, Iran

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There is a complex of metamorphic rocks 120 km far from west of Isfahan, part of which shows a typical shear zone. This area has been a part of geotectonic zone of Sanandaj-Sirjan that is located in a 25 km distance from the main Zagros thrust. This thrust is where the Iranian plate collides with the Arabic plate.

Metamorphic rocks that are the oldest ones in the area are as old as the late Paleozoic and covered by Permian conglomerate and limestone. This complex of metamorphism is originated from igneous (basic and acidic) and sedimentary rocks and such as parageniss, metapsammite, schist, calc-schist, amphibolite, garnet amphibolite, orthogeneiss and mylonitic metagranite.

In this shear zone, granite bodies have intruded in the metamorphic rocks of the area. Metamorphic rocks are influenced by barrovian metamorphism and are progressed up to the upper amphibolite facies. Intrusion of these granite bodies had been occurred at the peak of thermal metamorphism. In addition to metamorphism, the rocks of the area are heavily deformed. The rocks have different grades of deformation.

Development of mylonitic fabrics in these granites has caused a mylonitic foliation that is specified by the orientation of dark minerals such as biotites. According to the grade of deformation, metagranites can be classified into protomylonite granites, mylonitic granites and ultramylonite granites.

Field evidences and microscopic studies indicate the regime of deformation in various rocks and especially in granites has been ductile and ductile-brittle. Increase in the rate of deformation in these metagranites and development of mylonitic fabrics has decreased the rate of plagioclase, but added the rate of muscovite. This occurrence has been along with the formation of myrmekit, expressing pressure increase around the grains under influence of intergrnular fluids. In the more deformed granites, white mica is formed in or around lenses and porphyrocalasts. In ultramylonite granites, white mica is formed as a thin film between quartz porphyroclasts.

NEO-TETHYAN OPHIOLITES

Tectonic setting of the Yüksekova ophiolite and its relation to the Baskil magmatic arc within the southeast Anatolian orogeny

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The late Cretaceous Yüksekova ophiolite, tectonically bounded by the Göksun-Sürgü fault zone to the south and the Malatya metamorphics to the north, is located in the "nappe zone" of the southeast Anatolian orogenic belt in the area between Göksun and Afşin (Kahramanmaraş). The Yüksekova ophiolite is characterized by a mostly complete ophiolitic sequence, in an ascending order, ultramafic-mafic cumulates, isotropic gabbro, sheeted dike complex, plagiogranite and volcanic association. The ophiolitic rocks and the underlying basement in the study area were intruded by syn-collisional granitoids (74 to 51 Ma).
The magmatic rocks in the Yüksekova ophiolite are part of a co-magmatic differentiated series of subalkaline tholeiites. Selective enrichment of some LIL elements (Rb, Ba, K, Sr and Th) and depletion of the HFS elements (Nb, Ta, Ti, Zr) relative to N-MORB are the main features of the upper crustal rocks. The presence of negative anomalies for Ta, Nb and Ti is indicative of subduction-related environment. The similarity of normalized REE patterns for the volcanics, sheeted dikes and isotropic gabbros indicate a possible comagmatic relationship. All the geochemical evidence both from the volcanics and the deeper levels (sheeted dikes-isotropic gabbro and cumulates) show that the Yüksekova ophiolite was formed in a suprasubduction zone (SSZ) tectonic setting.

The Baskil arc magmatic rocks are predominantly composed of plutonics (gabbros, diorites, monzodiorites, quartz-diorites, quartz-monzodiorites, quartz-monzonites, granodiorites, tonalities) and calc-alkaline volcanics of Coniacian to early Campanian age (Yazgan and Chessex, 1991). Geological and petrological data suggest that the Baskil magmatic arc is a typical Andean type active continental margin that occurred as a result of northward dipping subduction.

Geological and petrological data on the Yüksekova ophiolite and the Baskil magmatic arc suggest that there have been double-subduction, namely the first one beneath the Malatya-Keban platform generating the Baskil magmatic arc and the second one in the oceanic side generating the Yüksekova ophiolite in a suprasubduction zone environment. Due to the thickening of the oceanic crust at the later (mature) stage of arc magmatism and thrusting/collision of the metamorphic massifs (Malatya-Keban-Engizek) with the thickened arc crust, from north to south, as a result of the continuation of the subduction. This successive events created the felsic intrusives (Esence granitoid) that cut the Yüksekova ophiolite and Malatya metamorphics in the region

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Geology and Petrology of Dehshir-Surk Ophiolites from Central Iran

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Dehshir-Surk area is located in the west-northwest of Yazd province. This area reported as a part of Central Iran unit between Sanandaj-Sirjan structure zone Urumieh-Dokhtar volcanic belt.

Rock units which constitute this ophiolite complex are as follows; 1- Ultramafic rocks which consist of serpentinite, harzburgite, minor dunite, lherzolite and pyroxenite. 2- Pyroxene gabbro, amphibole gabbro with trace diorite 3-Plagiogranite 4- Sheeted dykes 5- Massive basalts with minor pillow lava 6- Upper cretaceous pelagic limestones and radiolarites 7- Metamorphic rocks which are undergone to subseafloor, dynamic and regional metamorphism (up to amphibolite facies).

Based on the field relationships, plagiogranites are classification in two groups; in association with sheeted dykes, and as intrusive bodies in regional metamorphites.

Geochemistry of major, trace and rare earth elements in basic units of ophiolitic melanges show that the nature of magma is tholeiitic and parental magma is garnet lherzolite with 20% partial melting.

Both of plagiogranites types display similar geochemical characteristics and are located in oceanic plagiogranites field and probably the second one is formed due to partial melting of hydrated gabbroes and amphibolites.

As a result, the Dehshir-Surk Ophiolites may be formed in oceanic rift environment.

Net tectonic rotation analysis of extreme rotations in the Baër Bassit ophiolite of N. Syria

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The Late Cretaceous Baër-Bassit ophiolite of northern Syria forms part of a series of thrust sheets emplaced over Mesozoic carbonates of the Arabian platform in the middle Maastrichtian. We present the first palaeomagnetic results from this terrane.

Magnetisations recovered from 27 sampling sites within layered gabbros, sheeted dykes, sills and pillow lavas are proved to be pre-deformational in origin by a variety of positive field tests. Site mean directions of magnetisation show large relative rotations within the ophiolite, following application of standard palaeomagnetic tilt corrections. These data demonstrate that extreme rotational strains are recorded within the ophiolite on a kilometric scale. A more sophisticated approach to the interpretation of remanence directions is provided by analysis of the poles and angles of net tectonic rotation (NTR). This provides additional insights into the nature of rotational deformation, and removes the assumption that tilting occurs around present-day lines of strike.

The NTR approach identifies variably inclined rotation axes around which up to c.200° of counterclockwise rotation has occurred. These net rotations are almost certainly composite in origin and potentially include components produced during intra-oceanic detachment and subsequent emplacement of the ophiolite onto the continental margin. A progressive north to south increase in the magnitude of rotation may result from either: (a) increasing rotational strain accompanying an increase in the degree of structural imbrication and thinning of the ophiolite towards the south; or (b) the influence of a ENE-WSW trending neotectonic strike-slip fault system which affects the southern part of the ophiolite. Unfortunately, the net rotations can not be further decomposed into intra-oceanic detachment and tectonic emplacement-related components in this ophiolite because of a lack of cross-cutting igneous units generated during progressive deformation. Data are therefore required in more extensive ophiolites where such units are observed in order to resolve the *timing* of rotational deformation within the peri-Arabian Neotethyan ophiolites.

Tectonic Setting of the Kızıldağ (Hatay) Ophiolite Inferred from the Whole Rock and Mineral Chemistry of the Ultramafic-Mafic Cumulates (Southern Turkey)

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The Kızıldağ ophiolite in southern Turkey is a remnant of the Neotethyan oceanic crust and displays a well-preserved ophiolite pseudostratigraphy such as, in an ascending order: mantle tectonites, ultramafic-mafic cumulates, isotropic gabbros, sheeted dike complex, volcanics and associated sediments.

The well-preserved ultramafic-mafic cumulate rocks are situated in the southeastern flank of the Kızıldağ massif. The detail stratigraphic sections in three locations namely Karaçay valley, Aydınlı village and Üçgedik village show that the cumulates possess 165 to 700 m thickness and are characterized by igneous layering-lamination, cross-bedding, graded bedding isoclinal folding and slump structures. The ultramafic cumulates ranging in thickness from 100 to 300 m are mainly represented by dunite and wehrlite. Whereas the low-Ti gabbroic cumulates ranging in thickness from 165 to 400 m are characterized by olivine gabbro, olivine gabbronorite and gabbro. The crystallization order within the cumulates is olivine (Fo_{86} to Fo_{76})±chromian spinel, clinopyroxene (En_{53-41}, Fs_{14-4}, Wo_{48-34}), plagioclase (An_{94-83}) and orthopyroxene (En_{83-74}, Fs_{20-12}, Wo_{6-3}). The cumulus and postcumulus minerals do not show significant zoning from core to rim.

The presence of high Ca-plagioclase (An_{94-83}), highly magnesian clinopyroxene ($Mg\#_{86-78}$), olivine ($Mg\#_{86-76}$) and their coexistency in the cumulate gabbroic rocks are indicative of suprasubduction zone environment. The major and trace element geochemistry of the cumulate rocks and isotropic gabbros from the Kızıldağ ophiolite are also analogous of the rock units that formed in present-day subduction-related environments. The sakalavites within the volcanics of the Kızıldağ ophiolite reflect Mg-rich magma (Boninite) composition indicating modern fore-arc tectonic setting. All the evidence strongly suggest that the Kızıldağ ophiolite were formed in a suprasubduction zone tectonic setting during the closure of the southern branch of the Neotethys in late Cretaceous.

Was the "Supra-Subduction Zone" (SSZ) type Central Anatolian Ophiolite (CAO) (Turkey) formed in forearc or back arc basin? Comparison with its modern oceanic analgues

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Previous studies suggested that tectonic settings for the generation of SSZ ophiolites include back arc basins, rifted island-arcs (initiation of back arc basin formation), and magmatic forearcs that form above nascent, retreating intraoceanic trenches. Recent results from the DSDP and ODP that focused primarily, although not exclusively, on the Izu-Bonin-Marianas (IBM) intra oceanic arc system testing various proposed origins of SSZ ophiolites.

Back arc-arc-forearc geochemical transects in the IBM intra oceanic arc system reveal variations in the composition of subduction-related magmatic rocks thought to reflect (1) a diminished effect of slab fluid in back-arc regions, and (2) progressive trenchward decline in HFSE and certain major element concentration , most notably ultradepleted compositions in the forearc regions (e.g.Taylor et. al., 1992; Taylor ve Nesbitt, 1992).

Mafic rocks dredged from modern bakc-arc basins either exhibit common N-MORB composition or a restricted combination of N-MORB and SSZ signatures. Back arc basin SSZ-type ophiolite material can apparently be produced only during arc-rifting and the initial stage of spreading (due to hydrated sub-arc lithosfer, boninites produced (Crawford, et. al., 1981). But the proportion of SSZ magma decreases and N-MORB compositions, with later predominant in the mature stage of back arc basin activity. Oceanic lithosfer formed during the mature stage of back arc basin evolution apperas to be indistinguishable from N-MORB ophiolites in terms of internal structure, lithology, and chemistry and contains few, if any, rocks with SSZ composition: thus mature back arc basins are probably not appropriate analogues for the generation of SSZ ophiolites (e.g Taylor 1995).

On the other hand, the igneous rocks recovered from the Izu-Bonin-Mariana (IBM) forearc are low-tholeiitic and boninitic basalts and related silisic differentiates, which carry SSZ geochemical signatures. Between the SSZ analogue regions of the IBM system, the forearc rocks are characterized by highly depleted HFSE and high concentration of LILE.

Petrological and geochemical investigation of the Middle Turonian-Early Santonian SSZ type CAO reveal broad chemical characteristics of low-K tholeiites and failed to find common rocks with N-MORB characteristics. In terms of immobile elements, CAO characterized by highly depleted HFSE relative to elevated LILE (Yalınız et al., 1996; Yalınız et al., 2000). These geochemical signatures are consisted with the interpretation that SSZ type CAO were generated in forearc setting rather than MORB and mature back arc basin. A major ocean basin spreading (MORB) or mature back arc basin seems unlikely.

Geochemical character and tectonic environment of the ophiolite related metamorphic rocks and their mafic dike swarms in the Pozanti-Karsanti Ophiolite: New age constraints on the metamorphic sole rocks and dike swarms

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Pozantı-Karsantı ophiolite (PKO) is located in the eastern part of the Taurus calcareous axis in Turkey. The metamorphic sole rocks in the Pozantı-Karsantı ophiolite have been observed along Küçükçakır, Ulupınar and Delialiuşağı villages.

Highly folded and faulted ophiolite related metamorphic rocks at the base of tectonites of the (PKO) present a thickness about 400-500m. The outcrops of these are the best exposures along the Tauride belt. The distribution of mineral parageneses in this unit define an inverted metamorphic zonation ranging from amphibolite facies to greenschist facies.

The metamorphic sole of the (PKO) consist of ortho-amphibolites at the top and meta-sedimentaries of para-origin at the base. At Ulupinar and Karadag the amphibolites at the top of the sole are tectonically conformable with the overlying mylonitized peridotites. Near the contact the foliation and lineation in the two units are parallel. The lower contact with the mélange unit is also tectonic.

The fold axis of the amphibolites varies between NW-SE and E-W. However, the dikes cutting the metamorphic sole rocks have a trend approximately between N 50 E and E-W. Outside the region of mafic dike swarms, some pyroxenite and albitite dyklets 10 and 30cm thick, also cut the metamorphic sole of the (PKO) around Bagboyundere and Ulupinar village. The pyroxenites have an igneous texture and look like the “static” mafic segregations. The geochemistry of the amphibolites show that they are derived from tholeiitic basalt and within plate basalt (Seamount). Namely, primitive mantle-normalized incompatible trace element diagram for amphibolites show close similaritiy to typical ocean island basalt (OIB) pattern. According to Rock/Chondrite normalized REE diagram, amphibolites are represented by OIB and IAT. Tectonomagmatic discrimination diagrams based on the immobile trace elements for the amphibolites suggest within plate alkali basalt (WPB) environment.

The dikes cutting the metamorphic sole are enriched in LILE and depleted in HFSE. However, enrichment of LILE, such as Th, relative to HFSE is indicative of subduction component. In addition flat -lying REE pattern of the dikes also confirm IAT the source. Tectonomagmatic discrimination diagrams for the dikes show that they developed in MORB and IAT environments.

Preliminary age determinations by the K/Ar method on hornblende give ages between 80 and 100Ma for the amphibolite facies metamorphism. This age could be thought the initial detachment of the oceanic crust, in the other way closure of the Neo-Tethyan ocean in the Eastern Mediterranean. However the dikes cutting the metamorphic sole yield ages between 65 and 75Ma.

Geochemistry of the volcanic rocks from the Pozantı-Karsantı ophiolite (S. Turkey)

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The Pozantı-Karsantı ophiolite (PKO), having a NE-SW trend and being offset from the Mersin ophiolite by the sinistral Ecemiş fault in the eastern Tauride belt (Aladağ region), is one of the best preserved oceanic lithosphere remnants of the Mesozoic Neotethys in southern Turkey. The eastern Tauride belt in southern Turkey comprises two major tectonostratigraphic units; these are the mid to late Cretaceous ophiolite related rock assemblages within the upper thrust sheet and the parautocthonous carbonate platform rocks ranging in age from the late Devonian to the early Cretaceous within the lower thrust sheet. The parautochthonous platform type carbonate rocks observed in the lower thrust sheet form the basement above which the PKO was tectonically obducted during the late Cretaceous. The upper thrust sheet in the Aladağ region comprises an ophiolitic mélange, a metamorphic sole and the PKO senso strictu. The contacts between these units are tectonic. The Upper Campanian-Maastrichtian unmetamorphosed ophiolitic melange is composed of a variety of igneous, metamorphic and sedimentary blocks structurally dispersed in a serpentinitic to pelitic matrix. The subophiolitic metamorphic rocks beneath the PKO exhibit a typical inverted metamorphic zonation from amphibolite to greenschist facies and are cut by approximately E-W trending isolated microgabbro-diabase dikes. The PKO is represented by a complete oceanic lithospheric section, including from bottom to top, harzburgitic to dunitic tectonites, ultramafic and mafic cumulates, isotropic gabbros, sheeted dike rocks and basaltic pillow lavas.

Two types of basaltic rocks have been observed in the PKO in terms of their petrographical and geochemical features. The first group contains normative quartz-hypersthene and classified as quartz-tholeiite. Whereas the second group contains normative olivine and classified as olivine tholeiite. The first group of volcanic rocks is represented by low concentrations of Cr (32-62 ppm), Ni (10-32 ppm), Nb (1-7 ppm), Ba (9-76 ppm), Sr (21-345 ppm) and high concentrations of TiO_2 (1.65-1.88 %), V (432-540 ppm). The second group is represented by high concentrations of Cr (39-199 ppm), Ni (32-86 ppm), Nb (5-18 ppm), Ba (39-444 ppm), Sr (149-410 ppm) and low concentrations of TiO_2 (1.13-1.63 %) and V (254-337 ppm) The chondrite normalized REE patterns of the first group is almost flat [$(La/Yb)_N$=0.95-1.01], identical and similar to the volcanics formed in a subduction-related environment in the eastern Mediterranean ophiolites. Whereas the second group exhibits more fractionated patterns [$(La/Yb)_N$=1.84-1.90] relative to the first group and indicate more enriched mantle source. Selected tectonomagmatic discrimination diagrams based on the immobile elements suggest that the first group was formed in a suprasubduction zone (SSZ) environment whereas the second group was formed in a back-arc basin tectonic setting.

Geotectonic Setting of Güneş (Divriği-Sivas) Ophiolite in Eastern Taurus, Turkey

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Güneş Ophiolite crops out in a large area between Divriği and Çetinkaya (Sivas). This study aims to determine the geological characteristics and to discuss geotectonic setting of Güneş Ophiolite in the regional context. This unit tectonically overlies Lower Carboniferous-Lower Campanian platform type carbonates and Lower Campanian ophiolitic melange containing metamorphic and limestone blocks in the serpentinized matrix. Tectonites, essentially consisting of serpentinized hartzburgite are observed at the base of Güneş Ophiolite in the Divriği area. Cumulate peridotites containing clinopyroxenite interlayers and dunite pods overlie tectonites. Pyroxenites are found as irregular segregations and lens forms. Layered gabbros overlie cumulate peridotites. Troctolites are observed at the bottom of layered gabbros, which essentially crops out near Çetinkaya. The isotropic gabbros are dominant elsewhere. Isole dyks are observed at the top of isotropic gabbros. These dyks are generally diabasic composition and increase upward in number and finally form sheeted dyk complex. This dyk complex is underlain by a thin pillow lava level. Güneş Ophiolite contains all units of complete ophiolitic suit except sedimantary sequence. The contacts of the units forming Güneş Ophiolite are faulted. For this reason, it can be defined as a dismembered ophiolitic suit. This assemblage is underlain by a volcano-sedimentary sequence containing conglomerate-sandstone-aglomerate and tuff alternations, some Maastrichtian limestone lenses and spilitic lavas and diabasic dykes. For this reason, it can be accepted that age of ophiolite emplacement is Campanian. Tertiary granitoids cut Güneş Ophiolite, ophiolitic melange and Maastrichtian aged volcano-sedimentary sequence. Tertiary sedimentary and volcanic rocks also overlie these units. Güneş Ophiolite which is located at the north of Taurus platform axis must be derived from northern branch of Neotehys rather than İnner Taurid Ocean. Because of that tectonic setting of Güneş Ophiolite, ophiolitic melange and Maastrichtian-Tertiary cover of the Divriği region are ressembling to that of Northern Anatolian Ophiolitic Belt.

From MORB to SSZ – the South Albanian Ophiolites and their Dinaric-Hellenic framework

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Within the eastern Mediterranean ophiolites the Albanian portion forms very well developed sections. They are part of the western ophiolitic belt, ranging from Croatia in the north to Greece in the south. Generally, the Albanian ophiolites are divided in a western and an eastern zone, where the former shows MORB and the latter SSZ signatures.

The ophiolite complex of Voskopoja is located in the southernmost part of the Albanian (Mirdita) ophiolites. Most of the ophiolitic mantle sections in the Voskopoja and neighbouring ophiolites contain lherzolite together with a subordinate amount of harzburgite and dunite. Wehrlites are common and form the majority of the ultramafic cumulates. Troctolites, metagabbros and olivinegabbros represent the mafic cumulates, clinopyroxene gabbros, occur in addition. Fragments of a sheeted dike complex are were found rarely. A volcanic section occurs.

Geochemical data of lavas of the Voskopoja massif indicate a relatively wide range of geochemistry intermediate between typical MORB and island arc tholeiites erupted in a SSZ environment. They can be grouped into four groups: a high Ni-group; a low Ni-group; a high Ti-Zr Group and a low Ti-Zr group. In the spider diagrams both the high and the low Ni groups are similar to MORBs, but often slightly depleted as observed in back arc basins. The high Ti-Zr basalts are significantly enriched, the low Ti-Zr group is markedly depleted.

Compared with other ophiolites in the Dinaric-Hellenic realm there is obviously a wide variety in lithology and geochemistry of the ophiolite. The geochemistry indicates a geochemical variation from MORB to SSZ tholeiites, not only between the eastern and the western zone, but also in a north-south direction along the main axis of the ophiolites on a regional scale.

Four different magmatic associations at the southern part of Yozgat, central Anatolia

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The granitic rocks at the southern part of Yozgat, Central Anatolia have been studied at the scale of 1/100.000 under a regional exploration project of Mineral Research and Exploration General Directorate (MTA). Four different magmatic associations have been differentiated in the field. From the oldest to the youngest the associations are represented by the leucogranites, the gabbro-monzonites, the granodiorite-granites and by the syenites.

The leucogranites, outcropped at the northwest, are coarse grained and mainly composed of quartz and alkali feldspar with some biotite, muscovite, and locally garnet. These rocks are characterized by the presence of rounded big quartz crystals. Penetration of some irregular basaltic magmatic phases near Yozgat and some gneissic texture near Salmanfakılı are observed within this unit. Several hundred meter thick aplitic stocks and several meter thick pegmatitic veins, which may be good to be used in ceramic industry, are the last products of the leucogranite association.

The gabbro, diorite, monzonite, porphyritic monzonite and porphyritic quartz monzonite show a normal magmatic zoning around Kerkenez Dağ. The zoning is not clear at the southwestern part of the association where magma mingling and lots of faults present. The gabbro is fine to medium grained and cut by complex and near vertical basic dykes. The phenocrysts of the porphyritic rocks are K-feldspars exceeding sometimes 5-6 cm in length. Uranium contents of the monzonite and quartz monzonite is anomalous, higher than 6 ppm and it is more than 10 ppm at Kerkenez Dağ in a 7-8 km square area.

The granodiorite-granite association occurs at the southern part of the studied area. Equigranular, medium grained size granodiorites are cut by porphyritic granites at Sivri Tepe. Fe and Cu skarns, polymetallic veins and Mo porphyries are all related to the granite-granodiorite association.

The syenites in the area are seen as dykes, smaller than 50 m and sometimes contain disseminated fluorite crystals. Similar to the gabbro-monzonite association the syenites also present between the other two associations and used the same deep fractures extending ENE-WSW direction.

It can be concluded that the leucogranites are related to the syn-collision granites and the granodiorite-granite to the volcanic arc granites. On the other hand the gabbro-monzonites and the syenite exhibit alkali character and rift style magmatism. Therefore, rifting prevailed before and after the subduction is thought to be responsible for the formation of the gabbro-monzonite and the syenites, respectively.

Unravelling ophiolite emplacement history with microfossils

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This study initially focuses on the age of tectonic emplacement of the Baer-Bassit ophiolite (NW Syria) onto the Arabian continental margin. Sedimentary samples have been taken from the platform carbonates tectonically beneath the ophiolite, and from the sedimentary cover sequences above. These samples have been analysed for their micropalaeontological content, primarily planktonic and larger benthic foraminifera. The dates obtained by analysis of the samples suggest emplacement during the Maastrichtian. It is hoped that further study will enable dating to within a single foraminiferal biozone/subzone and will yield some palaeoenvironmental data.

Geological-petrographical investigation of Mersin ophiolitic melange

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The aim of this study is to investigate geological and petrographical features of the Mersin ophiolitic melange.

The Mersin ophiolitic melange was formed as a result of the obduction of the ophiolite some time during late Cretaceous . It consists of various rock association such as fragments of the ophiolitic material, the sedimantary rock unıts limestone blocks and the magmatic comlex ranging in age from Devonian to late Cretaceous .The magmatic comlex is located between Gölbeleni and Çam tepe district in the north of Mersin city. Microscopic investigations show that this magmatic comlex is represented by diabase, spilite, tuff, diorite, granite and ceratophire. This rock association as a whole, was affected by greenschist to zeolite facies metamorphısm. K-Ar isotopic age determinations done by Parlak (1996) on the muscovites from granites yielded 350 ma (Devonian)

The ophiolitic melange is tectonically overlain by the ophiplitic slab Mersin ophiolite that contains , except sheeted dykes, all the units of an oceanic lithosphere. All the above mentioned units emplaced on the Tauride carbonates during late Cretaceous

The cover units in the Mersin area is Gildirli, Kaplankaya and Karaisalı formations This younger units are oligo-miocene in age.

PALAEONTOLOGY

Enigmatic Fossil Mammals from the Early Paleogene of Central Anatolia and their Biogeographic Significance

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Central Anatolia lies at the paleobiogeographic crossroads of Africa, Asia, and Europe but until recently almost nothing was known of its role in Paleogene vertebrate evolution. Since 1994, we have located over 50 vertebrate fossil localities in the Paleogene age Uzunçarsidere Formation in the northern Haymana Basin and the Paleogene continental redbeds of the Kizilcay Group in the western Beypazarı Basin. The Haymana Basin vertebrate fauna consists of fifteen mammalian species and remains of lizards, snakes, turtles, and crocodiles. Mammals and reptiles are also known from the less diverse Beypazarı Basin fauna. The Haymana Basin mammals include at least two marsupials, three new species of archaic ungulates, a possible proboscidean, and two representatives of the order Embrithopoda, an extinct group of large herbivorous mammals. However, despite its diversity, this central Anatolian fauna is a biogeographic puzzle. While some species (one of the marsupials, the embrithopods, and the proboscidean) suggest links to Africa, none shows close affinity to African taxa. Biogeographic links to Paleogene European faunas are even more tenuous, and, contrary to some previous biogeographic scenarios, none of the Turkish fossils resemble species from the increasingly well-known early and middle Eocene mammal faunas of Indo-Pakistan, central Asia, or eastern Asia. This suggests that the central Anatolian Paleogene mammalian fauna evolved in isolation from known contemporaneous faunas. Whether this evolution occurred as part of a previously unsampled endemic radiation, or whether the mammals dispersed to Anatolia from some as yet paleontologically unexplored Neo-Tethyan land mass remains to be seen.

The *Loftusia* species of Turkey

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The *Loftusia*, an index benthic foraminifera of Maastrichtian, is well known larger textulariid from the various localities of Middle East countries. The focus, here, is on the *Loftusia* data obtained from the Maastrichtian carbonate and clastic sediments in Turkey. Third main subjects have been critically reviewed and re-studied. The first is the species concept of the genus *Loftusia* which needs a revision. Up to now, 15 *Loftusia* species have been identified. Among these, 7 of them have been named from the Maastrcihtian of Turkey. The quantitative results from the Malatya and Adıyaman regions indicate that some of the *Loftusia* species should be emended. Although *Loftusia morgani* has been only known from microspheric forms (B forms) in the previous literature, co-occurrences of *Loftusia anatolica*, *L. matsumarui*, *L. baykali* and *L. morgani* show that *Loftusia morgani* should have both megalospheric forms (A forms) and microspheric forms (B forms). The second point is biofabric and fossilization process of fusiform type larger benthic foraminifera. In-situ, para-autocthonous, residual and reworked *Loftusia* assemblages from the different parts of Turkey allow us to understand better the sedimentalogical history of fusiform type larger foraminifera. The fossilization observations include re-working physical activity, filling material and chemical changes related to dolomitization. The third main subject is on the age, distribution and changes in time and place in the views of fauna association, the stratigraphical sections from the different localities of Turkey.

Cuisian Orthophragminae assemblages (*Discocyclina*, *Orbitoclypeus* and *Nemkovella*) from Haymana-Polatlı basin (central Turkey)

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Paleocene-early Lutetian sedimentary succession of Haymana-Polatlı basin (central Anatolia- Turkey) comprises extremely fossiliferous shallow-water units. Some sections of this succession were formerly proposed to serve as reference-sections for early Thanetian - early Lutetian shallow benthic zones (SBZ), realised in the frame of integrated zonation of Tethyan Paleogene. Çayraz Formation representing the uppermost unit of Haymana-Polatlı basin is a thick, shallow-marine clastic-carbonate unit known by its diverse assemblages of nummulitid, alveolinid and orthophragminid foraminifera. This unit that is regarded as ranging in age from Cuisian to early Lutetian, was studied for its orthophragminae in its type-locality. Cuisian orthophragminae (shallow benthic zones 10-11/12?) identified for the first time in Anatolian material from the lower part of Çayraz Formation revealed diverse assemblages of Discocyclina, Orbitoclypeus, Nemkovella and partly Asterocyclina, typical for Tethyan deposits. A sequence of populations of Discocyclina, Orbitoclypeus and Nemkovella has been subjected to biometric analysis of the embryo and equatorial chamberlets. A comparison of biometric data with those assemblages previously introduced from other Tethyan Cuisian localities mainly in Europea and Crimea is also made.

Ilerdian-early Cuisian orthophragminae from the Haymana-Polatlı Basin succession (central Anatolia-Turkey)

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An extremely fossiliferous shallow- water succession in central Anatolia, proposed to be a reference-section for Ilerdian- early Cuisian (shallow benthic zones 9 and 10) by 'Early Paleogene working group' (IGCP n. 286) was sampled to study its orthophragminae. Different developmental stages of *Discocyclina*, *Orbitoclypeus*, *Nemkovella* and *Asterocyclina* have been identified. The lower part of the succession contains only *Discocyclina* and *Orbitoclypeus* specimens, whereas, upper part considered to be early Cuisian in age contains a diverse assemblage of orthophragmina represented by Discocyclina, *Orbitoclypeus*, *Nemkovella* and *Asterocyclina*. The biometric features of the identified foraminifera introduced in numerous equatorial sections for the first time from Anatolian material are also documented.

Micropaleontological significance of the foraminiferal fauna recorded from the Jurassic of Antalya nappes (Çataltepe unit), western Taurus, southern Turkey

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The study area is in the western part of Murtiçi (Antalya, Western Taurus) where most important tectonic units comprise the Alanya and Antalya nappes. Two stratigraphic sections have been measured in the Mesozoic limestones and clastics of the Çataltepe unit of the Antalya nappes and sections are located close to the tectonic contact of Antalya and Alanya nappes in the region.

In measured sections, the Triassic Kasımlar Formation consists of red-green shales, claystones and siltstones, intercalated with sandstones with plant debris and limestones. No detailed paleontological investigation has been carried out on this formation. The Jurassic Karasay Formation, basically represented by carbonate facies, is characterized by shallow to open marine deposits containing resedimented material transported from the platform margin into the depositional area.

Micropaleontological studies revealed several foraminiferes among which 3 are probably new taxa. *Mesoendothyra croatica* (Aalenian-Bajocian) and *Protopeneroplis striata* (Bajocian-Kimmeridgian) biozones are established in the Karasay Formation. Based on these zones, the age of the measured stratigraphic section covering an important part of the Karasay Formation ranges at least from Aalenian to Kimmeridgian. Levels without fossils are attributed questionably to Liassic and post-Kimmeridgian ages in the Jurassic. *Protopeneroplis striata* and the new taxa are analyzed taxonomically and compared with those reported from previous studies in Taurides and Pontids.

A hardground from the Upper Cretaceous Beydağları Carbonate Platform, Korkuteli area (Western Taurides)

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The Upper Cretaceous Beydağları carbonate platform exemplifies important sedimentary breaks and facies changes related to the evolution and drowning of the platform in the Korkuteli area of western Taurides. Beydağları formation forms the base of the Upper Cretaceous sequence and is made up of neritic and hemipelagic limestones. Neritic part of the formation accumulated in a peritidal environment that prevailed from Cenomanian to Early Santonian and forms an approximately 600 m thick sequence. The sequence includes two rudistid levels, which corresponds to the Cenomanian and Early Santonian. The benthonic foraminifera fauna accompanying the rudist fauna is rich in number but poor in diversity indicative of a restricted environment. Slight drowning of the platform after Early Santonian, yielded a hemipelagic environment that would last to the end of the Santonian and caused deposition of massive, 15 m thick hemipelagic limestones that form the uppermost part of the Beydağları formation. These limestones include a planktonic foraminifera fauna accompanied by abundant calcispheres that suggest a Santonian age.

Transgressive Akdağ formation consists of thin bedded, pelagic, cherty limestones and disconformably overlies the different stratigraphic levels of the Beydağları formation. The formation is approximately 75 m thick and characterized by a rich planktonic foraminifera fauna suggesting a Late Campanian-Middle Maastrictian age. Paleogene Garipçe formation composed of planktonic foraminifera bearing pelagic marls and disconformably or unconformably lies over the erosional surface that cuts the different stratigraphic levels of the Beydağları and Akdağ formations.

The hardground with bioturbation and crust of iron oxide formed at the end of Santonian because of relative starvation, separates hemipelagic limestones of the Beydağları formation and the pelagic limestones of the Akdağ formation. In some localities hardground and the limestones of the Beydağları formation eroded because of subaerial exposure during post Santonian regression. The second and more effective regression took place after Middle Maastrichtian because of regional compression and short-term major sea-level fall and erosion reached to the neritic limestones of the Beydağları formation.

Palynological Investigations of the Seyitömer Coals

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The coal seams and intercalated fine clastic layers of the Seyitömer Basin are examined palynologically. Palynomorphs encountered in the samples are included in 9 spore, 48 pollen, 9 fungal spore, and 3 *Incertae Sedis* taxa.

The overall palynomorph assemblage is characterized by the frequent occurrences of *Laevigatosporites haardti, Ulmipollenites undulosus, Inaperturopollenites hiatus, Triatriopollenites coryphaeus-bituitus, Tricolporopollenites cingulum, Tricolpopollenites henrici* and *Pityosporites* spp., and by the rare occurrences of *Subtriporopollenites simplex, Pterocaryapollenites stellatus, Cyrillaceaepollenites exactus, Monoporopollenites polygonalis* and *Tricolporopollenites microreticulatus*.

This assemblage sugg-ests a Lower-Middle Miocene (15-20 Ma) age for the coal-bearing Seyitömer deposits. Palynological analyses also showed that the coal-forming flora was rich in subtropical forest taxa together with some riparian and hill-side forest elements.

Palynostratigraphic correlation of coal bearing Eocene sediments between Çorum-Amasya and Yozgat (Çankırı-Çorum Basin, Central Anatolia - Turkey)

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The lignite bearing Eocene sediments of Yozgat and Çorum-Amasya areas were palynologically examined. Between Çorum-Amasya and Yozgat, the sedimentary fill in the Middle Eocene-Pleistocene age consists of three rock successions separated by angular unconformities. The Middle Eocene-Oligocene lowermost succession can be divided into two parts. In the western part of the basin, the Middle–Late Eocene lower part comprise three formations such as, the Hacıhalil formation (delta-lagoon conglomerates and sandstones intercalation with coal seams), the Yoncalı formation (shallow to deep marine sandstone, shales and limestone lenses) and the Bayat formation (subaerial lavas and pyroclastic rocks) grade laterally and vertically into each other. Similarly in the eastern parts of the basin, the Yuvala formation (alluvial fan conglomerates, sandstones and mudstone), Çeltek formation (fluvial-lacustrin sandstone, claystone and marl), Armutlu formation (shallow to deep marine sandstone, shales and limestone lenses) and Narlı formation (subaerial lavas and pyroclastic rocks) grade laterally and vertically into each other as well. The Late Eocene-Oligocene upper part gradually overlies the lower part and consists of two formations. The İncik formation (terrestrial conglomerates and sandstones) grades laterally and vertically into Bayındır formation (lacustrine laminated marls, sandstones, limestones, gypsum intercalations). Osmanoğlu formation is only observed in the north-west of Amasya and unconformably overlies the Armutlu formation. The Middle Eocene-Oligocene succession is in turn overlain unconformably by the continental deposites of the Middle-Late Miocene Kızılırmak and Bozkır formations and alluvial deposits of Pleistocene.

Studying of the samples collected from coal and bituminous shale horizons of the Hacıhalil, Yoncalı, Çeltek, Armutlu and Osmanoğlu formations yields a Middle-?Late Eocene age for the HacihaliL, Yoncalı, Armutlu, Çeltek, and Early Oligocene age for Osmanoğlu formation. The coal seams and shales of the Yoncalı and Armutlu formations were deposited in swamps between the channels of a deltaic environment under the moist tropical climatic conditions. The Hacıhalil and Çeltek formations were formed in swamps of flood plain and shallow lakes under tropical climatic conditions.

Based on the stratigraphic, sedimentologic features and the palynologic data, the Yoncalı and Armutlu formations are stratigraphically submarine equivalents of the terrestrial the Yuvala, Hacıhalil and Çeltek formations.

Early Paleogene Orthophragminae from central Anatolia (Turkey)

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Late Paleocene- Eocene sedimentary succession of Haymana-Polatlı basin (central Anatolia- Turkey) comprises extremely fossiliferous shallow-water marine units. Some sections of this succession were formerly proposed to serve as reference-sections or key-localities for early Thanetian, Ilerdian, Cuisian and early Lutetian Shallow Bentic Zones. Orthophragminae, which occur abundantly in these sections were studied in oriented sections, considering the qualitative and quantitative aspects of megalospheric embryo and morphologic elements of equatorial and lateral chamberlets in equatorial and partly vertical sections. Thanetian, orthophragminid foraminifera, closely associated with Assilina yvettae, Operculina heberti *and* Glomalveolina *spp. is represented by* Discocyclina seunesi, Orbitoclypeus neumannae, Discocyclina *sp.1 and new species of* Orbitoclypeus*;* Orbitoclypeus haymanaensis *n. spp*. D. archaici bakhchisaraiensis- D. archaici staroseliensis *and* Orbitoclypeus suvlukayensis *assemblage was identified from Ilerdian reference-section. Cuisian marks the increase in abundance and diversity of orthophragminae.* Discocyclina augustae, Discocyclina trabayensis, Discocyclina 'dispansa', Discocyclina 'archiaci', Discocyclina fortisii, Discocyclina 'stratiemanuelis', Nemkovella fermonti, Nemkovella evae, Orbitoclypeus douvillei, Orbitoclypeus *sp.1 (*Orbitoclypeus portnayae*),* Orbitoclypeus suvlukayensis, Orbitoclypeus munieri *were identified from Cuisian strata. A new Discocyclinid taxon;* D. fortisii çayrazi *n. spp. is described from the upper part of Cuisian section. The biometric data for the recognition of orthophragminae is also presented.*

Paleoecological interpretation of Oligo-Miocene sediments based on the palynological data (Southwest molasse basins, Denizli Province, Turkey)

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This study deals with climatic conditions and vegetation based upon palynological data through the Oligocene and Early Miocene in the SW Molasse Basins. Three different sporomorph assemblages which belong to the Early Oligocene, Late Oligocene and Early Miocene are indicated here. The Early Oligocene sediments which are known as an Acıgöl group are present north of the Çardak and Dazkırı towns. The Late Oligocene and Early Miocene sediments belong to Denizli and Kale-Tavas Molasse Basins. Kale-Tavas Molasse Basin is distinguished at three areas which are namely Yemişendere, Kale and Tavas. Only Tavas area doesn't include Early Miocene sporomorph assemblage.

During the Oligo - Miocene period, the vegetation includes freshwater aquatic members, swamp forest, riparian elements and upland flora. The Early Oligocene vegetation is represented dominantly by swamp forest and upland flora. Swamp forest comprises *Myrica, Nyssa, Taxodium,* Cyrillaceae and Araliaceae. Upland flora consists of *Tilia, Podocarpus, Castanae, Abies, Quercus, Carpinus, Acer,* and Hamamelidaceae. Riparian elements and freshwater aquatic members represent a few species. These are *Spargania, Aglaoeridia cyclops, Pterocarya, Carya* and *Alnus*. The Late Oligocene vegetation dominantly contains swamp forest and riparian elements. But upland flora and freshwater aquatic members are depicted by restricted species. The Miocene vegetation composes mainly of swamp forest.

Climatic conditions through the Oligocene and Early Miocene are mainly subtropical. The Early Oligocene flora comprises paleotropical species such as Schizaeacea, Myritaceae, Santalaceae and Elaeagnaceae. But paleotropical elements disappears in the Late Oligocene. Because of this, the Early Oligocene flora indicates drier subtropical climate than the Late Oligocene. Moreover the late Oligocene flora defines wetter conditions than the Lower Miocene flora due to the abundance of Polypodiaceae and *Calamus* species.

Recent ostracoda fauna of the Mersin Gulf; Southern Turkey

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In this study ostracodes have been examined in 12 bottom samples collected from 3 different localities (Karaduvar front, Mersin Port, Pozcu front) from east to west in the Mersin Gulf, southern Turkey. 2 sub-ordo, 3 super family, 19 family, 10 sub-family, 37 genera and 62 species have been identified in actuel ostracodes.

Considering the abundance numbers obtained by counting the ostracoda covers and the environment factor 2 communities, which are *Costa edwardsii* (Roemer)-*Cytherois fischeri* (Sars) and *Argilloecia conoidea* (Sars) are determined.

In the *Costa edwardsii* (Roemer)-*Cytherois fischeri* (Sars) community the most dominant species is *Costa edwardsii* (Roemer). *Cytherois fischeri* (Sars), *Microcytherura* sp., *Cushmanidea elongata* (Brady), *Semicytherura sulcata* (Müller) compose the other abundant genus and species in decreasing abundance of order.

Additionally, rare species which are limited in number are also present together with the dominant species in this community.*Cytheridea acuminata acuminata* Bosquet, *Neocytherideis cylindrica* (Brady), *Acanthocythereis hystrix* (Reuss), *Carinocythereis antiquata* (Baird) species are less abundant. *Cytherella vandenboldi* Sissingh, *Leptocythere porcellanea* (Brady), *Cyprideis torosa* (Jones), *Cyprideis seminulum* (Reuss) species are much less abundant and *Bosquetina carinella* (Reuss), *Cytheretta adriatica* Ruggieri, *Loculicytheretta pavonia* (Brady) compose some of the rare genera and species.

In the *Argilloecia conoidea* (Sars) community the most dominant species is *Argilloecia conoidea* (Sars). *Costa edwardsii* (Roemer), *Cytherois fischeri* (Sars), *Microcytherura* sp., *Carinocythereis antiquata* (Baird) and *Acanthocythereis hystrix* (Reuss) compose the other abundant species in decreasing abundance of order.

Also in this community there are abundant species such as *Cytherella vandenboldi* Sissingh, *Carinocythereis carinata* (Roemer), *Cytheridea acuminata acuminata* Bosquet, *Cytheridea acuminata neapolitana* Kollmann, *Xestoleberis communis* Müller; less abundant species such as *Leptocythere porcellanea* (Brady), *Loxoconcha granulata* Sars, *Loxoconcha agilis* Ruggieri, *Semicytherura acuticostata* (Sars), *Xestoleberis decipiens*; much less abundant and rare genera and species such as, *Cyprideis torosa* (Jones), *Heterocythereis albomaculata* (Baird), *Paracytheridea depressa* (Müller), *Cyprideis seminulum* (Reuss), *Callistocythere mediterranea* (Müller), *Hirschmannia viridis* (Müller), *Aglaiocypris complanata* Brady-Robertson are present together with other dominant species.

The dominant species commonly present in this two ostracoda communities namely *Acanthocythereis*, *Costa* are characteristics of neritic; *Microcytherur*a, *Cushmanidea*, *Carinocythereis*, *Cytherois* are characteristics of epi-neritic; *Semicytherura* is brackish, littoral-epineritic and *Argilloecia* is characteristics of infraneritic-bathyal environment.

Ostracodes which characterize marine, brackish, littoral and lacustrine environments are found mixed up together in some samples collected from the gulf. This can be explained by the fresh water flows coming from the land side or present in the sea floor.

Miocene Corals of Ermenek Regions (Central Taurus-Karaman, Turkey)

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This study is the first detailed systematic investigation of the corral the results of which aids to solve the stratigraphic problems of marine Miocene sediments in Konya-Ermenek region. According to determined *Tarbellastraca reussiana, Tarbellastraca raulini, Heliastraca tchihatcheffi, Parites collegniana, Favites neglecta, Plesiastraca desmoulinsi* and *Caulastraea* sp., *Stylophora* sp. genus and species the age of this units is of Upper Burdigalian-Langhian.

Fossil communities of selected patch reefs in Middle Miocene Mut Formation (Mut-İçel/ Turkey)

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Typical patch reefs are common within the Mut formation that exposes in Mut (İÇEL) and surrounding areas. These reefal limestones of Mut formation and intercalated claystone-clayey limestone-marl of Köselerli formation transgressively and unconformably overlie the Burdigalian stream–lake deposits of Derinçay formation, Fakırca formation and Upper Cretaceous limestones and ophiolities. The sedimentary rocks of Mut and Köselerli formations are unconformably overlain by Tortonian reefal limestones of Tırtar formation and intercalated argillaceous limestone-marl of Ballı formation.

The patch reefs form present day topographical rises at Kızıldağ hill, Kızılkaya hill, Ardıçlı hill, Elmedin hill and etc. similar to pre-existing relief in the depositional environment. Five typical patch reefs were chosen to study. In these reefs, three main reef facies are recognized. These are; 1) Reef base facies (packstone with abundant pelecypod and echinoid); 2) Reef core facies (bindstone-framestone with coral, red alga, bryozoa and grainstone-packstone-wackestone with red alga that fill space between the framestone-bindstone); and 3) Reef sealing facies (wackestone with red alga and packstone-grainstone with abundant intraclast and echinid). The most important factor controlling the patch reef development is sea level fluctuation.

Reef organisms are separated into two groups due to their effects on the reef development. 1) Wave resistant organisms that build up reef frame or core and topographical rise at the sea bottom. These are corals, red algae and bryozoans 2) The organisms, their skeleton parts and carbonate products are form the reef flank deposits and fill the space between reef frame; These are alga, mollusca, bryozoa, benthic and planktic foraminifera.

The fossil contents of patch reefs in the Mut formation are given below:

<u>Benthic foraminifer</u>: *Peneroplis evolutus HENSON, Peneroplis* cf. *thomasi HENSON, Peneroplis* cf. *forsensis HENSON, Gyroida* cf. *subangulata (PLUMMER), Borelis* cf. *melo (REICHEL), Idalina* aff. *sinjarica GRIMSDALE, Archaias kirkukensis HENSON, Praerhapydionina* cf. *huberi HENSON, Delheidia hayderiei DOUVILLE, Peneroplis* sp., *Operculina* sp., *Rotalia* sp., *Planorbulina* sp., *Neoalveolina* sp., *Quinqueloculina* sp., *Triloculina* sp., *Textularia* sp., *Pentelline* sp., *Nodosaria* sp., *Gyroidina* sp., *Anomalina* sp., *Opthalmidium* sp.

<u>Planktik foraminifer</u>: *Acarinina broedermanni (CUSHMAN ve BERMUDEZ), Globigerinatheka* sp.

<u>Algae</u>: *Mesophyllum* cf. *guamense JOHNSON, Amphiroa propria (LEMOINE), Corallina* cf. *abundans LEMOINE, Lithothamnium* sp., *Lithophyllum* sp., *Archaeolithathamnium* sp., *Jania* sp., *Halimeda* sp.

<u>Corals</u>: *Dendrophyllia* cf. *candelabrum HENNIG, Litharaeopsis subepithe cata (OPPENHEIM), Porites* sp., *Favosites* sp.

Others: Annelid, Bryozoa, Pelecypod, Echinoid, Gastropod and Ostracod.

Miocene stratigraphy of Antalya Basin based on molluscan fauna, Western Taurids, SW Turkey

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In this study, 8 measured sections have been taken from the Miocene deposits richin Molluscan fauna in Antalya Basin. This Molluscan fauna were obtained from the Oymapınar limestone, Altınkaya formation and Aksu formation.

Oymapınar limestone unconformably overlies the older units including terrestrial Sevinç conglomerate, Alanya and Antalya Nappes. This formation includes Upper Burdigalian (=Karpatian) marine taxa as *Chlamys (Aequipecten) scabrella bollenensis* (Mayer), *Pecten fuschi* Fontannés, *Acanthocardia (Acanthocardia) turonica* Mayer, *Cardiocardita* cf. *monilifera* (Dujardin), *Venus (Ventricoloidea) multilamella* (Lamarck), *Athleta ficulina* (Lamarck) which are known both from Mediterranean Tethys and Central Paratethys realms.

Altınkaya formation which is described for the first time in this study is exposed in the central part of the basin and it has lagoonar and partly marine characteristics. Following fauna indicates the Upper Burdigalian- Langhian = Karpatian – Lower Badenian age for this formation: *Triphora adeversa miocenica* Cossmann and Peyrot, *Cerithium (Thericium) pseudotiarella* (d'Orbigny), *Turritella (Turritella) turris* Basterot, *Tinostoma woodi* (Hoernes), *Neritina picta* (Férussac), *Hydrobia (Hydrobia) frauenfeldi fraunfeldi* (Hoernes), *Pirenella gamlitzensis gamlitzensis* (Hilber), *Terebralia subcorrugata* d'Orbigny, *Irus (Paphirus) gregarius* Partsch, *Crassostrea gryphoides* (Schlotheim). This fauna has characteristics of low salinity (brackish- marine) environment and wellknown both from Mediterranean Tethys and Central Paratethys regions. Especially three of them (*Hydrobia (Hydrobia) frauenfeldi fraunfeldi* (Hoernes), *Pirenella gamlitzensis gamlitzensis* (Hilber), *Irus (Paphirus) gregarius* Partsc) could be only found in Central Paratethys. In addition this fauna, two new species (*Alvania ispartaensis* n.sp., *Alvania tanerae* n.sp.) were described in Altınkaya formation.

Aksu formation which is cropped out in the western part of the basin, again unconformably overlies the older units. It includes the Mediterranean originated taxa representing normal marine salinity conditions such as *Gibbula (Gibbula) magus* (Linné), *Strombus (Strombus) bonellii* Brongniart, *Xenophora infundibulum* (Brocchi), *Cypraea (Bernaya) fabagina mioporcellus* Sacco, *Gibberulina (Gibberulina) philippi* (Monterosato), *Charonia stefaninii* (Monterosato) and one new species: *Voluta erentoezae* n.sp. The age of this formation is early Tortonian based on this fauna.

BIOSTRATIGRAPHY AND PALAEONTOLOGY

Stratigraphy and Trace Fossil Assemblages of the Lower Cambrian Succession in the Sandıklı Region, Southwestern Turkey

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In the Afyon-Sandıklı region, the trilobite-bearing Middle Cambrian rock units unconformable cover the Kocayayla Group which is considered to be Infracambrian in the previous studies. The Kocayayla Group is divided into the Celiloğlu Formation, Göğebakan Formation, Kestel Çayı Volcanics and Taşoluk Formation in ascending order. The trace fossils in the Kocayayla Group are found in the Celiloğlu Formation and in a transitional interval from Celiloğlu and Göğebakan Formations, and indicate the Early Cambrian age.

The Kocayayla Group, which is more than 3000 m in thickness, starts at the base with the Celiloğlu Formation composed of quartzite with phyllites. The quartzite beds of the Celiloğlu Formation include cross-stratification and bioturbations. The Celiloğlu Formation is conformably overlain by mudstones with mafic volcanic rocks of the Göğebakan Formation. This unit vertically and laterally interfingers with the Kestel Çayı Volcanics, which is composed of felsic volcanic rocks, volcanic sandstones and mudstones. The felsic rocks of the Kestel Çayı Volcanics are represented by rhyolite and hyaloclastites which have been previously named as Sandıklı porphyroids. They were extruded in a shallow sea and formed volcanic piles that emerged above the sea level and was eroded to form channel-fill conglomerates. Along this laterally discontinuous channel conglomerates the Kestel Çayı Volcanics changes upward into quartzite and phyllite succession of the Taşoluk Formation.

The trace fossils in the Kocayayla Group are produced by trilobites, suspension feeding annelids and deposit-feeding “worms”, probably polychaetes. In the Kocayayla area, in the Celiloğlu Formation and the transitional zone between Celiloğlu and Göğebakan Formations the trace fossils of *Cruziana* isp., *Rusophycos* isp., *Phycodes* isp., ?*Treptichnus* isp., *Planolites* isp., *Diplichnites* isp., *Cruziana* isp., *Arenicolites* isp., and *Skolithos* isp. have been determined. In the Taşoluk area, *Skolithos* isp. has been found in the Celiloğlu Formation. These trace fossils indicate that the age of the Celiloğlu Formation is the Tommotian (Early Cambrian).

Rusophycos, *Cruziana*, *Phycodes*, *Treptichnus*, *Diplichnites* represent the *Cruziana* ichnofacies, which is typical of subtidal, poorly sorted and soft substrates, from moderate energy to low energy environments between the fairweather and storm wave base. *Arenicolites* can occur in the proximal *Cruziana* ichnofacies in the lower shoreface settings. The transition interval from the Celiloğlu Formation to the mudstones of the Göğebakan Formation belong rather to the proximal *Cruziana* ichnofacies, representing lower shoreface. The Taşoluk section bears abundant *Skolithos* isp. and represents the *Skolithos* ichnofacies, which is typical of high energy environments with loose sandy, well sorted to slightly muddy substrates in intertidal to shallow subtidal zones.

Dating of the Huğlu tuffite based on the radiolarian fauna, Huğlu unit (Beyşehir-Hoyran nappes), Central Taurides, Turkey

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Radiolarian fauna of the Huğlu Tuffite within the Huğlu Unit is studied in detail from the Hacıyunuslar Measured Section close to Bozkır Town. Huğlu unit, in general, is made up of tuff and basic volcanics with subordinate intercalations of Radiolaria bearing limestones and shales at the base (Huğlu Tuffite) and pelagic limestones with chert nodules (Huğlu Limestone) at the top (Monod, 1977).

Huğlu Tuffite in Hacıyunuslar Measured Section is mainly characterized by an alternation of green to brown tuffs, tuffites and basic volcanics with limestone intercalations. The limestone intercalations at the base of the Huğlu Tuffites are mainly red to reddish brown, thin to medium bedded and contain moderately preserved but diverse Radiolarians. Towards to upper part, rare limestone intercalations present in the tuff-tuffite-basic volcanic beds. The limestone intercalations at the upper part of the Huğlu Tuffites are mainly grey-pale grey-beige, thin to medium bedded with many filaments and calcified Radiolarians.

Radiolarian assemblages obtained from the limestone intercalations at the base of the Huğlu Tuffites in this section indicate the middle Carnian age based on the following fauna: *Tetraporobrachia haeckeli*, *Kahlerosphaera longispinosa*, *Dumitricasphaera simplex*, *Divatella austriaca*, *Weverella tetrabrachiata aspinosa*, *Triassocrucella baloghi*, *Heliosaturnalis transitus*, *Palaeosaturnalis hugluensis*, *Veghicyclia austrica*, *Spongosaturnaloides multidentatus*, *Picapora robusta* and *Spinotriassocampe carnica* (Tekin, 1999). Due to high calcification, no Radiolarians are obtained from the upper part of the Huglu Tuffites in the section. But conodonts (*Paragondolella polygnatiformis noah* and *Gladigondolella* sp.) obtained from one of the limestone intercalations at the top of the Huğlu Tuffites also indicate a middle Carnian age.

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Borings from a Miocene rocky shore in the Mut Basin, Southern Turkey

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Cretaceous limestones from the basement of Neogene Mut Basin are strongly bored in a locality NE of Mut. The bored surface is very uneven, with several small cliffs. The borings include clionid sponge borings Entobia ispp., bivalve borings Gastrochaenolites topedo and G. lapidicus, and the polychaete boring Caulostrepsis taeniola. G. torpedo occur exclusively in steep surfaces. Most probably, it was produced the bivalve Lithopaga lithophaga, which is common in the recent Mediterranean Sea, no deeper than 10 m, mostly above 1 m. This bivalve is very intolerant of sediments, and therefore it colonizes steep surfaces. Producers of G. lapiducus and C. taeniola were more tolerant of sediments, and they colonized less steep surfaces. The cross-cutting relationships prove that C. taeniola colonised the substrate earlier than G. lapiducus. Entobia ispp. occur alone cross cut the other borings on different surfaces. Most probably, their producers lived in deeper water and overprinted the other borings during progressing transgression. The intensive bioerosion indicates long (several years) exposition of rocks on the Miocene shore.

The oyster shells, which occur locally at the lowermost part of the Miocene deposits, are also intensively bored, mostly by Entobia and small Gastrochaenolites. The external side of their shells is more intensively bored than the internal side, probably because the oysters have been infested by boring organisms already during their life.

The boring assemblage does not represent one community, but several communities overprinted during migration of shoreline. In general, occurrences of it indicate very shallow turbulent, well-oxygenated waters, especially in the case of. G. torpedo. Potentially, the borings can be used for determination of course of rocky coast and several local parameters of palaeoenvironment.

New age determinations for the Palaeogene Continental Succession North of Ankara, central Anatolia, Turkey

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Palaeogene deposits occur in central Anatolia and are well known in the areas of Haymana-Polatlı, Tuzgölü, Çankırı-Çorum, Orhaniye-Güvenç and Nallıhan. These continental sequences are composed predominantly of red conglomerates, sandstones and mudstones but are locally replaced by or intercalated with shallow marine sediments and evaporites. The overall thickness varies from 450 to 2500 m and these units are separated into many lithostratigraphic units with names that differ from place to place. The underlying late Cretaceous flysches and overlying Lutetian marine carbonates are two key regional formations used to assign a Palaeogene age to these deposits even though marine intercalations at Haymana-Polatlı offer potential for a more precise age determination. The scarcity of fossils and/or lack of detailed prospecting within these continental units has also contributed to the uncertainty of their age. We present the results of our investigations of the Orhaniye-Guvenc Palaeogene sediments near Ankara. The continental succession consists of coarse-grained alluvial-fan deposits, interbedded locally with volcanoclastics, which pass to braided and meandering river sediments and finally to lacustrine marls. The latter sediments pinch out toward the southeast and pass laterally into lacustrine limestones toward the west. We have discovered the remains of mammals, reptiles and turtles in the middle part of alluvial-fan and fluvial sediments that represent a typical Eocene assemblage. In addition, a tuff layer within the fluvial sequence that is about 35 m below the lacustrine marls is dated at 45.7±0.3 Ma. Based on this combination of facies development, biostratigraphic, and radiometric data, we suggest that the Orhaniye-Güvenç portion of the continental Palaeogene succession in central Anatolian formed during the early Middle Eocene only to be later terminated by the regional Lutetian transgression.

Revision of the litho- and bio-stratigraphy of the Oligo-Miocene sequences in the northern central part of the Sivas Basin, Turkey

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The litho- and bio-stratigraphy of the Oligo-Miocene sequences of the Sivas basin have been revised on the basis of planktic and benthonic foraminifera, mollusc, charophyt, pollen analysis, nannoplankton and ostracods. Both marine and continental deposits have been investigated.

From north to south the Miocene paleo-environments are successively: (1) open marine shelf (planktic marls of Sivas); (2) fringing reefs with corals and red algae (Taşli Tepe reef and İşhani algal limestones); (3) subsiding lagoon (Bingöl marls and clastics, and Fadlun resedimented gypsum).

During the Oligocene the open marine deposits were also localized along the northern margin of the Sivas basin (Sivas marls). Further to the south, two contrasting contemporaneous sequences were deposited: massive gypsum (Hafik formation) and fluvio-lacustrine/marine for a part, conglomerates (Karayün formation).

As a result, the litho-stratigraphic sequences vary considerably from north to south and a single synthetic litostratigraphic columnar section can not be given for the whole Sivas basin. As an example, the western part of the basin, in the Gemerek area, is characterized by a completely continental sequence from Oligocene up to Pliocene. İt is also the case for the southern margin of the basin, to the south of the Tecer Dag, at the border of the Kangal basin. Contrarily,the eastern part of the basin is characterized by thicker marine sequences and was connected to open marine, in direction of the East Mediterranean basin (by the way of a N-S coridor), and possibly also with the Caspian-Black Sea basin.

Recent tectonics (northwestward post-Early Pliocene thrusting), have considerably modified the previous paleogeographies. They mask the Oligocene syn-sedimentary faulting and the angular unconformity which underlines the Oligo-Miocene boundary.

Planktic foraminiferal biostratigraphy of the Neogene Sequence in the Adana Basin and their correlation with standard biozones

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The aim of this study is to describe the biostratigraphical, chronostratigraphical and ecostratigraphical relationships of the Neogene sequence in the Adana Basin

The Adana Basin is located in southern Turkey and is bordered by the Tauride Orogenic Belt in the north, the Amanos Mountains to the east, the Mediterranean coast in the south and the Ecemiş Fault Zone in the west. From base to top the Neogene sequence consists of the Karsanti formation (fluvio-lacustrine and lagoonal), the Gildirli formation (continental redbeds), the shallow marine Kaplankaya formation, the reefal limestones of the Karaisalı formation, the shales of the Güvenç formation (slope to deep marine), a thick submarine fan complex (Cingöz formation), the shallow marine and fluvio-deltaic Kuzgun formation and the shallow marine- lagoonal-continental Handere formation.

The planktic foraminiferal biozones identified within the Neogene sequence of the Adana Basin are *Globigerinoides trilobus* and *Praeorbulina glomerosa curva* (Burdigalian); *Globorotalia fohsi peripheroronda/Orbulina suturalis* (Langhian); *Globorotalia mayeri* (Serravallian). The Tortonian is characterized by the first occurrences of *Globorotalia suterae*. There is a non-distinctive zone in the Messinian, and the Pliocene is represented by the *Sphaeroidinellopsis* Acme Zone.

Foraminiferal biostratigraphy of Seske and Kırkgeçit formations, Elazığ-Turkey

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In this study, biostratigraphic characteristics of the Upper Paleocene-Lower Eocene Seske Formation and Middle Eocene Kırkgeçit Formation were investigated in the Elazığ area. 35 planktic foraminifera species and 23 benthic foraminifera species were identified. 8 planktic and 8 benthic foraminifera zones were defined in the sedimentary rock and washing samples were taken from the measured stratigraphic sections in the study area. These are; in the Upper Paleocene (Thanetian) *Planorotalites pseudomenardii* and *Morozovella velascoensis* zones, in the Lower Eocene (Ilerdian-Cuisian) *Morozovella edgari, Morozovella subbotina, Morozovella formosa formosa, Morozovella aragonensis* and *Acarinina pentacamerata* zones and in the Middle Eocene (Lutetian-Barthonian) *Acarinina bullbroki* zones. (Planktic foraminifera zones). According to benthic foraminifera species; *Coskinon rajkae, Assilina yvettae, Idalina sinjarica, Cuvillierina vallensis, Discocyclina archiaci archiaci, Asterocyclina alticostata gallica, Asterocyclina stellata stellata and Nummulites perforatus* zones.

Flora and climate of South-east of the greater Caucasus during Cretaceous period (according to palynological data)

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Research on study of flora and vegetation during the late Cretaceous period is carried out by different paleobotanic methods. Palynological method gives a full idea of flora development, its quality changes. Interesting data permitting to observe successive change of some floras by other ones, has been obtained as a result of palynological study of sections of Dibrar mountain and Takhta-Yailag nomad camp. There are three sporo-pollinic complexes, characterizing flora during three periods of the late Cretaceous. The first sporo-pollinic complex has been defined in Cenomanian clays of Dibrar mountain, where spores of mosses and pterido-spermaphytes prevail over pollen of holosperms and angiosperms. Florisitic analysis of palinocomplex allowed to recognize groups of vegetation characterizing Cenomanian period. the extensive of moss, lycopods, dendrite ferns, quercus, castanea in forests with high humidity shows the warm and humid climate. The second and third sporo-pollinic complexes have been defined among clayey samples of Campanian and Maastricht deposits of Takhta-yailag nomad area. Dendrite ferns and grassy plants are mainly spread in humid tropic forests being prevailing in forest assemblages of Campanian. Conifers-pine-tree, cedar are the main forest-forming rocks and are able to plant under different climatic conditions. Broad-leaved mesophyllous rocks are in content of angiosperm plants, they can widely be found in tropics and subtropics. They are inhabitants of arid climate. Climate was changing from humid to arid during Campanian period.

Due to intensive development of angiosperms flora of participation of ferns was reduced in content of phytocolnosis in forests of Maastricht period. The participation of Ulmaceae, Myricaceae, Fagaceae, Junglandaceae in content of phytocoenosis shows xerophile subtropic nature of vegetation during Maastricht period. Climate becomes arid during Maastrichtian. Analysis of palynological material shows that vegetation of Cenomanian period when spore plants were prevailing developed under conditions of warm and humid climate and is typical for Mesozoic flora. Campanian period is characterized by change of humid and arid climatic conditions, it is due to existence of plant assemblages typical for early periods of late Cretaceous and appearance of Ulmus, Myrica, Betula pollen shows subtropical form of flora close to Maastricht period. Maastricht flora can be characterized by subtropical vegetation developed during arid climate and it is close to Cenozoic flora.

Calcareous nannoplankton zonation of Upper Cretaceous deposits of minor Caucasus and their correlation with different parts of the world

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Upper Cretaceous calcareous nannophossils were studied from Minor Caucasus with the help of light and electrone microscope. The investigatigation of calcareous nannoplankton revealed eleven coccolith assemblages stratigraphically ranging from Cenomanian to Maastrichtian, which made possible to mark the same number of coccolith zones. Among them, three zones have local importance and defined for the first time, eight zones were suggested by different authors of the world. Cenomanian deposits are spread in central part of Minor Caucasus. Lithologically, they consist of clays, argillites, sandstones, tuffs and limestones. By nannofossils, two zones are marked: lower zone with Lithraphidites alatus, upper zone with Gartnerago obliquum.Turonian deposits have restricted distribution in Minor Caucasus.They develope mainly in the Central part and in Araz zone. Lithologically these deposits consist of argillites, sandstones, marls, tuffs, conglomerates. Two zones are marked in Turonian :Microrhabdulus decoratus lower zone and Lithastrinus grilli upper zone. Each one corresponds to substage by volumes. Coniacian deposits are comparatively greatly distributed in Minor Caucasus. Lithologically, this stage consists of clays, sandstones, marls, tuffs, limestones. Two zones are defined in Coniacian by nannoplankton: Rucinolithus hayi lower and Marthasterites furcatus upper zone. Santonian stage is not yet divided by nannofossils, one zone is defined in it, Cribrosphaerella arkhangelskii-Ahmuellerella mirabilis zone. Campanian deposits are wide-spread within Somkhit-Agdam and Araz zones and represented mainly in carbonate facies, lying in conformity with Santonian deposits. Two zones are marked in these deposits: Arkhangelskiella specillata lower zone and Broinsonia parca upper zone. Maastrichtian sediments are developed mainly in Somkhit-Agdam, Araz tectonic zones and consist of limestones with some admixture of terrigene material. Two zones are defined in this stage by nannofossils: Lithraphidites quadratus lower zone; Nephrolithus frequens and Tetralithus murus-upper zone. Defined zones based on calcareous nannoplankton are well correlated with the same age zones from different parts of the world (France, Italy, Georgia. Crimea, Indian, Pacific oceans etc).This demonstrates that calcareous nannofossils can be used in establishing regional and interregional correlations.

A biostratigraphy of the Central part of Achara-Trialetian Folded Zone by Nannoplankton

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The nannoplankton from different facies sediments of Paleocene and Eocene of the central part of Achara-Trialetian folded zone is investigated. 16 biostratigraphic units-zones and subzones are established. It has enabled to specify an age and volume of lithostratigraphic divisions within the limits of Borjomi flysch and volcanogenic formations of the given region. The scheme developed by I. Gamkrelidze and G. Lobjanidze (1984) was chosen as initial lithostratigraphic scheme. The variegated suite here is represented by zones *Cruciplacolithus tenuis-Fasciculithus tympaniformis* of Danian-Montian stages. In subsuites of the Borjomi flysch suite the following complexes are established: Dabiskhevi-zones *Heliolithus kleinpellii - Discoaster multiradiatus*; Rveli - subzone *Tribrachiatus contortus* and the lowermost part of the subzone *Discoaster binodosus*; Kvibisi-upper part of the subzone *Discoaster binodosus* and zone *Tribrachiatus orthostylus*; Tsophiani-zone *Discoaster lodoensis*. In volcanogenic formations following suites are identified: Likani-zone *Discoaster sublodoensis* and lower part of the subzone *Discoaster strictus* of the zone *Nannotetrina fulgens*; Kvabiskhevi-upper part of the subzone *Discoaster strictus* and subzone *Chiasmolithus gigas*; Dviri-subzone *Cruciplacolithus staurion* of the zone *Nannotetrina fulgens* and zone *Discoaster bifax*.

Upper Barremian-Lower Aptian (Cretaceous) Biostratigraphy of Georgia and Adjacent Regions and its implication for global biostratigraphical zonation

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Among the eastern Mediterranean regions (Georgia, Turkey, Azerbaijan, Armenia, Iran,Turkmenistan, etc.) the ammonite biostratigraphical subdivision of the Upper Barremian deposits most completely is provided in Georgia. Tha data of this region have to be considered as one of basic for correlation of Upper Barremian deposits of Mediterranean regions. As to biostratigraphy of Lower Aptian of eastern Mediterranean regions, first of all the data of Turkmenistan (Bogdanova, 1978, 1983) should be taken into account.

The Upper Barremian zonal scheme of Georgia consists of 6 biostratigraphical units; these are zones – Ancyloceras vandenheckii, Heinzia sartousiana, Hemihoplites soulieri, Imerites giraudi, Colchisites securiformis and horizon Pseudocrioceras waagenoides. Noted zones are well characterized by zonal ammonite complexes and established in many sections of Western Georgia and their biostratigraphical interpretations are already published (Kakabadze, Kotetishvili, 1995). Hence, a detailed account of these zones is omitted here and only problems of uppermost of Barremian and lowermost of Aptian biostratigraphy and correlation are considered. The uppermost Barremian horizon Pseudocrioceras waagenoides is well traced above the deposites of zone Colchidites securiformis in many sections of Western Georgia. However, its upper boundary with the lowermost Aptian horizon Acrioceras sp. is unclear, because in the latter the guide zonal fossils are not found. In Tvishi section (type section of Upper Barremian in Georgia) from this level are found Acrioceras cf. furcata d'Orb., Costidiscus cf. recticostatus d'Orb., Pseudocrioceras sp., but in the upward following beds there are typical ammonite complex of Lower Aptian zone Deshayesites weissi. The horizon Pseudocrioceras waagenoides established in Georgia (Kakabadze, Kotetishvili, 1995) is regarded as equuivalent of the Turkmeniceras turkmenicum zone of Turkmenistan (Tovbina, 1963) and of the Pseudocrioceras waageni subzone of SE France (Cecca, Ropolo & Gonnet, 1998). As to horizon Acrioceras sp. of Georgia, it correlates with lowermost Aptian zone Deshayesites tuarkyricus of Turkmenistan and SE France.

Correlation of the Upper Barremian-Lower Aptian zonal schemes of SE France, Georgia and Turkmenistan shows that the data of Georgia play one of the general role in process of integration of global biostratigraphical zonation.

BASINS IN SOUTHERN TURKEY

Tertiary basin formation on the North African plate margin in NW Syria: Implications for the collisional processes in the Eastern Mediterranean region

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The NE margin of the African plate in the Lattakia region of NW Syria has an important bearing on the closure and collisional history of Tethys in the E Mediterranean region. This study focuses on the Tertiary of the Lattakia Basin including sedimentation, biochronology, structure and regional tectonics. Three Tertiary megasequences are identified: 1. Late Maastrichtian-Mid Eocene; 2. Miocene; 3. Messinian-Late Pliocene.

Megasequences 1 was initiated by Late Maastrichtian marine transgression over recently emplaced Baer-Bassit ophiolitic rocks and melange. Water depths increased, giving rise to Palaeocene hemipelagic carbonate deposition, rich in planktonic foraminifera, on a deeply submerged shelf (nannofossil studies by Dan Howard of UCL). Nummulite-rich carbonates accumulated on a shallower shelf during Early-Mid Eocene time. Siliceous accumulation is reflected in common diagenetic chert formation. Shallowing, coupled with tectonic instability, then emergence, was followed by a Late Eocene-Oligocene hiatus. Mega-sequence 2 began with Early Miocene pelagic carbonate deposition, with an increasing input of basin margin-derived high-density turbidites and debris flows in Mid-Miocene time. Localised reverse faulting/thrusting was then followed by megasequence 3, beginning with accumulation of mainly laminated gypsum during the Messinian salinity crisis. This was followed by Pliocene shallow-marine open-shelf muddy sedimentation, shallowing up by Upper Pliocene to marls and bioclastic carbonates. Quaternary time was marked by uplift, marine and continental terracing and erosion.

The Al-Lattakia -Killis fault zone is recognised as a long-lived lineament that strongly controlled sedimentation and structuration within successive Tertiary basins. Rifting (transtensional?) influenced the Miocene basin, followed by Late Miocene basin inversion (transpressional?). The Al-Lattakia –Killis fault zone links southwestwards with the S Cyprus active margin and northeastwards with the Dead Sea Transform Fault and thus forms an important segment of the Africa-Eurasia plate boundary.

Mesozoic sedimentary and magmatic evolution of the Arabian continental margin in Northern Syria

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Aside from Oman, the only detailed record of Mesozoic deep-water sedimentation and volcanism preserved along the tectonically emplaced Arabian continental margin is from the Baer-Bassit region of northern Syria. South-Tethyan units there occur as blocks and disrupted thrust sheets within a tectonic melange (Bear-Bassit Melange), locally interleaved with ophiolitic rocks. During this study we carried out detailed mapping and measured 17 lithological logs, supplemented by facies analysis, petrographic, mineralogical and geochemical studies. Two rock associations are present, one comprising mainly sedimentary successions ranging from Late Triassic-Late Cretaceous (Cenomanian) age, the other comprising an assemblage of Upper Triassic and Middle Jurassic - Early Cretaceous alkaline/per-alkaline volcanics and minor intrusives, intercalated with radiolarian sediments and capped by ferromanganese-rich pelagic limestones of Cenomanian age. Facies comparisons suggest the Triassic-Cenomanian mainly sedimentary succession originated along the base of slope of a carbonate platform constructed on continental crust, presumably the Arabia to the south. The volcanogenic succession developed in a more distal setting some distance out onto the south-Tethys ocean. Regional comparisons (SW Cyprus, SW Turkey) suggest that continental break-up to form a south-Tethyan oceanic basin took place in Late Triassic time. Alkaline volcanism of Late Triassic and Middle Jurassic to Early Cretaceous age may reflect activity of a mantle plume that was episodically active beneath the Arabian plate. The sedimentary successions were mainly controlled by an interplay of post-rift thermal subsidence, plume-related uplift, oceanographic siliceous productivity events, climatic change on land and eustatic sea-level change. The south-Tethyan margin/ocean units in northern Syria were detached from their basement (oceanic?) and emplaced onto the Arabian platform during Middle Maastrichtian time.

Depositional geometries and facies of Lower and Middle Miocene carbonate and mixed carbonate/siliciclastic systems in the Mut Basin of South Central Turkey

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The Mut basin, located in south central Turkey, shows exceptional three dimensional exposures of a rich variety of depositional geometries in a carbonate dominated succession of approximately 800 meter thickness of Lower and Middle Miocene age. This basin, that covers an area of about 80 by 100 kilometers, has been the subject of a number of high resolution sequence stratigraphic studies over the last four years of which the results are summarised in this paper. The main themes addressed are: 1) the relationship between depositional geometries and sedimentary facies, 2) the variation of the sedimentation pattern in different depositional environments in the same basin, and 3) the relative influence of tectonism, eustatism and climate on the sedimentation pattern.

The complex relict topography of the Mut basin was flooded during the Miocene by a rapid marine transgression, when it was connected with the open sea (the Neotethys) through a small seaway in the Silifke area. In the Lower Miocene (Burdigalian) succession three different depositional environments have been studied: a backstepping carbonate dominated margin, a backstepping mixed carbonate/siliciclastic margin, and the infill of the seaway. High resolution sequence stratigraphic analysis (3rd, 4th and 5th order) in combination with nannofossil dating, provides the time framework within which these three sites can be compared. The main controlling factor on the sedimentation pattern are fluctuations in relative sea level, but depositional geometries, texture and lithology are demonstrated to be extremely variable and are strongly controlled by local siliciclastic influx, paleotopography, and ecological change.

In the Middle Miocene (Langhian) of the Ermenek region a three dimensionally exposed aggrading and prograding platform-margin (250 meter thick and 2 kilometer long) has been studied. The well preserved depositional geometries allow to define depositional sequences based on volumetric partitioning. Transgressive hemicycles (4th order) show isopacheous geometries, and regressive hemicycles are sigmoidal shaped. This interpretation is confirmed by the facies distribution (deeper water facies in the isopachous, and shallower water facies in the sigmoids). An overall evolution of the ecosystem has been observed with a more grainy ramp type system dominated by red algae, oysters and benthic forams (foramol) in the lower part, and a platform type morphology with a fauna dominated by corals and porcelaneous forams (Miliolids and Alveolinids) and a generally more muddy lagoonal facies in the upper part.

A case of basin analysis and water flow through extensive jointing and various fault-joint geometric/genetic relationships in the Beer Sheva syncline, Israel

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Extended research over two decades reveals more than twenty distinct fracture episodes in the Beer Sheva syncline. The Eocene sediments in the syncline are divided into four units according to stratigraphic-fracture criteria. In addition, jointing is grouped into four: Burial, syntectonic, uplift and post-uplift that are unequally distributed among the four units. A variety of fault-joint systems that differ from each other in their geometric/genetic relationship further complicates the fracture network. Water drainage may be considerably improved along certain fault-joint systems. Accordingly, the particular distribution of fault-joint domains and their properties throughout the wider joint distribution need to be taken into consideration in formulating the fracture network models of the "basin".

Timing and Causes of Tertiary Deformation in the Çukurova Basin Complex, Southern Turkey: New seismic-sequence stratigraphic interpretations

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The Çukurova Basin Complex is one of the larger Neogene basin of southern Turkey. This basin complex, comprises the Adana and İskenderun sub-basins which are separated by the Misis Complex Structural High. The investigated area limited by major sinistral Ecemiş Fault to the west, Eastern Anatolian Fault Zone to the east and Tauride belt to the north. The macro deformation patterns seen in outcrop and in the seismic profiles indicate that the deformed Tertiary fill sequence gained its character in response to both orogene collapse following crustal thickening during subductive accretion of the Alanya-Cyprus block and also continental convergence and collision of the Afro-Arabian plates against the Taurides. The main Çukurova Basin was initiated after the thrust emplacement of ofiolitic complex and associated mélange in the Taurides to the north of the area. A widespread early Miocene phase of rapid extensional subsidence, manifest in the Misis Complex, accompanied by rapid marine invasion both to the north (Adana) and to the south (İskenderun) and everywhere followed by gradual filling and shoaling of the basin during the mid-to late Miocene. Late Miocene deformation (post Tortonian) is prominent in the Misis Complex Structural High area which coupled with continued fault-controlled subsidence in the adjacent gently folded Adana and İskenderun sub-basins and the evidence for minor compressive deformation in these troughs may result from the switch to general transpression following continental collision further to the east and consequent tectonic escape of Anatolia. However, this late Tortonian deformation is only weakly developed elsewhere in the Çukurova Basin Complex.

Integrating the seismic profiles, basically three mega-sequences and two main mega-sequence boundaries can be described. The first megasequence is partly coincident with the early Miocene rifting event and it comprises reefs and fore-back reef sediments that have grown on fault footwall crests. Following this, faulting and rapid subsidence generated an underfilled basin which was then passively infilled by highstand sequence of late Burdigalian-late Serravalian age turbiditic and basin plain sediments showing aggradational character of megasequence “2”. Structural analysis in the NE margin of the investigated area supports the seismic interpretation that this phase of deformation involved extension in approximately N-S or NNE-SSE directions. The distinct onlap and aggredational sequence of the passive infill result from major subsidence during early-mid Miocene. Further extensional faulting took place after the deposition of the Megasequence “2”. The third megasequence is represented by unconformably overlying lowstand sequence of Tortonian-Messinian age fluvial-deltaic and shallow water sediments showing localized progradational sequences. In early Tortonian, the basin fill are marked by uplift and/or sea level changes and followed by extensive erosion.

Following that, further minor extensional faulting took place after magasequence “3” was deposited.

Analysis of a Relict Miocene Basin High in the Taurus Mountains (NE Aladag): New Insights Regarding the Palaeogeography of the Adana Basin, SE Turkey

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Dikme Basin, a Miocene area at top of the Aladag Mountains (Eastern Taurides), consists mainly of coarse-grained continental sediments of various facies. These Early-Middle Miocene sediments were studied here from the viewpoint of depositional environments and the factors controlling the basin formation and basin fill architecture. A generally southeast flowing axial fluvial system and interfingered coarse-grained marginal alluvial clastics from NW and SE were figured out. The marginal facies at the NW is bounded by a N 55 E running structural lineament, that starts from the Ecemis Fault Zone and traces in the field, in digital elevation models and in satellite images up to north of the study area. Throughout its trace, the Miocene sediments onlap the steep fault scarps, certain Miocene levels are tectonically disrupted, and an intraformational unconformity and boulder conglomerates were developed in the Miocene sequence. The SE boundary is similarly defined by a NE trending fault that rised episodically the SE margin, the Tufanbeyli autochtone, producing coarse clastics from this area. This boundary fault also resulted in the fining upwards vertical patterns and synsedimentary deformations in the marginal facies. Additionally, the central part of the basin exhibits a distinct fault-defined morphology that characterized by small-scale (10’s to 150 meters high) valley-and-sill topography. A thin and unique marine interval was also encountered at the southernmost part, signalling that the clastic system originated around of the investigation area debouched to Miocene sea situated in the further south. The proposed palaeogeography and basin fill model suggests that the Dikme basin constitutes the northernmost part of the Adana basin, and is controlled mainly by a NE running fault system.

The Nature and Setting of Miocene Alluvial Fans feeding a Sand-rich Submarine Fan system (northern Adana Basin, southern Turkey)

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The fluvial-alluvial Gildirli Formation is the oldest Miocene unit in the northern Adana Basin and rests discordantly on tectonically deformed Paleozoic and Mesozoic basement rocks. Its present areal extent (about 10 km^2) is limited to a narrow zone located between Nergizlik and Gildirli villages, 10-15 km north of Karaisalı, Adana province. This formation is predominantly composed of red continental clastics (mostly channelised conglomerates, sandstones and mudstones). Proceeding from east to west a distinct change in the composition of the component detritus can be observed. A close examination of the system indicates that at least two different source areas existed in this area before the main Miocene marine transgression. One alluvial system, occupying the northern and eastern parts (Gildirli area), was fed by streams draining an area in which ophiolitic melange and older carbonates were exposed, while another system occupied the western and northwestern parts (north of Nergizlik) and was fed mainly by debris flows from a hinterland dominated by carbonate rocks. These alluvial units occupy steep-sided valleys incised into Mesozoic carbonates. The coarse alluvial sediments gradually onlapped on to the steep sides of these palaeovalleys but display none of the tectonic deformation seen in the underlying units. These terrestrial fan systems also can be traced downstream into the proximal sector of a submarine canyon feeding a relatively small, sand-rich deep-water fan which was deposited in bathyal marine conditions further to the east-southeast, and which has been termed by previous researchers the Western Fan or Karayer Fan.

Microcontinent collision processes: closure of Neotethys as recorded by the Ulukışla Basin (South Central Turkey)

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Incipient collisional processes in many orogens remain poorly understood. The Eastern Mediterranean includes zones of "soft collision" which preserve evidence of early collisional processes. One such is the Lower Tertiary Ulukışla Basin (120 km north of Adana), which lies along a proposed oceanic suture zone (Inner Tauride Ocean) and regionally reflects closure of a northerly Neotethyan oceanic basin.

The Ulukışla Basin overlies an ophiolite mélange (Alihoca mélange) between the Bolkar (Tauride) Block to the south and the Niğde-Kırşehir Block to the north. From the Maastrichtian to the end of the Eocene the stratigraphy records phases of transgression, subsidence, volcanism, evaporite deposition and uplift. Subsidence curves for the Ulukışla Basin show marked deviation from the recognised trends of strike-slip or foreland basins, but are consistent with an extensional basin that was terminated by uplift.

The Ulukışla Basin includes a thick succession (c.2 km) of Upper Palaeocene-Lower Eocene basaltic to andesitic submarine pillow lavas, lava flows, volcaniclastics and intercalated limestones. This profuse volcanism distinguishes the Ulukışla basin from other Lower Tertiary basins in central Anatolia and suggests an unusual tectonic setting. Whole-rock XRF chemical analysis indicates a within plate-origin, with a marked subduction signature (e.g. Nb depletion).

The stratigraphically related Ulukışla Basin in the south, Tuzgölü Basin to the west and Sarkışla Basin to the east all border the Niğde-Kırşehir Block. These Early Tertiary marine sedimentary basins developed during a period of regional plate convergence beginning with latest Cretaceous ophiolite emplacement and ending with deformation, emergence and onset of Oligo-Miocene non-marine deposition. According to Görür et al. (1998) "no reliable evolutionary tectonic model for this region has been formulated". Our work indicates that the Ulukışla Basin records a relatively simple history of Early Tertiary extension, culminating in volcanism, followed in turn by regional compression and uplift. We propose that the Ulukışla and adjacent basins reflect diachronous collisions of irregularly shaped converging continental margins and microcontinents during a prolonged period of "soft collision". The Ulukışla Basin could represent a localised pull-apart basin generated in response to palaeo-rotation of the Niğde-Kırşehir Block and bounded to the east by strike-slip along a precursor Ecemiş Fault Zone.

Reference

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Chaotic Sedimentation in the Ulukışla Basin (south- central Anatolia)

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The Ulukışla Basin is an important element within the Central Anatolian Basin complex and is located between the Niğde Massif and the Bolkar Mountains. Marine sedimentation began here in the Late Cretaceous (Campanian), depositing units that discordantly succeed ophiolitic melange in the area south of Çiftehan. Subsequently, important sea level changes have controlled sedimentation in this region. Thus the Paleocene also rests unconformably on ophiolitic melange near Halkapınar, indicating further modification of the Basin geometry and the beginning of a new transgression. Volcanic activity accompanied the sedimentation, especially during the Paleocene. Periods of volcanic quiescence were marked by carbonate sedimentation. The Middle Eocene marks another important transgression which was much more extensive than the previous marine invasions. The Paleocene and Eocene sequences in the area between Pozantı and Ereğli are dominated by episodes of chaotic sedimentation during which huge blocks of Paleocene carbonates and ophiolitic slices slid down from the margins of the basin. Evaporites also were formed in the Eocene, marking the end of marine deposition in the Ulukışla region. An important phase of structural deformation then isolated this basin from marine influence and activity on the Ecemiş Fault also may have been initiated at this time. This event was followed by continental sedimentation which was dominantly lacustrine at the beginning and later became fluvial in character. The relations between the lacustrine and fluvial sediments indicate that some tectonic deformation continued even after the Middle Eocene. Taking into account the present elevations of the marine Eocene sediments found on the Kırşehir Massif and on the Bolkar Mountains, the latter must have been uplifted by at least 2000 metres since the Middle Eocene.

Facies architecture and depositional evolution of alluvial fan-fan delta complexes in the tectonically active Miocene Köprüçay Basin, Isparta Angle, Turkey

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The facies architecture and depositional environment of the Miocene infill of the Köprüçay Basin is studied and interpreted to evaluate the basin formation and deformation. The Köprüçay Basin is an elongated N-S trough opening and deepening southward to the present Antalya Bay and bounded by a right-lateral strike slip fault (Kırkkavak Fault) along its eastern side. The sedimentary infill of the basin is characterised by two distinct sets of axially and transversally derived Alluvial Fan-Fan Delta (AF-FD) complexes: the Kesme and the Selge AF-FD complexes.

The Kesme AF-FD complex is an axially derived depositional system that originated from a source area to the north. It is characterised by a set of facies associations representing an evolution from Colluvial Fan through Alluvial Fan to Fan-Delta that prograded into a shallow marine setting interbedded with fault generated limestone breccias, in time and space. Colluvial Fans are represented by gravity to mass flow induced limestone breccias. Alluvial Fans are characterised by debris flow to stream flow conglomerates. Fan-Deltas are mostly made up of subaqueous debris flow originated and wave reworked conglomerates which contain scattered patch reefs. These conglomerates pass, vertically and laterally to turbiditic sandstones and mudstones.

The Selge AF-FD complex is a transversally derived depositional system that originated from a source area to the west. As in the Kesme AF-FD complex a few kilometres thick Fan-Delta system with its continental and shallow marine originated conglomerates interbedded with ostrea bearing lagoonal mudstones-sandstones and patch reefs is present here.

A precise distinction between the conglomerates and breccias of different origin and the sedimentological processes involved makes possible accurate paleogeographic reconstructions and emphasises the strong tectonic asymmetry of the basin.

Sedimentological evolution of the southern part of the Darende-Balaban Basin (Yenice Darende area, Malatya, eastern Turkey)

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The study area is located to the northwest of Malatya, in the southern part of the Darende-Balaban Basin, which is flanked to north and south by structural highs comprising Upper Jurassic-Lower Cretaceous limestones. The basin fill is represented by an Upper Cretaceous to Eocene succession which rests discordantly on ophiolitic and carbonate rocks of the Tauride basement. This study focussed on the southern margin of this basin, between the villages of Yenice and Aşağı Ulupınar.

In this area, the southern margin of the basin is characterised by inter-fingering of continental and shallow marine sediments during the Late Cretaceous and early Eocene. These are represented within the Tohma, Ulupınar and Kırankaya formations of the Upper Cretaceous (total maximum thickness of 850 meters), discordantly succeeded by the Korgantepe, Yenice, Asartepe, Balaban and Darende formations of the Eocene (total maximum thickness of 1295 meters)

Sedimentological logs have been measured from the Ulupınar to Darende succession in order to determine the vertical and lateral variability of these formations. Around 37 samples also were collected to examine their petrographical and palaeontological properties.

As a result of these studies the sedimentary and paleoenvironmental evolution of this area can be summarised as follows: Basin sedimentation started with marine transgression in the Late Cretaceous, resulting in the reefal carbonates of the Tohma Formation. These pass up into coastal plain and shallow marine (Ulupınar Fm.). A second transgressive phase in latest Cretaceous times is represented by the calcarenites (offshore lime sands) of the Kırankaya Fm. The succeeding discordance marks a hiatus in sedimentation (probably caused by gentle uplift) until the Early Eocene, when the coastal plain sediments of the Korgantepe Fm. were laid down, mainly in palaeotopographic depressions that are locally cut into the underlying Upper Cretaceous rocks. During the Lutetian a third marine transgressive cycle is marked by the shallow marine carbonates and marls with minor siliciclastic inputs of the Yenice Fm., the reefal limestones of the Asartepe and finally the shallow marine deposits (mainly represented by calcarenites, sandstones, siltstones and marl intercalations with some evaporitic occurrences) of the Balaban and Darende formations. Petrographical data from siliciclastic sediments demonstrates that the main sediment supply throughout this time interval was from ophiolitic and older carbonate sources that presently are exposed to the south of this basin. All data confirm that the basin sedimentation was largely controlled by local tectonics, that were responsible for the major transgressive and regressive cycles within the basin.

Onlap features of Eocene carbonates in the vicinity of Akcadağ (Malatya, eastern Turkey)

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Onlap relationships of Eocene carbonates on to Tauride basement can be readily examined in cliff sections to the west of Akcadağ, Malatya. Here Lutetian carbonates discordantly overlie crystalline limestones of Late Jurassic-Early Cretaceous age. The Lutetian limestones pass upwards, over several tens of metres, into marls with fine grained sandstone intercalations and finally are discordantly overlain by Miocene rocks, which are mainly represented by limestones. The spectacularly developed onlap features at the base of the Eocene help to elucidate the sequence stratigraphy of the local basin-fill. Moreover, the geometry of the onlap contacts and other characteristics of the Lutetian demonstrate the excellent potential reservoir properties of these rocks in the subsurface.

Four detailed sedimentological logs have been measured through the onlap sequences to determine the lateral and vertical variations within the Lutetian carbonates. In addition, around 30 samples were collected to examine petrographical and paleontological properties of these limestones. All these data demonstrate that the Eocene carbonates were formed under marginal marine conditions in which corals, algae and other frame-building organisms flourished, creating low-relief build-ups, subject to local reworking into carbonate shoals, within an upwards-deepening (transgressive) setting. These carbonates were deposited in relatively nearshore settings that locally were isolated from the strong siliciclastic inputs that characterise other parts of this basin during the Lutetian.

Sedimentary characteristics of the Hüdai Formation (Early Cambrian) within the Aydıncık (İçel) area, Southern Turkey

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The study area is located in Aydıncık (İçel) area where Early Cambrian rocks are represented by the Hüdai Formation. The formation represents three different parts in the vertical sequence, which has a thickness of approximately 830 metres. The basal part of the formation consists of a rhythmic alternation of horizontal laminated sandstone, ripple trough cross-laminated sandstone, mixed sandstone-shale, and rarely metashales. The middle part comprises dominantly metashales. The upper part is made up by an alternation of horizontal laminated sandstone, mixed sandstone-shale and rarely metashales. Vertical variations in the formation is caused by marine transgressious and regressious, and by fluctuations in sediment supply. Lower to middle parts of the formation characterize a fining upward sequence, and middle to upper parts display a coarsening-upward sequence.

In the Hüdai formation, four lithofacies are recognized based on lithology and sedimentary structures. These are (1) horizontal laminated sandstone (predominantly quartzarenite) indicating deposition from tidal currents during the high velocity phases of tidal cycles; (2) ripple cross-laminated sandstone (predominantly quartzwacke) deposited in lower part of intertidal (sand-flat) environment; (3) mixed sandstone-shale revealing deposition in mid-intertidal flat environment; and (4) shale (or metashale) deposited mainly in upper intertidal (mudflat) environment.

Sedimentology of Liassic Carbonates (Pirencik Tepe Measured Section) within the Aydıncık (İçel) area, Southern Turkey

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The Liassic carbonates are widespread in the Aydıncık (İçel) area. There, they are represented by the Dibekli member of the Cehennemdere Formation (Jurassic to Early Cretaceous). Seven lithofacies have been delineated in the Pirencik Tepe (hill) measured stratigraphic section. Its thickness is approximately 489 m. The Facies are: (1) Dolomite (supratidal environment), (2) Algal laminated limestone (intertidal environment), (3) Intraformational conglomerate (dominantly subtidal environment), (4) Megalodont-*Orbitopsella* bearing micrite (shallow subtidal environment), (5) Gastropod bearing micrite (restricted subtidal environment), (6) Mudstone/micrite (restricted shallow subtidal environment), and (7) Oolite-intraclast bearing micrite/sparite (high energy intertidal environment).

From base to top, the Pirencik Tepe measured stratigraphic section consists of predominantly dolomite, algal laminated limestone, and cyclic carbonates which are composed of intraformational conglomerate, Megalodont-*Orbitopsella* bearing micrite, and algal laminated limestone. Among cyclic carbonates, gastropod bearing micrite and mudstone are irregularly present. The upper most portion of the section is oolite-intraclast bearing micrite/sparite. In overall, the Liassic carbonate sequence characterizes a deepening upward sequence in contrast to each cycle in the cyclicity.

Sedimentary characteristics of Dağpazarı patch reef (Middle Miocene) (Mut-İçel/Turkey)

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This study aims to determine sedimentary characteristics of the Dağpazarı patch reef which is situated at 13 km north of Mut (İçel) town in the Central Taurides. Middle Miocene time in the Mut Basin is represented by the Mut formation and Köselerli formation. The Mut formation is composed of by reefal limestones. However, the Köselerli formation is made up by claystone, argillaceous limestone and marl. Both formations interfinger with each other. In the Mut formation, patchy carbonate buildups such as Dağpazarı reef are abundant. The patchy carbonate buildups recently form topographical rises similar to pre-existing relief in the depositional environment.

Dağpazarı patch reef seems to be in a gently dome-shape. The reef is approxiamately 15 meters thick, 500 meters long and 200 meters wide. In the Dağpazarı patch reef, five lithofacies have been delineated based on the reef geometry. These lithofacies are: (1) reef-bottom facies: dominantly packstone, and also wackestone with red alga, pelecypod and echinoid; (2) reef-core facies: mainly framestone-bindstone with in situ reef forming organism such as coral and red alga, wackestone is also present including gastropod and pelecypod; (3) fore-reef flank facies: showing well bedding and subdivided into two subfacies as inner flank subfacies (packstone-wackstone with red alga, intraclast and planktic foraminifera, and also including carbonate debris derived from the reef-core such as coral fragments) and outer flank subfacies comprising an alternation of argillaceous limestone and shale with planktic foraminifera; (4) back-reef flank facies: illustrating well bedding and consisting of packstone-wackestone with red alga, intraclast and foraminifera; and (5) reef-sealing facies: packstone-grainstone with red alga, echinoid and intraclast.

The Dağpazarı patch reef reflects effects of sea level fluctuation. During the reef development, abundance of grainstone, intraclast and marine cement relatively increases when the reef gets close to the wave base. When the reef goes far away from the wave base or water depth increases, abundance of micritic matrix increases. Planktic foraminifera content in the flank beds increases, when the reef is subjected to greater water depths.

Components, sand-body architecture and proximal-distal changes within a sand-rich deep-water fan complex: the Cingoz Formation (Miocene), Adana Basin, southern Turkey

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A clastic, deep-water turbidite system of mid-Miocene age in the northern Adana Basin, southern Turkey, provides excellent quality exposure that permits detailed analysis of the component parts of a small, sand-rich submarine fan and enables accurate definition of sand body geometries within these components. During the early Miocene in the Adana Basin, rapid subsidence accompanied by extensional faulting gave rise to a deep-marine basin during a phase of major marine transgression. This deep basin was bordered to the north by a narrow, shallow marine, carbonate platform beyond which the uplifting Tauride mountain belt provided a source for large volumes of clastic detritus. This terrigenous sediment by-passed the shallow marine shelf and reached the deep marine basin via steep-sided feeder channels. At least four such channels are exposed along approximately 40 km of the ancient basin margin and these supplied an extensive complex of small, sand-rich submarine fans. In this study the westernmost sections of this deep-water fan complex have been examined from the proximal feeder to the more distal depositional elements.

The main components of this fan-complex include the alluvial fans/fan deltas at the apex of the feeder channel, together with a 3.5 km wide and 360 m thick channel body that passes down-system into 1-2 km wide and 30-50 m thick tongue- and lobe-shaped depositional sandstone bodies. The internal architecture of these components will be described and discussed, together with the observed proximal-to-distal changes in net: gross ratios, the vertical organization of beds and the lateral changes in bed dimensions.

The Lower Miocene of the Mut Basin, South Central Turkey: an excellent analogue for the sub-surface Miocene carbonate platforms of the Pearl River Mouth Basin, China

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Miocene carbonate platform complexes have been the subject of extensive exploration efforts in the Far-East (for example, the Gunung Putih carbonate complex - East Java Sea; the Zhujiang and Liuhua Platforms - Pearl River Mouth Basin). However, few outcrop equivalents of these Miocene platforms have been published to-date: this study presents such an outcrop.

The Pirinç outcrop is a carbonate platform-to-basin transition exposed on the northern flank of the Mut Basin (Southern Turkey). The platform was deposited against a relict palaeotopography during a time of relative tectonic quiescence. The Burdigalian interval described here has been interpreted to contain three large relative sea-level cycles with a 100-150m amplitude. These generate a steep-edged platform with prograding slope geometries during highstands, while during lowstands thin carbonate platforms develop in onlap against slump-deposits. Stratigraphic relationships indicate collapse of the platform margin occurs during late highstand to early lowstand, and is coincident with sea-level fall. During transgression an isolated platform complex develops. Production on these platforms shuts-down before the maximum flooding because of limited production potential.

The subsurface Zhujiang Platform (Pearl River Mouth Basin, China) is a Lower Miocene Platform, showing a gradual to steeply sloping prograding margin with major zones of slumping along strike. The resemblance of seismically imaged slumping in PRMB with the Pirinç platform outcrops is striking. Information gained from the outcrop study serves to constrain the stratigraphic processes active in the sub-surface example and hence to better understand the spatial distribution of rock fabrics when evaluating the formation's prospectivity.

Tectono-stratigraphical aspects and geological evolution of Sipahili-Gözsüzce area (Aydıncık-İçel), Southern Turkey

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The investigated area, which covers the area of Sipahili-Gözsüzce around Aydıncık (İçel), includes the Geyikdağ and Aladağ tectonic units. These tectonic units, which have tectonic contact relation with each other, primarily deposited within the same basinal setting but far from each other. The Geyikdağ tectonic unit, which represents the basement, comprises 15 formations deposited between Infra-Cambrian and upper Cretaceous. The sediments of Infra-Cambrian period is represented by low metamorphosed detritic and calcareous alternations which deposited within the tectonically active rift basin where the edge of the basin faulted. Early Paleozoic rocks, which also reflect low grade metamorphism, start with quartzite and pass upward into shelf type platform carbonates and then continue with transgressive deep marine shale. Upper Ordovician-lower Silurian stage rocks are represented by basal conglomerates, which deposited after a stratigraphic gap. Lower Silurian is represented by calcareous interbedded detritics followed by deep marine shales comprising graptholites. This is followed by shale limestone intercalations representing shallow marine and back shelf conditions. The earlier formed sediments is covered with intercalations of shale-limestone-quartz sandstone alternations of lower Devonian deposits which was deposited within the shelf near to the continent. The period of middle Devonian-lower Carboniferous is represented by carbonates containing abundant macro fossils and detritics, which unconformably cover the earlier formed deposits, reflecting the characteristics of shallow shelf, reef and shore plane environments. There are stratigraphical gaps between the period of early Carboniferous and Upper Permian and late Permian and Upper Triassic in the Geyikdağ tectonic unit. The Upper Permian stage rocks were developed in carbonate facies. Some geological findings prove that the Triassic epoch represents a rifting event and basin formation all around the Taurides. Triassic sediments, which is mainly made of detritics and shows different thickness in different locality, rest on the older rocks with an angular unconformity on an irregular topography. The period of Jurassic-lower Cretaceous is a typical development for carbonate platfrom. Due to deepening of this platform during the upper Cretaceous, reddish biomicrites with Globotruncana reflecting an open sea conditions during Maastrichtian, and turbiditic sediments deposited on the lower Cretaceous carbonates including Miliolidaes with an angular unconfirmity. The abrupt transition among the units proves that Carbonate palatform tectonically depressed during the late Cretaceous. In the stdy area, Aladag tectonic unit, which thrusted on the Geyikdağ tectonic unit, comprises four formations. This unit shows a comprehensive sequence between upper Devonian and Lower Triassic apart from the unconformity seen locally only during lower Permian. The sequence is mainly made of quartz sandstone interbedded neritic limestone reflecting reef, shallow shelf and coastal plane environments. The middle Miocene reef limestone which is the youngest unit of the investigated area, covers the earlier formed formations with angular unconformity. The trends of major thrust zones and fold axis are towards northeast-southwest in the study area. The geological data shows that the northwest-southeast trending thrust development formed due to the compressional tectonic regime which started during late Cretaceous.

The Coastline Changes of the Manavgat delta (the Titreyen Lake) on the Mediterreanean Sea Coast of Turkey: Their engineering and environmental effects

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The Titreyen Lake and the Manavgat Delta are located on the Mediterranean Sea shore where the most active coastline changes have been occurred. Coastline changes related to the Titreyen Lake were examined using aerial photos and satellite images taken in the different times of the century; then the rates of progradation and retrogradation were determined. The results show that progradation on the mouth of Manavgat River in the years between 1939-1984, a period of 45 years, summed up to about 990851 m^3. Construction of the Oymapınar and the Manavgat dams in the years 1984 and 1986 respectively greatly reduced sedimentation in the Manavgat delta, and an erosion in the southwest side of the Titreyen Lake started at a rate of 1125 m^2/yr. From 1984 to 1996, an area of 13500 m^2 was lost, then the west part of the delta became retrogradational. However, the total amount of progradation in the years 1939-1996 is about 999796 m2. About 98 % of the progradation occurred with a rate of 22220 m2/yr before the construction of the Oymapınar dam in 1984 and of the Manavgat dam in the 1986 on the Manavgat river. The rate of progradation after 1984 reduced to about 8580 m^2/yr. Under prograding and retrograding conditions, a progradation of 22080 m^2 has been occurred between the years 1984 -1996.

Map of the recent sediment distribution of the Mersin Bay

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A large number of surface sediment samples were taken from the Mersin Bay bottom using orange-peel and other types of grabs aboard research vessel "Çubuklu" Department of Navigation, Hydrography and Oceanography of Turkey. The samples were analyzed with standard sedimentary petrographic techniques. The resulting grain size distribution of bottom sediments was used to produce a map at 1:150.000 scale.

Water current, living organisms in the sea and carrying materials of Seyhan, Tarsus, Göksu and other small rivers, effect sediment depositing in Mersin Bay.

Sediments on the floor of the Mersin Bay range from mud to mudy sandy gravel in size. According to relative proportions of gravel, sand, silt and clay, the following sediments types are distinguished in the study area: mud, sandy mud, gravely sandy mud, gravely mud, clay, silt, sandy silt, clayey sand, silty sand, muddy sand, sand, gravely mudy sand, gravely sand and muddy sandy gravel.

The coarse materials become dense especially in a part of east side of Mersin Bay between depths of 80-150 meters. Fine material decreases in this region. Especially it has more mud than %90, in central region and west side of Mersin Bay according to the other areas. Silt and clay, which are total of mud, show different distribution in Mersin Bay. Clay had become rich in western side of Mersin Bay. Asymmetric bathymetric structure of Mersin Bay effects this image.

In Mersin Bay fine materials which are originate in land and coarse materials which had been consisted by from shell of some organisms, had been formed by water current and bathymetric structure.

The sedimentary petrographical features of Dulup and Anamas carbonate sequences (Eğirdir, SW Turkey)

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The investigation area is located in the south of the Eğirdir Lake, south west Anatolia. In this research, were measured the carbonate sequences of the Dulup Dağ and Anamas Dağ region. Various carbonate facies and their paleoenvironments were separated by examining the petrographic features of the carbonate rock samples from the collected of measured stratigraphic sections under the polarizan microscope. Dulup stratigraphic succession was divided into two different facies in ascending order Dolomite and wackestone facies.

In the former facies, the dolomite crystales in the carbonate rocks of the dolomite facies are usually idiomorph, partly unidiomorph crystale-shape petrographic data indicates that dolomites of this kind of facies occurs from the secondary dolomitization of micritic limestone. Secondary porosity depending on fractures is wide-spread. These fractures have sparycalcite fillings, and partly contain hidrocarbon remainings.

In the latter mudstone-wackestone facies located on the top of the Dulup carbonate sequence are intraclast, bioclast and pellets. These grain constituents have usually matrix-supported and poor- sorted- primary and secondary porosity are developed in locally.

The age of the Dulup carbonate succession in assumed to be Middle-Late Jurassic according to microfauna contents. Petrographic and paleontological data indicate that the carbonates of the Dulup succession were deposited within the open marine platforme plain.

The Anamas carbonate succession is divided into two carbonate facies in ascending stratigraphic order, packstone and oolitic grainstone facies. Constituents of the packestone facies are intraclast, bioclast, oncoid and very rare ooids.The packstone facies have generally grain-supported and poor-sorted texture, and grain contents are more than 10%. Constituents of the oolitic grainstone facies are ooid, oncoid, intraclast, bioclast and composite algal fragments and have grain and cement-supported and well- sorted texture and grain contents more then 10%. Petrographic analyses shows that primary and secondary porosity is developed very well. Primary porosity mostly occurs as inter-particle and intra-skeletal porosity. Secondary porosity develops depending mainly of fractures. Secondary dolomitization can be seen partly along the fractures.

The age of the Anamas carbonate succession is Middle- Late Jurassic (Dogger-Malm) according the microfauna contents.

Petrografic and paleontological characteristics of Anamas carbonates indicate that they were deposited within the very shallow marine environment, probably in the inter-tidal plain.

VOLCANISM

Helium and Heat Distribution in Turkey: Relations to Tectonic Provinces, Volcanism and Recent Seismic Activities

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Previously-published He-isotope record and the results of geothermometry applications on Turkish fluids are examined along with the results of a recent survey along the North Anatolian Fault Zone (NAFZ) after the devastating 1999 earthquakes. $^3He/^4He$ ratios cover a wide range with R/Ra values (R = sample $^3He/^4He$, R_A = air $^3He/^4He$) extending from 0.05 to 7.87, and reveal the presence of mantle-derived helium in most parts. The distribution of mantle-He in Turkey has close connections with the distribution of heat and age of tectono-magmatic activity. Mantle-He contribution is high (> 50 % of total composition) in regions of historically active volcanoes (eastern and central Anatolia) and the most recent seismic activity (western central segment of NAFZ) where low-to moderate-enthalpy fields are located. In the high-enthalpy fields of western Anatolia, mantle-He contribution is relatively less, the highest values being recorded from historically active Kula volcanoe and from Denizli area which has been a site of frequent seismic activities in recent years. The negative correlation between ^3He and heat distribution in Turkey suggests different mechanisms for the transfer of heat and helium in different provinces. While recent and extensive volcanism in central and eastern Anatolia is consistent with the release of both helium and heat from cooling magmatic systems, the low ^3He/enthalpy ratio (1.7 x 10^6 atoms ^3He/J) in western Anatolia appears to result from lithospheric stretching which provides a regional and significant source of heat but comparatively low helium additions from localised magmatic activity. High ^3He / low enthalpy values of northern Anatolian fluids (^3He/enthalpy = 2.8 x 10^6 atoms/J) deserve particular attention as there is no evidence of recent volcanism associated with NAFZ. Continuing monitoring of He-isotope compositions along NAFZ should lead to a better understanding of the relationship between heat and helium transport, as well as the possible relation of He-isotope variations to the seismic activities in this region.

Geology of the Bodrum magmatic complex, SW Turkey

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There are two major rock groups in the Bodrum peninsula as a basement and a cover. The basement rocks cropping out at the eastern parts of the peninsula, is represented by different rocks of the Lycian nappes. The cover consists mainly of the plutonic, hypabyssal and volcanic rocks of Miocene age. The cover rocks are located at the western part of the region.

The magmatic activity in the Bodrum peninsula began when a monzonitic stock emplaced in the basement during the Middle-Late Miocene time. A group of hypabyssal rocks of the same petrochemical features were injected into the radial and concentric faults and cracks, developed above the stock. The dykes possibly acted as feeder dykes, because above this magmatic center petrographically similar lava flows and pyroclastic rocks were formed.

The volcanic rocks display an apparent stratigraphical ordering. The volcanic succession begins with the felsic lava and pyroclastics at the bottom, and is followed by CA intermediate lavas. The alkaline basalt and rhyolite dikes and lava flows of Upper Miocene age are final products of the volcanic activity.

The plutonic, hypabyssal and volcanic rocks are partly coeval and genetically related to one another, and represent a collapsed caldera environment. The major part of the caldera is buried under the waters of the Aegean sea. On land only the eastern side of the caldera is presently exposed. Further east young faults elevated the basement rocks against the volcano, and partly offset its original ordering. In this paper tectono-magmatic evolution of the Bodrum peninsula will be discussed.

A new age data set for the Bodrum Volcanic Complex (S-W Anatolia)

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The Bodrum Volcanic Complex is a major volcanic structure in SW Anatolia. Upper Miocene in age, this complex is part of a chemical province which includes also the Greek islands of Kos and Patmos. Its importance is based on several grounds: it is the largest and most well-preserved volcano-plutonic edifice in this area and it shows the widest chemical spectrum of rock types including number of mafic varieties. Most of these rocks can be found as either volcanics (fall and flow-deposits or lava) or subvolcanic intrusives. Mafic rocks occur as flows, dykes, inclusions or cumulates.

We have studied the geology and stratigraphiy of the complex which shows two prominent but contradictory structural features. One of them is the general concentric arrangement of the various facies which suggests that this might be the original lay-out of one large volcanic complex. Accordingly, samples from well-defined sections in different parts of the complex, North, central part and South, have been chosen for dating. On the other hand, a series of small mozonitic intrusions is located along a line stretching from the monzonitic complex in Kos towards NE suggesting a batholite-type setting with originally several smaller volcanoes. Dated samples are from from three localities on this line.

Age measurements have been performed on separated minerals (amphibole, biotite, sanidine) by either K-Ar or ^{39}Ar-^{40}Ar methods. Control tests have been made by K-Ar on whole-rocks for several samples. A series of alkali-trachytes has been analyzed for Sr isotopes and the results allow to define a Rb-Sr isochrone.

The corresponding data set fixes the duration of this volcanism to approximately 3.5-4 Ma beginning around 11.5 Ma in the northern part of the complex. Activity then moved southwards. Latest manifestations of 7.5 -7.8 Ma are dykes and domes in the S and SE. Intermediate age of the intrusives show that they are genetically related to the volcanics.

Evolution of the pyroclastic deposits in Bodrum magmatic complex, Northern part of the Bodrum Peninsula-SW Anatolia

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The Bodrum peninsula in western Anatolia is covered by volcanic rocks of Middle-Upper Miocene age, known as the Bodrum magmatic complex. The volcanic succession is mainly intermediate in composition and is represented by lava flows and pyroclastic deposits. The volcanic activity began with porphyry intrusions and extrusion, which are connected with monzonitic stocks. This phase is continued with lava flows and related pyroclastic deposits. The volcanic succession is represented mainly by andesitic, latitic, basaltic andesitic lavas and related breccias flows and pyroclastic deposits. Later basaltic andesite and young basaltic dykes and flows cut the previously formed volcanic succession.

Northern part of the Bodrum peninsula is a key region to understand the evolution of the explosive volcanic activity. These are widespread pyroclastic deposits, composed of pyroclastic fall and flow units. All these units are intercalated with epiclastic deposits at all levels this indicates non-explosive stages. Pyroclastic fall and flow deposits intercalated each other in a few meter. They display different grain size, volume and thickness because of the type and magnitude or intensities of the eruptions

Correlations between several volcano-stratigraphic sections from the pyroclastic deposits from north to south indicate that this region is similar to the northern flank of a stratovolcano. Kıranca and Dişlen hills, which are trending approximately N-S direction, are the youngest and morphologically well-defined plugs of the Bodrum volcanics.

Geology of the Foça volcano, Western Turkey

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Foça area represents a big polygenetic volcano, resulting from multiple eruptions, separated by relatively long periods and involving different (intermediate-silicic-basic) magma compositions. It covers 150 km^2 area, and reaches 450 m altitude.

The Foça volcano was built upon a sedimentary basement. The volcano has a central caldera formed by the collapse of the pre-existing, mainly andesitic, basaltic andesitic volcanic cone. Despite its Miocene age the topographic profile of the volcano still still recognisable. Top of the volcano disappeared during the late phases of eruptions and was replaced by a caldera measuring 5x5.km, bounded by precipitous cliffs, which may be interpreted as old fault scarps, up to 200 metres high. The subsequent phase of the eruption produced felsic volcanic rocks while the earlier phases were characterised by dominantly andesitic and basaltic andesitic activity. Many rhyolitic domes and related pyroclastic rocks occured in arcuate distributions around the central caldera in this phase. At the Foça volcano an arcuate line of rhyolitic volcanics represents activity over part of an actively developing ring fracture system. Volcanic activity is then concentrated on this ring fractures. Explosive phases producing plinian and subplinian air fall deposits and ignimbrites precede the eruption of rhyolite domes and flows. The flanks of the Foça volcano were thus covered by ignimbrites and nuées ardentes of the second stage.

Without a major interruption in the volcanism, the late phase formed distinctly mafic lavas. These are represented by mafic dykes injections and lava flows. Petrographically, they are basaltic trachyandesite and basalt in composition.

Geodynamic significance of potassic and ultrapotassic magmatism in collision zones: New evidence from SW Turkey

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Potassic and ultrapotassic magmatism is commonly associated with post-collisional lithospheric extension and provides important clues to collision-related mantle-lithosphere dynamic interactions. However, the genesis of these magmas is controversial and has been considered according to two broad groups of models. The first of these invokes collision-induced delamination of thickened continental mantle lithosphere leading to 'in situ' partial melting of the thinned lithosphere. This assumes that mantle enrichment processes pre-dated the continental collision presumed responsible for delamination. Alternative models appeal to enrichment (via the introduction of delaminated or subducted continental crustal materials) of the collision-perturbed asthenosphere, implying that mantle enrichment was a direct consequence of the preceding collision. Here, we report results from a study of igneous activity in the Afyon-Isparta region in the Aegean extensional province (SW Turkey) which comprises potassic (sodic, shoshonitic, midly potassic), and ultrapotassic (Roman Province Type, lamprophyre, and lamproite) intrusions and eruptives. Spatial-temporal distribution of the activity between c. 14 to 4 Ma, suggests a prograde pattern from north to south. Considering two parts of the region (Afyon-Sandıklı and Isparta-Bucak), the relatively potassic activity in Afyon-Sandıklı is dominant on north (Afyon) with ultrapotassic activity concentrated in the south (Sandıklı). This pattern appears to be repeated in Isparta-Bucak, with potassic activity dominating in Isparta (to the north) and ultrapotassic in Bucak (to the south).Overall, the activity matches a progressive southward thinning of the crust and a secular change from crust-dominated to mantle-dominated magmatic sources (87Sr/86Sr ratios c. 0.70707 -> 0.70365). Trace element and isotopic data are used to discriminate between 'in situ' lithospheric mantle and 'contaminated' asthenosphere sources for these magmas, and the extent to which they have been subjected to wallrock reaction. We present a geodynamic model for the mode and nature of the post-collisional, late Cenozoic extensional tectonics and associated magmatism in western Anatolia based on the spatial, temporal, and chemical relations of these high-K volcanic rocks.

The stratigraphic framework of the potassic – ultrapotassic volcanism in Başören - Balçıkhisar region (Afyon / Turkey)

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The Afyon volcanic province is located in the eastern part of the western Anatolia. Products of the extensive potassic-ultrapotassic volcanic activities took place during Middle Miocene. The study area forming a part of Afyon volcanic province is located in the south of the Sandıklı–Şuhut trend. Products of various volcanic activities intrude and cover the sedimentary formation of the northeastern portion of the Western Tauride Belt.

According to stratigraphic setting, three stages of potassic and ultrapotassic volcanism are distinguished. Leucitite, tephriphonolite, and spotted trachyandesite lavas are the products of first stage volcanism. Trachyandesitic lavas and thick-widespread pyroclastic rocks, which are named as Başören trachyandesite and Başören pyroclastic succession, represent the second stage volcanism. The lamproites, which are the products of the second stage volcanic activity, extrude during the successive trachyandesitic volcanism.

Volcaniclastic rocks related to leucitite volcanism, which are described as Balçıkhisar volcaniclasitic succession mainly covers the products of the leucitite, tephriphonolite, spotted trachyandesite, lamproites, and the products of the Başören trachyandesitic volcanic succession. The characteristic feature of the Balçıkhisar volcaniclastic succession is the presence of mafic mineral-rich xenoliths. The mineralogical compositions of the xenoliths are variable and a general mineral assemblage is consisting of clinopyroxene – phlogopite – melanite – melilite – leucitite - perovskite – ilmenite – apatite. The xenocrysts are mechanically originated from upper mantle and are precursor of mantle metasomatism.

The lacustrine sedimentary rocks cover the products of the first and second stage volcanism. Lacustrine sediments consisting of limestone, claystone, sandstone, and pebblestone alternations, are gradationally overlain by the Tokluk volcanosedimentary succession. Phonotephritic, phonolitic, basaltic trachyandesitic, and nosean-bearing trachyandesitic lava domes, dykes, and flows represent third stage volcanic activity in the study area. The lava flows and dykes of third stage volcanic rocks cut and cover the Tokluk volcanosedimentary succession.

The geodynamic setting and the source of the highly K-rich and strongly alkaline parental magma are related to widespread subduction and postcollision process of Eurasian and African plates. Two possible processes are suggested to generate potassic alkaline magmatism. The first possibility is different degrees of partial melting of same source (e.g. depleted primitive mantle) and followed by fractional crystallization - variable assimilation fractional crystallization. The second possibility includes two different sources; leucitite tephriphonolite, and phonolite can be generated from primitive source by partial melting process, which is followed by assimilation fractional crystallization (upper crustal contamination). Phonotephrite, basaltic trachyandesite, and nosean-bearing trachyandesite can be modelled by partial melting and assimilation fractional crystallization process (pelagic

sediment contamination) or only partial melting, which is derived from enriched mantle source.

Petrography and Geochemistry of the Bayburt Tuffs: An Acidic, Pyroclastic Volcanism during Eocene time in Southern Pontides; NE Turkey

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As an island-arc complex, the Eastern Pontides are characterised by three main groups of volcanic cycles broadly; Liassic, Upper Cretaceous and Eocene. Volcanic products of Eocene show differences in terms of rocks type, chemistry from north to south, and especially extend E-W direction as isolated outcrops in southern part of Eastern Pontide. In the Bayburt area, volcanic products of the Eocene time are reported as tuff-tuffite within sedimentary lithologies although there is no detail work on significance of these rocks in terms of their petrography, geochemistry, occurrence and origin.

The Bayburt tuffs are made of two levels as bottom and upper units, separated with a claystone-marl interlayer. Bottom unit contains two whereas upper unit one cycle, and every cycle shows gradating from coarse towards fine grained tuffs. Tuffs contain dominantly glass shards, pumice and crystal fragments (plagioclase, quartz, biotite, sanidine). Coarse and fine grained levels are characterised by their crystal fragment/glass shard ratio. Based on modal composition, coarse grained level is vitric-crystal tuff and fine grained level is vitric tuff. Geochemically, tuffs are rhyodacite to dacitic in composition with 68-71% SiO_2, 10-12% Al_2O_3, 1-5% CaO, 0.2-2% Na_2O, 1.6-7%K_2O, 6-13% LOI contents. They exhibit medium-K, calcalkaline and metalumineous characteristics. They show chemical variation trends, probably reflecting pre-eruption magmatic processes such as differentiation. REE patterns is spoon-like in shape, with $(La/Lu)_N$=14-20, and pronounced Eu anomalies indicating plagioclase fractionation.

The investigated Eocene tuffs are limited to the Bayburt area, and differ from the rest of Eocene volcanites in the south by their field characteristics and acidic composition. Very fresh and angular glass shards and crystal fragments, and lack of rounded lithic fragments may indicate syn-sedimanter acidic volcanism in or very near to Eocene basin in the region. Furthermore, geochemical data suggest that these rocks derived from an intermediate magma source (i.e. andesitic parent).

High and low bulk rock densities in the welded İncesu ignimbrite from Cappadocia

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The 2.8 Ma old İncesu ignimbrite from the upper part of the Cappodocian tephra series is the most densely welded ignimbrite of the volcanic province. Conservative estimates of distribution and volume revealed about 5,580 km^2 and 35 km^3 of erupted magma. The regional distribution is strongly controlled by (paleo) topography between older volcanic cones and the Taurus forehills. Bulk rock density of the ignimbrite is as high as 2.34g/cm^3 in the basal vitrophyre of the type section in the town of İncesu. It decreases up section down to 1.77 g/cm^3 on top of the outcrop but superposing density maxima occur in the central and upper parts. Lateral variations of the bulk rock density (BRD) allow to identify flow lobes. Although a vertical increase in lithic and pumice content is obvious in many sections, primary depositional structures are extremely rare.

The NW-Himmetdede lobe shows a more or less constant decrease from proximal dense welding with high BRD of 2.37 g/cm^3 to distal incipient / non-welding with low BRD of 1.50 g/cm^3. These principals can be observed in lobes the distal ends of which were not terminated by topographic barriers. In contrast, the S Firaktin-Hosca lobe exposes unexpected high BRD of 2.09 g/cm^3 at its distal and in front of the Taurus mountains although lower values were already observed farther away from the barrier. This distal re-increase in BRD can be observed in flow lobes the distal ends of which were terminated by barriers. A regional low in BRD was found in the area of Köprübaşı, about 30 km from source. The low BRD corresponds to the development of primary depositional structures of particle segregation such as lithic concentration layers at the base and pumice concentration in the upper parts of individual flow units.

The lack of depositional structures indicates compaction welding of the ignimbrite after the flows came to rest that the final BRD largely depends on the inherent temperature and depositional thickness. The high BRD at the distal end of a flow terminated by a topographic barrier is explained by thickening due to partial back flow from the upper slopes of the barrier. The intralobate low in BRD around Köprübaşı is interpreted by a local agitated state of turbulence that caused extra cooling of tephra so that dense welding is inhibited in this part of the deposit.

Interaction of asthenospheric and lithospheric mantle: Genesis of calc-alkaline volcanism, Erciyes example, Central Anatolia, Turkey

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Quaternary monogenetic Erciyes volcanism testifies the tholeiitic, alkaline and calc-alkaline basaltic associations, but the volcanic complex generally represents by calc-alkaline lavas. These calc-alkaline products are basaltic, andesitic and dasitic in composition.

Calc-alkaline basalts exhibit similar trace element abundances with tholeiitic products (Erciyes) but differ from elevated Rb, K and Nb elements. These magnesian products resemble Rio Grande rift tholeiites. Andesites and dacites have similar trace element patterns with Taos (North-central New Mexico) andesites and Egan range (east-central Nevada) evolved calc-alkaline products. Ba/Nb >28 is the typical ratio for arc volcanism, suggested by Fitton et al., (1988). Ba/Nb ratio of calc-alkaline lavas range between 27-47 for andesites, 27-50 for dacites. Furthermore, Rb/Nb ratios are also high in calc-alkalies (4-7.5). These values indicate the crustal contribution on the generation of calc-alkaline products. Moreover, $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ ratios range between 0.703344-0.703964; 0.51292-0.51278 for tholeiites and 0.703434-0.705143; 0.512942-0.5126 for andesites and dacites.

The difference in LIL and HFS elements and isotopic ratios (Sr, Nd) between basalts and andesites imply that chemically different source components may have been involved in the genesis of these products. These evolution can be outlined by three main points.

-Tholeiitic basalts are generated with 1-1.5 % partial melting of a primitive mantle source.

-Minor amount of basaltic products, especially basalticandesites were generated by interaction of depleted (tholeiitic) and enriched asthenospheric sources.

-Calc-alkaline basalts (basalticandesite) and andesites were derived from initially tholeiitic basalt end-member via 10-15 % assimilation of crustal material (Kürkcüoğlu, 2000).

Erciyes volcanism was developed in central Anatolia, as a result of post-collisional extension. Calc-alkaline products were derived from a tholeiitic source mainly by AFC processes but interactions of chemically different source components are also responsible for the calc-alkaline evolution.

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Devitrification of volcanic glasses in Konya volcanic units, Turkey

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The study area is composed of volcanic, sedimentary and volcano-sedimentary units, which are exposed south and southwest of the city of Konya. XRD analysis indicates that volcanic units contain halloysite, kaolinite, smectite, illite and sepiolite type clay minerals and opal-CT, feldspar, quartz, minamiite and jarosite type non-clay minerals. SEM studies show that volcanic glasses, which are the main component of volcanic units, appeared as curviplanar, vesicular-planar and in highly fractured shapes. Fractures and dissolution voids of the volcanic glasses are generally filled by hexagonal kaolinite, fibrous halloysite and smectite. Volcanic glasses there play an important role in the formation and transformation of clay minerals as a cation supplier within alteration environments. Presence of jel-like zone between glass and clay minerals indicates that fresh glass is dissolved and the material moved and deposited over very short distance developing clay minerals following precipitation of jel-like zone. The mobilities of the elements released from the volcanic glasses and the micromorphology of the volcanic glass dominated units favoured the physico-chemical environment for the precipitation of these clays. Thus, clay minerals are neoformed on or adjacent to volcanic glasses because of the reaction of water with the volcanic glasses; so that halloysite, kaolinite and smectite are neoformed.

Volcanism of the Çubukludağ graben, Western Central Anatolia

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The Cumaovası volcanics are situated in the Çubukludağ graben elongated in NE-SW direction located between İzmir – Kuşadası areas. The Cumaovası volcanics form an upper unit within the Çubukludağ graben sequence. They are represented by felsic lavas and pyroclastic deposits that are alkaline in nature and upper Miocene-Lower Pliocene in age.

The first products of the volcanism are the pyroclastic fall deposits which are partly deposited, in a lacustrine environment. The volcanic activity continued with explosive eruptions, and the main products of this stage are rhyolitic domes and pyroclastic flow deposits. Within the pyroclastic flow deposits cold and hot flows may be distinguished. The latter is represented by ignimbrites while the former formed ash-block tuffs. The rhyolite lavas in places cut across co-genetical fall deposits. The rhyolite domes are aligned along NE-SW trends with the Çubukludağ graben and form spacely-developed hills. Güney, Temese, Dededağı, Çakmak, Dikmen and Ayıdağ are the most significant domes of the Cumaovası volcanics. There are also fissure eruptions near the domes. In rhyolite lava flows a variety of lithological and the textural features may be recognized such as obsidians, spherulites layers, pumiceous layers, foliated stony rhyolites and perlites. The flows have an autobrecciated flow front and flow bands.

In this paper evolution of the volcanic activity and their major products will be described.

Young magmatism and tectonics of Aliağa area and surrounding, Western Anatolia, Turkey

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Three main rock groups are present in the Aliağa area and surroundings. The first group is the Triassic metamorphic basement rocks of the Sakarya continent. The second group is a volcano-sedimentary association, namely the Dikili group. The Dikili group is Lower to Middle Miocene in age, and consists mainly of the intermediate lavas and related pyroclastic rocks, and the lacustrine sedimentary rocks. This unit is regarded as the products of a post-collisional volcanism. The volcanic rocks are hybrid in origin, derived from upper mantle and contaminated with the crustal material, and are represented commonly by andesite, latite, dacite, rhyolite and their pyroclastic rocks. There is an apparent stratigraphical ordering in the volcanic succession; the volcanism starts with felsic rocks, and pass upward into intermediate rocks. The latter dominates the volcanic sequence. At the final phase of the volcanism more basic members of this family together with rhyolitic and perlitic domes were formed co-evally. The volcanic rocks of Dikili group exhibit high-K, calc-alkaline character. The geochemical data displaying the subduction-related signature is inherited from the earlier subduction event prior to the collisional tectonics. The sedimentary rocks of the Dikili group are bituminous shale, marl, siltstone and limestone, which are deposited in low energy lacustrine environment.

The third rock association is the Zeytindağ group of late Miocene-Pliocene age. It rests on the different rocks groups unconformably, and consists mainly of lacustrine detritals and limestones with rare basaltic lava interbeds. The basaltic rocks are geochemically distinctly different from the volcanic rocks of the Dikili group. The basalt lavas exhibit alkaline affinity and display the OIB-type features.

The Aliağa region is one of the tectonically active provinces of western Anatolia. The most prominent structural elements of the region are the faults. The two fault sets which are NE and NW trending, are recognized in the region. The NW trending ones commonly displays right lateral slip with dip-slip component, while the NE trending faults display left lateral slip. The relationship between the fault sets together with the age of the rock groups displaced by these faults indicate that they were formed simultaneously and post early Pliocene in age. In the northern areas of the region, there are NE trending faults have contrasting lateral slip directions as a consequence of the parallel escape-type faulting.

Geological and morphological characteristics of the three Miocene volcanoes of western Anatolia

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Western Anatolia witnessed widespread volcanic activity since the late Oligocene-early Miocene. The young magmatism of western Anatolia may be divided into two episodes. These two volcanic phases were formed under different tectonic regimes. The first phase developed under the N-S compressional, and the second phase formed under the N-S extensional regimes. The volcanic vents of the first phase are represented either by calderas connected to the shallow level intrusions in a caldera collapse environment or by monogenic vents. They form stratovolcanoes.

In this paper three well-developed Miocene volcanic centres of the Western Anatolia will be introduced. These are the Altinova volcano in the north, the Çukurköy volcano in the central area near Menemen and the Turgutreis volcano of Bodrum Peninsula in the south.

All three volcanoes have a numbr of common features. The Çukurköy and Altınova volcanoes are partly coeval volcanoes elongated in N-S direction. They produced intermediate and acid products. Turgutreis and Altınova volcanoes both were connected to shallow level granitic intrusions in a caldera collapse setting.

All the three volcanoes are stratovolcanoes formed by the alternation of lava flows and pyroclastic layers. A steep cone with a summit crater is the simplest type of their volcanic structure, but the alternation of quiet effusion with explosive activity caused frequent changes in the shape of craters, and the opening of new fissures and vents caused formation of rather complex volcanic edifice.

The volcanoes began to form with fissure eruptions, along the major transtensional faults of the western Anatolia. The faults were apparently associated with a conjugated pair of oblique fault system, which formed under the north-south compressional regime. The volcanoes built a cone and crater when the volcanic activity intensified. During the subsequent eruptions, the volcanic centres constructed a cone. Near the end of this stage, the central vent was commonly blocked. This led to the initiation of flank eruptions. Consequently, a number of subsidiary cones, domes and dikes were formed on slopes along flanks of the volcanoes, locating preferentially on radial and tangential cracks. There are many dikes and sills some of which are seen to have fed lava flows. Following this, the volcanic activity gradually waned.

The data suggest that the all the three volcanoes and the associated structures were formed when the crust was excessively thickened as a result of the N-S shortening. This predates the present N-S extension of the Aegean region.

Petrographical, Petrochemical and Technological Investigation of Zeolitic Tuffs in Sandıklı Region (Western Anatolia), Turkey

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Sandıklı is located in the western part of Central Anatolia in Turkey. In the studied area, the Middle-Upper Miocene aged trachyandesitic, andesitic and phonolitic lavas, tuffs and tuffits are situated. Tuffs are essentially vitritic and vitritic-crystal tuffs. They have various ratio pyroclast, extraclast, pyrogenetic and secondary minerals. There is shapeless emptiness in glassy matrix which has intense zeolitization. Augite, hornblende and biotite were observed as pyrogenetic minerals in matrix. For the separation processes of zeolite from the zeolitic rock were used by heavy liquid (tetra brom ethane) and than purity of zeolite specimens were tested by x-ray diffraction method. Zeolite contents of tuffs were determined between 35-65 %. Zeolite contents of some tuff specimens are higher than %65. In investigated area, crème tuffs contain chabazite and/or chabazite and phillipsite, milky brown tuffs contain phillipsite. Three phillipsite forms were determined. These are potasium-sodium-aluminium-silicate hydrate, sodium-aluminum-silicate hydrate and potassium-calcium-aluminum-silicate hydrate.

The studied zeolites were more active in the experiments done with H_2SO_4 than the experiments with HCl. Ca is the most soluble element (Ca^{+2} ion) in the experiments which were done with both of the acids. The zeolites have more linear activitation trend with HCl than H_2SO_4.

The suitability of tuffs for cement industry was investigated and determined that.the chemical composition and physico-mechanical properties of tuffs are suitable to trass standards. The abundance zeolite minerals cause a decrease in specific gravity value but make increase of the Blaine value. The high amount of zeolite and glassy phase has been affected to the increasing of puzzolanic activity value. Because of the chemically homogenous composition, welded tuffs and/or composed tuffs have high puzzolonik activity

On the other hand, the zeolite minerals within the zeolitic tuffs, how affect to strength of concrete was investigated by producting the lightweight aggregate concrete. As a result, it is shown that welded tuffs of high content zeolite may be used in production of insulated light weight aggregate concrete and they must be used in construction sector.

Analcime occurences in the volcanic rocks of the Polatlı-Ankara region, Central Anatolia, Turkey

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Phonolitic, tephriphonolitic and trachytic lavas (their silica content ranges from 49 to 59 based on LOI free basis) from the Polatlı-Ankara region, Central Anatolia, Turkey, contain euhedral analcime phenocryts (up to 0.5 cm in diameter) as well as feldspar, clinopyroxene, apatite and oxide phenocryts. The mineralogy and chemistry of some analcime-rich igneous rocks have been investigated to establishe the origin of the analcime phenocryts. Analcime occurences in igneous rocks are either products directly from liquid (primary origin) or alteration products of leucite by reaction of Na-rich fluids (secondary origin). For Polatlı analcime, it seems to be two evidence for primary origin: 1. Euhedral analcime phenocryts in trachyts provide at least textural evidence of primary origin (Luhr and Kyser, 1989). 2. Rb is known to subsititute for K in leucite, but dos not subsititute readly for Na in analcime. Therefore, Rb content of analcimes can be used to determine the primary and secondary origin (Pearce, 1983). Rb content of analcime in Polatlı is about 45 ppm which is consistent with primary analcime.

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Sources of regular density variations within the Welded İncesu ignimbrite /Cappadocia

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In Cappadocia a sequence of at least eight single or compound ignimbrite units is mainly intercalated with a plateau-forming succession of lahars or with local lacustrine limestones in the north respectively. The youngest of these ignimbrites is the 2.8 Ma old dacitic Incesu Ignimbrit. It is welded and differs significantly chemically (e. g. lower in SiO_2, higher in TiO_2 and Zr) as well as mineralogically (absence of biotite, presence of both Ca-poor and Ca-pyroxenes) from all other ignimbrites in the region. It covers an area of at least 7500 km² around Erciyes.

Within the framework of a diploma thesis the impact of phenocrysts and lithic fragments on the rock density of the ignimbrite was investigated. This information was needed because the maximum density of the vitrophyre zone is normally taken as a direct measure for the degree of welding and thus indirectly for the reconstruction of the paleo thickness of welded ignimbrites. However, within these calculations the lithological variation, especially lithic and crystalline clasts, remain unconsidered.

The investigations centered around the mineral-chemistry of phenocrysts as well as density determinations on samples of whole rocks and xenoliths. The results indicate, that the phenocryts and xenoliths modify the density variation within the Incesu ignimbrite to less than 0,1 g/cm³, even if they reach 30 vol.-%. A slightly higher but still minor density variation of less than 0,1 g/cm³ as well is due to the degree of recrystallisation.

Within the non-crystalline basal part of the ignimbrite, the vitrophyre zone, the influence of phenocryts and xenocrysts is even negligable, as they only reach 11 vol.-%, half of which are characterized by a density of less than that of rhyolitic glass of the ignimbrite (2.37 g/cm³).

The uncorrected whole rock density of the vitrophyre zone of the Incesu ignimbrite is thus suited to serve as a measure for the paleo thickness of the ignimbrite. These thickness calculations indicate the source of the ignimbrite to be located underneath the stratovolcano Erciyes.

Geochemistry of the Volcanic Rocks from the Sivas Basin (East-Central Anatolia)

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The Sivas basin, one of the largest Tertiary basin in the eastern part of the central Anatolia, is located between Kırşehir metamorphics to the north and the Tauride platform to the south. The Neogene basin fill is characterized by marl, lacustrine and coal-bearing sediments and intercalated with the basaltic lava flows along the NW edge of the Sivas basin. K-Ar isotopic age determinations yielded an age range from 12 Ma to 15 Ma.

The volcanic rocks in the Sivas basin are characterized by alkali olivine basalts. They can be divided into three distinct groups on the basis of their SiO_2, TiO_2, Zr, Nb, Y, Hf, Ta, and Th. *The group I* is characterized by low SiO_2 (41.4-42.4 wt %), high TiO_2 (1.9-2.0 wt %), Zr (191-208 ppm), Nb (39-58 ppm), Y (23-25 ppm), Hf (3.78-3.80 ppm), Ta (2.51-3.62 ppm) and Th (10.76-10.78 ppm). *The group II* is characterized by medium SiO_2 (42.8-48.5 wt %), TiO_2 (1.6-1.9 wt %), Zr (110-170 ppm), Nb (21-27 ppm), Y (16-22 ppm), Hf (2.43-3.82 ppm), Ta (1.30-1.62 ppm), Th (2.71-6.35 ppm). *The group III* is characterized by high SiO_2 (45.9-48.5 wt %) and low TiO_2 (1.3-1.7 wt %), Zr (101-130 ppm), Nb (10-16 ppm), Y (18-20 ppm), Hf (2.28-2.89 ppm), Ta (0.74-1.19 ppm) and Th (1.38-3.33 ppm). Some of the selected incompatible element ratios such as Th/Y, Ce/Y, Zr/Nb, Nb/Y, Zr/Y, La/Ba and La/Nb are also identical for the three groups of the volcanic rocks within the Sivas basin. The primitive mantle normalized multi-element diagram of the volcanics exhibits close similarity to Ocean Islan Basalt (OIB). Zr/Nb versus Ce/Y and La/Nb versus La/Ba diagrams also suggest an OIB origin. Chondrite-normalized REE patterns of the alkali basalts from different groups show LREE enriched patterns and high REE fractionation [$(La/Yb)_N$ =21.7-5.6], suggesting enriched mantle source components for the generation of the studied volcanic rocks. The differences among the *three groups* of the volcanic rocks could be explained by different degrees of partial melting of compositionally similar mantle source at different depths. The elevated values of the La/Nb, Th/Nb, K_2O/P_2O_5 ratios suggest that the existence of variable degrees of crustal involvement during their genesis.

Petrography of the Middle Eocene volcanogenic-sedimentary formations of the Loki Massif

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Within the Loki massif volcanogenic-sedimentary formations of Middle Eocene are spread on its western periphery. Here, in the ascending succession are distinguished conglomerates and sandstones, nummulitic sandstones, sandy limestone's and volcanogenic suite. Volcanogenic formation petrographicaly is divided into two parts: lower Javakhy basic suite (P_2^2dz), and Upper-Moshevani silicic suite (P_2^2ms). The mentioned formation starts with basal conglomerate ($P_2^2dz_1$),which overlaps the formations of the different ages (Paleozoic-upper Cretaceous) and is covered with dolerites of Quarternary age and alluvium. On the separate peripheries basal formation are different and are built up with material sourced from the underlain rocks. Study of the lithologie cross-sections shows that Javakhy suite ($P_2^2dz_2$) is represented by: normal and subalkalic basalts and andesite-basalts, normal andesites and piroclastolites of the same composition (h-900m), Moshevani suite ($P_2^2ms_1$) is built up by - normal dacitic tuffs, dacites and dacitic tuffs with vein andesites (h-700m). In the synchronous sediments surrounding the given region (Achara-Trialeti) are represented by considerable deposits of zeolites. There are no zeolites in the sediments of peripheries of Loki Massif (Eocene).It is suggested that in the mentioned region palaeogeographic conditions of sedimentation were different.

Plio–Quaternary volcanism in Centeral Iran (A Preliminary Study)

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The studied area is located in Tertiary Central Iranian volcanic province. The area, includes west to south west of Yazd, north, north–west and east of Isfahan cities, occurs in Uromieh–Dokhtar volcanic belt. Based on field investigation, the volcanic rocks belongs to Plio–Quaternary are outcropped as lava flows, domes, ignimbrites and mud flow of pyroclastic debris or lahars. Volcanic activity formed in terrestrial environments. Also eruption dynamism of volcanic activities has revealed, the existence of two big stratovolcan for the first time.

These are known as sharzad (east of Isfahan) and surk (west of yazd) stratovolcanoes. Petrological studies indicated that volcanics are mainly composed of rhyodacite, dacite, andesite and basaltic andesite.

Mineralogical evidences in some volcanics indicated that magma mixing between acidic and basic magma has been occurred. Geochemical discrimination diagrams show a continental calc-alkaline nature of magmatism, which occurred in collision volcanic arc setting.

Geochemical studies also show that primary magma originates in upper parts of mantle and/or lower parts of crust and is contaminated by crustal materials when ascending.

Prospecting and Geochemical Exploration in Nyriz and Arsanjan area, Fars province, Iran

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In this study, all of geological units in north and northeast of Fars province (6400 km^2) southwest of Iran are evaluated for geological distribution and potential ore minerals.

In this work geological features, based on field observation, petrography and petrological analysis of different rock units using thin and polished sections, are evaluated. In addition geochemical and mineralogical characteristics of economical metal and non metals (e.g: cr, Fe, Mn, Pt, Bentonite, Mo, evaporated sand decorative stones). in order to has a detail exploration tragetes, the area is divided into Nyriz (A,B,C with 4500 km^2) and Arsanjan (2000km^2) regions.

In general, the rock formation of the area mainly consist of Cretaceous to Miocene limestones, dololimestones, mafic and ultramafic Intrusions and metamporphic units.

More than 200 samples has been collected from different geological units in the field works. rock samples were analysed by the Atomic absorption (AA) and neut ron activition (NAA) analysis.

Geochemical distribution patterns and frequency histograms for each element/ minerals in different regiones are plotted and evaluated.

In general, the A regions consist of high content of Mn. With average grasde of 36% more than 20 Mn anomaly were determined and evaluated. one of the most economic important elements in B regions is iron minerals with grade between 40% to 50%.

Chromite is a dominant and high distribution mineral in C area. more than 20 deposits and anomalies are distinguished and evaluated in this regions. In Arsanjan area few chormite and magnesite anomalies are determined.

Finally according to these results are used to provide low density geochemical maps. These maps indicate to distribution of minerals/ element based on geological features suitable area for new geochemical surveying and detail exploration are proposed.

Petrological and Geochemical study of north of the Molla-Ahmad stipp-hill igneous rocks (Esfahan-Naein road, Iran)

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Molla-Ahmad village and stipp-hill is located 100 km east of Esfahan and 40 km southwest of Naein. The studied mountains have NW-SE trend(as Uromiyeh-Dokhtar Volcanic Belt = UDVB) and up to 3000 m height. Various studies indicate that the intrusive, volcanic and pyroclastic rocks of this area have different characteristics and include granite, basalt, andesite, trachyte, rhyolite and dacite. The volcanic rocks of this area belong to different geological times(from Eocene to Plio-Plistocene). The youngest volcanic rocks have dacitic composition and can be observe as protrusion with special morphology. Because of various magmatic activities, hydrothermal alterations, and mineralizations that caused by fault movements in this area, a series of impotant mineral indices can be observe. Igneous rocks of this area belong to Calc-Alkaline magmatic series, and in vision of plate tectonics, the genesis of thies rocks possiblly realates to subduction and then Iranian and Arabian plate continental collision.

Geological , Petrological and Geochemical Studies of Qaleh-Khargooshi Shoshinitic Association (Sarve-Bala, West of the Yazd Province), Iran

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Qaleh-Khargooshi Area Situates in NE of the Gav-Khooni Lagoon and Western Part of the Yazd Province at Interface of the Yazd and the Esfahan Provinces. This Shoshonitic Volcanic Association belongs to Upper Eocene & 5th Volcanic Phase of Eocene. At Oligo-Miocene a Granitic Plutons Intruded to Studied Area (Post-Shoshonite Granite). In this Shoshonitic Association can be Observe all of the Shoshonitic Rock-Members such as Absarokite, Shoshonite , Banakite (Latite) & Toscanite. Petrological & Geochemical Studies Suggests that the Mother Magma of this Rocks Originated From an Enriched Mantle and their Source Rock is an Oxidized-Metasomatized Garnet Peridotite of Upper Mantle. By 3-5% Partial Melting of the Source Rock Occurs an Alkali-Basalt. Because of Low-Degree of Patial Melting , the Studied Rocks has High Content of Incompatibe Elements. This Alkali-Basalt has been Differntiated to Absarokitic-Shoshonitic & Banakitic Melts. Field , Petrographical & Geochemical Studies Shows that the Banded Toscanites has been Produced by Mixing of a Banakitic and a Continental Anatectic Granitic Melt. Up to 20 Reasons Demonstrates this Contamination and Magma Mixing.

Thermodynamic properties of sphene at temperatures of 1 to 10000 ^{o}C and pressures of 1 to 10000 bar

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Thermodynamic properties of sphene including G (Gibbs energy), H (Enthalpy), S (Entropy), Cp (Heat capacity at constant pressure), V (Molar volume), dCp/dT, dV/dT, dV/dP, d2V/dT2, d2V/dTdP, and d2V/dP2 have been computed using the MELTS program. To cover wide range of conditions, temperature ranges of 1 to 10000°C and pressure ranges of 1 to 10000 bar have been used in the experiments. Our computations showed that at temperatures 1 to 10000 ^{o}C when pressures increase from 1 to 10000 bar, values of S and V decrease: at T=1°C, S=117.896 to 116.493 J mol^{-1}K^{-1} and V=55.616 to 55.288 cm^{3} mol^{-1}; at T=10°C, S=122.214 to 120.812 J mol^{-1}K^{-1} and V=55.626 to 55.301 cm^{3} mol^{-1}; at T=100°C, S=162.382 to 160.979 J mol^{-1}K^{-1} and V=55.755 to 55.427 cm^{3} mol^{-1}; at T=1000°C, S=387.825 to 386.423 J mol^{-1}K^{-1} and V=57.017 to 56.689 cm^{3} mol^{-1}; and at T=10000°C, S=823.478 to 837.076 J mol^{-1}K^{-1} and V=69.639 to 69.310 cm^{3} mol^{-1}. C_p values increase as temperature increase from 1 to 10000 ^{o}C: 132.395 J mol^{-1}K^{-} at 1 bar, 135.011 J mol^{-1}K^{-1} at 10 bar, 155.391 J mol^{-1}K^{-1} at 100 bar, 202.594 J mol^{-1}K^{-1} at 1000 bar, and 224.308 J mol^{-1}K^{-1} at 10000 bar. We hope that availability of wide range of thermodynamic properties of will help design better physico-chemical models of sphene.

Thermodynamic properties of muscovite at temperatures of 1 to 1000 ^{o}C and pressures of 1 to 1000 bar

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Thermodynamic properties of muscovite including G (Gibbs energy), H (Enthalpy), S (Entropy), Cp (Heat capacity at constant pressure), V (Molar volume), dCp/dT, dV/dT, dV/dP, d2V/dT2, d2V/dTdP, and d2V/dP2 have been computed using the MELTS program. To cover wide range of conditions, temperature ranges of 1 to 1000°C and pressure ranges of 1 to 1000 bar have been used in the experiments. Our computations showed that at temperatures 1 to 1000 ^{o}C when pressures increase from 1 to 1000 bar, values of S and V decrease: at T=1°C, S=266.874 to 266.402 J mol^{-1}K^{-1} and V=140.757 to 140.516 cm^{3} mol^{-1}; at T=10°C, S=276.811 to 276.339 J mol^{-1}K^{-1} and V=140.799 to 140.558 cm^{3} mol^{-1}; at T=100°C, S=370.954 to 370.483 J mol^{-1}K^{-1} and V=141.224 to 140.983 cm^{3} mol^{-1}; and at T=1000°C, S=942.945 to 942.474 J mol^{-1}K^{-1} and V=145.475 to 145.234 cm^{3} mol^{-1}. C_p values increase as temperature increase from 1 to 1000 ^{o}C: 304.209 J mol^{-1}K^{-} at 1 bar, 311.082 J mol^{-1}K^{-1} at 10 bar, 370.736 J mol^{-1}K^{-1} at 100 bar, and 532.841 J mol^{-1}K^{-1} at 1000 bar. We hope that availability of wide range of thermodynamic properties will help design better physico-chemical models of muscovite.

Crystal structures of olivine group minerals

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In this study, crystal structures of 88 olivine group minerals from different environments have been calculated. Tables showing structure of olivines are composed of nine columns. Column 1 lists the formula of oxides concerned. Column 2 lists the composition of the mineral expressed as weight percentages of the constituent oxides. Column 3 shows molecular weight of oxides concerned. Column 4 is derived by dividing weight percent of each oxide to molecular weight of the oxides. Column 5 is derived from column 4 by multiplying by the numbers of oxygen atoms associated with each of the element concerned and at the end of column 5, the total (Σ) is calculated. Since olivine formula is calculated based on 4 oxygen atoms, this is performed by multiplying each oxide by 4. Column 7 lists the elements used in structural calculations of olivines. Column 8 gives the number of cations associated with oxygens in column 6. For divalent ions the column 8 is equal to the column 6; for monovalent ions the column 8 is equal to twice as the column 6; and for trivalent ions the column 8 is equal to 2/3 of the column 6. The column 8 includes adjusted number of ions in the formula assuming the total number of ions in the tetrahedral sites is 8. Column 9 consists of the number of ions in the formula. Analyses include basic plutonic rocks (20 analyses), volcanic and hypabissal rocks (26 analyses), magmatic rocks of granites, syenites, and pegmatites (10 analyses), metamorphic rocks (16 analyses), and ultramafic rocks (16 analyses). Crystal structure analyses of olivine group minerals include forsterite (Fo_{100-90}, a total of 21 analyses), chrysolite (Fo_{90-70}, a total of 29 analyses), hyalosiderite (Fo_{70-50} a total of 11 analyses), hortonolite (Fo_{50-30}, a total of 6 analyses), ferrohortonolite (Fo_{30-10}, a total of 6 analyses), and fayalite (Fo_{10-0}, a total of 15 analyses).

Crystal structures of garnet group minerals

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Crystal structures of a total of 110 garnet group minerals have been calculated. Tables showing structure of garnet are composed of nine columns. Column 1 lists the formula of oxides concerned. Column 2 lists the composition of the mineral expressed as weight percentages of the constituent oxides. Column 3 shows molecular weight of oxides concerned. Column 4 is derived by dividing weight percent of each oxide to molecular weight of the oxides. Column 5 is derived from column 4 by multiplying by the numbers of oxygen atoms associated with each of the element concerned and at the end of column 5, the total (Σ) is calculated. Since garnet formula is calculated based on 24 oxygen atoms, this is performed by multiplying each oxide by 24. Column 7 lists the elements used in structural calculations of garnet. Column 8 gives the number of cations associated with oxygens in column 6. For example, for SiO_2 there is one silicon for 2 oxygens so the column 6 entries are multiplied by 1/2; for Al_2O_3 there are 2 aluminiums for every 3 oxygen so the column 6 entries are multiplied by 2/3. For divalent ions the column 8 is equal to the column 6; for monovalent ions the column 8 is equal to twice as the column 6; and for trivalent ions the column 8 is equal to 2/3 of the column 6. The column 8 includes adjusted number of ions in the formula assuming the total number of ions in the tetrahedral sites is 8. Finally, the column 9 consists of the number of ions in the formula. Crystal structure analyses of garnet group minerals include pyrope (20 analyses), almandine (22 analyses), spessartine (20 analyses), grossular (18 analyses), andradite (20 analyses), and uvarovite (10 analyses).

REMOTE SENSING

Preperation of the instability risk map using image processing techniques in Altındağ (Ankara) settlement region

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Today, most of the metropolitan areas are facing the problem of squatter development, including Ankara, the capital city of Turkey, is. Altindag, at the central part of Ankara, is a typical settlement area where there is a great number of squatters which have been built unconciously in the old andesite quarries and in their vicinity. The rock type observed in the area is vertically jointed andesites which form steep topographical features.

The aim of the present study is to determine the probable modes of instabilities using kinematic analysis technique, and to prepare the map of instability risk of the region using DEM after the assessment of the results of these analyses. For this purpose, observations, measurements and sampling were carried out during field studies. Joints could be grouped under three main discontinuity sets: 74/220, 76/312/ and 79/026. The modes of instability each were estimated by kinematical analyses using the so determined joint sets. It was seen that, planar, wedge and toppling types of instabilities could be kinematically possible for different joint and slope orientations in the study area. The shear strength parameters are determined in laboratory by direct shear tests. Results of kinematical analyses were adopted to the DEM using image processing techniques and assessed for the each type of instabilities. Later, an instability map prepared by digital combination and it indicates that the areal distribution of instability risk for each type obtained as toppling 39 %, wedge type 19 %, planar 1 %, stable 41 %.

Rock type versus settlement: A GIS application in Çankırı province

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Relationship between the rock types and settlements in Çankırı province is investigated using a database generated from the existing data. The database includes detailed information about rock types (lithology), settlements (all minor and major), and the landscape.

Lithological information is derived from digital geological maps obtained from MTA. Original 97 different rock types are simplified into 8 categories, which are alluvium (Quaternary), soft clastics (Pliocene), layered clastics (Oligo-Miocene), hard clastics (Ordovician to Oligocene), volcanics (Jurassic to Miocene), carbonates (Devonian to Quaternary), Melange (Permian to Eocene) and metamorphics (Precambrian to Triassic). Settlement information consists of UTM coordinate, slope, aspect and elevation measurements of about 900 settlements read from 1/25.000 scale topographic map. Landscape information consists of slope, aspect and elevation of the area derived from 500 m grid spacing raster file.

Algorithm of the investigation involves following steps: 1) Regional elevation, slope and aspect values for the landform are obtained from grid data, 2) Elevation, slope and aspect values of the settlements are read from topographic maps, 3) Corresponding histograms of these values are subtracted from each other to define the threshold values, 4) Rock units which are out of threshold values are discarded from digital geological map, 5) Frequency of settlements is analyzed for each rock category within the final map. The results show that the most preferred lithologic units are alluvium and hardclastics. The least preferred rock units, on the other hand, are layered clastics and volcanics.

Enhanced lineament analysis and deformation modeling of active tectonic zones using satellite imagery, 17th August İzmit earthquake (MW: 7.4) region

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The 17th August 1999 Izmit earthquake (Mw: 7.4) was the largest and the most destructive earthquake in Turkey for the last 60 years. Here we show that remote sensing can provide conclusive evidence for the identification of seismogenic structures. Remote sensing and digital elevation model analysis complimented by geological structure have resulted in a new interpretation of the 17th August 1999 İzmit earthquake area.

This study is part of a larger effort to fully understand the tectonic character and its geomorphologic responses that have shaped the earthquake area. We used a conservative approach, limiting our interpretation to macro-lineaments and to clearly recognizable units. It is now clear that the fault produced permanent and recognizable effects on the landscape. This paper describes lineaments and geomorphologic units delineated from digital satellite images and Digital Elevation Model (DEM) of the earthquake area. In order to understand the relationship between tectonic structures and present-day topography, an analysis of topographic features has been carried out. In this way, a Digital Elevation Model (DEM) has been produced from the 1:25000 scale digital topographic maps. Then, LANDSAT TM and ERS SAR image data imagery and Digital Elevation Model were combined.

Both DEM and digital satellite imagery (LANDSAT TM and RADAR) express landforms and have synoptic views permitting detailed mapping of the neotectonic features over large surfaces, giving the geometry of the regional deformation. As a complement, field study analysis provides information on the mechanism of the deformation.

Assessing soil moisture associated with seismic activity causing destructions in the alluvial basins of the Northwest of Anatolia using landsat TM/ETM Satellite imageries

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The aim of this study is to find out the seasonal surface temperature changes and get information on the soil moisture based on the evaporative cooling principle of the damp ground in the alluvial basins (Düzce, Adapazarı, İzmit, İznik, Gemlik, Geyve, Bursa, İnegöl, Yenişehir, İnönü-Eskişehir-Alpu and Gölpazarı) of the northwest of Anatolia using the Landsat TM/ETM satellite imageries.

In this investigation, Landsat-5 TM and Landsat-7 ETM satellite data acquired on 12.10.1990, 27.03.1999, 10.08.1999, 18.08.1999 and 27.09.1999 and having path 179 and row 32 with 30 m resolution were used. These digital data were rectified to the UTM projection system by using image processing software. Then, the alluvial basins were limited and the spatial enhancement techniques were applied on the these limited areas. By resorting to the pixel values, the alluvial areas were density-sliced and color-coded for displaying the surface temperature (soil moisture) classes.

The alluvial basins in the northwest of Anatolia are controlled by the active faults and have ground water levels fairly closing to the surface, and these basins are suitable to the liquefaction. According to the analysis results of the satellite data acquired by the different dates in 1999, the soil moisture is at the top level in the spring season in these basins. The soil moisture decreases towards the summer and fall seasons. The 17 August 1999 Marmara and 12 November 1999 Düzce earthquakes in the northwest of Anatolia were happened in the lowest soil moisture periods. In case the earthquake takes place during the high soil moisture period, it is a high probability that the life and the property losses can be much more than before.

A lineament analysis using Landsat TM data of Gölmarmara/Manisa region, Turkey

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A lineament analysis using a Landsat Thematic Mapper (TM) dataset of the Gölmarmara (Manisa) region was performed to identify linear geologic features that could be attributed to paleotectonic and/or neotectonic structures. The main lithologies found in the area are metamorphic rocks of the Menderes Massif, carbonates of the Jurassic-Cretaceous, Izmir-Ankara Zone melange of the Campanian-Danian and Neogene units. In terms of being in a part of an ancient suture zone of the Neo-Tethyan ocean during the Post Eocene-Pre Miocene period and being in a continental extensional tectonic zone since the Middle Miocene, the region represents many structural features. Digital image processing and interpretation techniques were used to enhance these structures using the TM dataset. Directional edge enhancement and shaded relief techniques utilizing convolution kernels were applied to the band 5 of the TM data. Structural features enhanced with NW-SE, NE-SW, N-S and E-W directional filtering and illumination directions were analyzed and interpreted in the light of paleotectonic and neotectonic evolution of the region. Initial results indicated that extensive NE and NW trending lineament systems have developed in the region. Most of the NW trending lineaments are associated with recent normal faults, which are connected to the extensional regime of the western Anotolia after the Middle Miocene period. On the other hand, some NE trending lineaments may be correlated whith the thrust faults associated with the closing of the İzmir-Ankara ocean during the Upper Cretaceous-Late Eocene period. Moreover, the results showed that the lineaments mapped using the TM data are highly correlated with the recent geological findings of the western Anatolia tectonics.

The interpretation of lineament and rock units by spot XS image: An application to İsparta angle (SW Turkey)

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Isparta Angle (IA) is situated in the critical junction point of the western Taurides Belt, Turkey. Particularly extention-related structural lineaments of Neo-tectonic period play an important role on the geotectonic evolution of the region.

Two important subjects have been evaluated by using the SPOT XS colour infrared composites. The first is the lineament related to tectonical regime of the region. Lineaments also signify good relation between volcanism and tectonic-control.

The second is the rock units associated with petrography and stratigraphy of the Isparta Angle.

To interpret the relationship between geological units and lineaments, morphology, colour tone, drainage system and vegetation cover have been analyzed on the image. 20 autochthonous and allochthonous geological rock units and main the directions of structural lineaments have been defined. NE-SW, NW-SE and, the results N-S directions are the general orientations of structural pattern and coincide with the previous studies.

The application of Disaster Information System (DIS) for earthquakes by using Geographical information system (GIS) with special reference to the settlement area of Burdur province

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In this study, Burdur province is chosen as a study area since Burdur lies on a big fault zone and considered to be located on a highly risky earthquake zone.

Initially the maps (on 1/5000 scale) of the settlement area of Burdur province were digitized by using ArcInfo 7.2.1 version in this study. Some important buildings such as hospitals, factories, fire brigades, and some schools on the most risky areas were incorporated into 3 dimension (3D) forms by using ArcView 3.2 version, then database was prepared for these buildings. For instance, the number of doctors, nurses, trained nurses and beds at the hospitals and also the number of ambulances, fire engines and food factories were processed into the database.

The most risky areas and the areas suitable for settlement were identified by using the avaliable maps of engineering geology and liquefaction. Therefore, the database of the schools on the most risky areas was prepared, in which the number of students and personnel, starting and closing times of the schools were processed into the database. Furthermore, the roads in active use and their alternatives in case of the damage at the eartquake were also identified.

One of the main features of the ArcView program is that data can be formed as seperate layers and those wanted layers can be used for certain purposes. Moreover, by using these layers, queries can be made seperately, together and bilaterally.

After all these data entry, in the case of an earthquake the queries can be performed to determine the shortest possible road to the hospitals, the area for tents, the roads for fire-engines and ambulances and the roads for the casualties to be taken to which hospitals.

In conclusion with this study, DIS can be very useful tool to determine the possible relief points in an earthquake risky areas. It can also be used for other type of disasters and other regions at risk.

Mineral exploration by remote sensing and GIS Techniques in a densely vegetated area on the coast of the Black Sea in Northeastern Turkey

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This study aims mineral exploration using remote sensing (RS) and geographic information system (GIS) techniques in a densely vegetated area. Landsat TM and Jers-1 satellite data, and digital terrain model (DTM) have been used in the analyses. The study area is located from Ordu to Artvin on the coast of the Black Sea in northeastern Turkey.

The study area, which belonges Pontides geologically, are mainly composed of granite intrusions and acidic to basic volcanic rocks from Poleozoic to Eocene ages. The study area has the most important massive sulphide deposits of Turkey related with magmatic arc of Late Cretaceous time. Lineaments and annular structures have been extracted using satellite and multi angle shade images at first stage. In order to avoid the variation of extracted lineaments by the direction of the light source, multi angle shade image was developed by DTM. Three main periods of tectonic movement have been determined and known mineralizations have been compared with the direction of lineaments and annular structures. GIS techniques such as overlay and buffer type analyses were applied to extract of the target areas for ore deposits. Due to being of the dense vegetation in the study area, spectral information and alteration mapping could not be extracted. It is studied the erosion level using DTM data so that the difference of erosion can be figured out from the difference of denudation calculated by the DTM because the degrees of regional alteration are different according to the rock types.

Drainage systems were analysed by drainage pattern and drainage density. About 30000 drainage line was extracted by automatic methods using DTM. The relation between drainage system and structure and tectonic movement was studied.

On SAR images, high order processing also were carried out by DTM; evaluation of effectiveness of lineament interpretation by ortho projection conversion, development of topography correction of backscattering values, and possibility of distinguishing the roughness caused by difference of geology by backscattering characteristics. The result indicated that it is not possible to distinguish geologic units from backscattering values in this area.

In this study, altitudinal dispersion anomaly maps and some new developed methods of analyzing topography-geology-tectonic movement using DTM were applied and it became available to extract information which were not possible by conventional satellite data processing methods. Therefore, some new locations may be one of the high potential target areas for massive ore occurrences have been determined using these methods and GIS techniques.

Morphotectonic features of the Armutlu Peninsula: A Remote Sensing and GIS based approach

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The Armutlu Peninsula, Nortwestern Turkey, is delimited by two main branches of the North Anatolian Fault, main branch to the north, and Mekece-Sapanca-Gemlik branch to the south. The Peninsula itself consists of two main morphotectonic entities: Samanlı Mountains in the south and shore part facing to the Gulf of Izmit to the north.

The Samanlı mountain is an east-west trending mountain range which is a high plateau reaching up to 1100 metres. The basement of the Samanlı Mountains consists of different rock groups, pre-Upper Cretaceous metamorphic, magmatic and ophiolitic rocks of different origin and their common cover represented by Upper Cretaceous to Eocene sedimentary and volcanic rocks. The youngest rocks on this plateau are Miocene and Pliocene lagoonal and fluvial sediments.

Northern part of the Samanlı Mountains is delimited by strike slip faults with normal fault component. These faults controlled the deposition of Pliocene-Pleistocene alluvial fan deposits. During the Plio-Quaternary some large deltas developed along the northern shore of the Armutlu Peninsula, such as Hersek and Laledere deltas.

In this study SPOT and LandSat images of the Armutlu Peninsula were analysed by using remote sensing methods. The morphology of the region is analysed by using digital elevation data. All these data were combined with detailed geology, geomorphology maps in a GIS environment. In this paper we present these data and we propose a model for the morphotectonic evolution of the region.

Using optical and radar images in the classification and monitoring the coastal zones: A case study on the Sea of Marmara

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Information on the location and evolution of coastline and the overall coastal zone is valuable for scientific and practice applications such as monitoring coastal environment, morphodynamics, sediment transportation, mapping shallow bathymetry and detecting flood prone regions. Assessment of a complete coastal zone management system (CZM) requires a well-builded and periodically updated database that can be created accurately using multi-temporal satellite imagery.

In this study a combination of several image processing and classification algorithms were applied to satellite images acquired from different platforms. These data were combined and analyzed to contribute a coastal zone management system for the Sea of Marmara. In order to achieve the relationship between the tectonic pattern and coastline geometry for the region, terrain morphology and lineaments analysis were also performed.

Part of the study area (Gulf of İzmit) is located in a highly active tectonic region and the effects of 17th August 1999 earthquake over the coastline is investigated using phase preserved SAR imagery and digital terrain models.

The investigation of the Marmara earthquake effects using Landsat TM/ETM: Fault, fracture and lineament analyses by RS and GIS techniques

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The aim of this study, which is a part of the project of "The Investigation of the Marmara Earthquake Effects Using Landsat TM/ETM and ERS Satellite Data", is to determine the Neotectonic faults and fractures which are active/non-active and lineaments using RS and GIS techniques. In this investigation, Landsat-5 TM and Landsat-7 ETM satellite data acquired on 12.10.1990, 27.03.1999, 10.08.1999, 18.08.1999 and 27.09.1999, and have path 179, row 32 with 30 m resolution were used.

The study area, which fits to the image boundaries, approximately covers from 28º 45' E to 31º 30' E longitudes and from 39º 30' N to 41º 15' N latitudes by a partly rotated position.

The satellite data were rectified to the UTM projection system by using image processing software. Then, the data were analyzed using GIS softwares. The Neotectonic faults and fractures, which some are active and some are non-active, and lineaments were extracted visually by the knowledge-based methods using image-processing programs. The difference of the azimuth and incident angles of the sun in different seasons has got great advantages in the interpretation by the geological sense of the images. The data of the epicenters of the earthquakes that occurred in the last century have been obtained from Kandilli observatory via Internet, and adopted and classified according to their magnitudes and dates in GIS environment. Lineaments and earthquake epicenters were overlaid and analyzed visually. The fractures of Gölcük (İzmit) earthquake, which occurred on 17.08.1999, and Düzce earthquake, which occurred on 12.11.1999, were mapped by the ground-truth studies using GPS, satellite images and aerial photographs. The principal GIS analyses such as overlay and buffer were performed using earthquake epicenter and lineament coverages.

Therefore, the amount of epicenters, which fall inside the buffer zones of lineaments, were calculated and tried to evaluate whether they are active or not. The shoreline changes have been determined and the reason of subsidence in the coast has been found out. Besides, the transverse fractures, which dominated along the main branches of North Anatolian fault were extracted, and was emphasized that they could be effective in occurrences of earthquake damages.

Application of GIS and remote sensing techniques in the investigation of geologic-morphologic factors in western Black Sea region of Turkey

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Landslides, except for eartquakes, are the most destructive natural hazards in Turkey.They claimed the lives of many and caused economical last in the past. Because of its geological, morphological and meteorological characteristics, the study area has been suffering from these natural hazards for centuries. On the other hand, forthelast two decades because of the increase in population, subsequent human activities and unconciously made site selections, these natural events consequently became more destructive, like a disaster.

The study area, covering approximately 9200 km^2, is located at the northwestern part of Turkey and includes Karabük, Bartın, and Zonguldak cities.

In this study, it is aimed to evaluate the western Black Sea Region for the determination of potential areas of future hazardous landslides. The factors affected the previous lanslides are determined in order to evaluate where and when these events may occur in the future.

In this study; main factors that influence the landslides, including local geology, slope, aspect ratio, vegetation and precipitation are considered with the use of Geographical Information System (GIS) and Remote Sensing (RS) techniques. A layer zone is assigned for each factor to prepare potential lanslide susceptibility map.

It is determined that landslides commonly occur in area where flyschoidal the Çaycuma and Ulus formations expose. This makes-up approximately 35 % of the study area. The slope and aspect ratio maps are prepared from Digital Elevation Model (DEM) by digitizing six 1/100 000 scale topographic maps of the region. It is concluded that the areas where slope angles varies between 11-20^0 are more susceptible for landslides. Landslides occur in the lower angles according to this evaluation. Residual soil from weathering of bedrock cover these areas which are commonly used for agricultural purposes. On the other hand, the areas of steep topography are least susceptible for landslides because of unweathered bed rock exposures and dense vegetation. It is found that the slopes facing to the north are more susceptible to the landslides due to high precipitation rates coming from the north. In the present study, it is once again confirmed that landslides in regions of no vegetation and intense agricultural activities are more destructive then the areas of dense vegetation. In the Western Black Sea region has a humid climate and type of precipitation that may initiates landslides are divided into two groups: (1) sudden (violent) and (2) continous. Accordingly, the precipitation data of the region is statistically modeled in order to estimate the timing of precipitation that may lead to landslides.

Landslide susceptibility map has been prepared by giving relative susceptibility coefficients between 1 and 4 degrees for each investigated factor. Besides, the repitation of the precipitation amounts triggering the landslides have been estimated by modeling of precipitation data.

Regional Lithosphere Study on the Base of Remote Sensing Methods

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Remote geological mapping is a progressive method of regional geological investigations (RGR). Remote geological mapping consists of the geological models making on the basis of information obtained from satellites and Earth crust structure data acquired by traditional methods (geological, geophysical, geochemical etc). This specialized form of RGR should be carried out at the scale of 1: 500 000 – 1: 200 000 and in some cases at the scale of 1: 100 000. New geological models are appeared in a result of remote geological mapping. These models are the basis of tectonic, geodynamic, engineering–geological, geomorphologic, environment geological and other constructions and these new geological models are helpful in caring out the geological survey and mineral prospective works.

Investigations on overland control of geological objects revealed using remote sensing techniques and complex analysis of geological and geophysical materials are reasonable in future. These studies show the nature of interpreted objects, determine their relationship with possible ore occurrence, potential oil and gas structures and the perspectives of search works. The overland control of geological objects revealed using remote sensing techniques will allow to determine the informativity of remote sensing materials, will help to work out geoindicational methods of neotectonic investigation and deep structure of the area of ancient glaciations.

PALAEOMAGNETISM

Palaeomagnetism of the Cappadocian ignimbrite succession and neotectonic deformation in central-southern Anatolia

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The ignimbrite succession of Cappadocia comprises 9 major calc-alkaline rhyolite sheets emplaced at 1-2 Ma intervals between 11.2 and 1.1 Ma during the last phase of Neotethyan subduction during final stages of Tauride collision. Magnetic remanence resides primarily in Ti-poor titanomagnetites although secondary processes within the sheeets have produced composite ferromagnetic signatures and local hematite formation. Anisotropy of magnetic susceptibility describes tensors mostly consistent with northwards and eastwards flow away from eruptive centres located by remote sensing. The oldest ignimbrites from the Cardak Centre are all of normal polarity. Younger ignimbrites from the Derinkuyu Centre comprise the Sarimaden (R), Cemilkoy (R), Tahar (R), Kiziklaya (R), Incesu (N) and Valibaba-Sofular (R). Magnetisation directions are rotated anticlockwise and imply a mean rate of rotation of ~1.5º/Ma from 8-1 Ma B.P. with an acceleration during the last 1 Ma. The mean regional rotation of 9±5°/Ma is consistent with the pattern of distributed neotectonic rotation across south-central Anatolia which diminishes progressively from 30-50° anticlockwise close to the Arabian pincer to near zero west of the Cappadocian region. and then slightly clockwise at the eastern limb of the Isparta Angle. The regional pattern is a consequence of southwestwards extrusion of Anatolian crust and expansion of the curvature of the eastern Taurides. We also report paleomagnetic results from the young volcanics field east of the Adana (Bruhnes epoch, rotated slightly clockwise), at Karantas on the Gulf of Iskenderum (reversed, rotated clockwise) and the Karasu Valley which collectively define neotectonic deformation near the eastern extremity of the Cyprian Arc.

Neotectonic deformation at the western margin of escaping Anatolian terranes: a palaeomagnetic study of the Afyon, Isparta and Erenlerdağ volcanics

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The extrusion of Anatolian terranes to the westward of the Arabian pincer has resulted in complex and variable rotation of tectonic blocks. This can be monitored by study of the range of volcanic rocks that are widely distributed accross these regions. We have investigated the Erenlerdağ volcanics (eruptive over at 9.8 Ma and 2Ma), the Isparta volcanics (4.7-4.0 Ma), the Afyon volcanics (mostly Mid Miocene) and four volcanic suites near Kütahya (Mid Miocene and Pliocene). In contrast to the neotectonic (Mid Miocene and Younger) volcanic suites further to the east which are rotated variably anticlockwise in the Sivas Basin and Cappadocia, and just marginally anticlockwise at Karaman and Karapınar, these volcanics have been rotated by variable amounts clockwise since Pliocene times. Thus Anatolia between the NAFZ and EAFZ has not behaved as an integral plate. Crustal blocks on a scale of 10-100 km have been extruded to the south and west during the latest phase of neotectonic deformation and have had the net effect of expanding the curvature of the E.Tauride arc.

Palaeomagnetic study of the Western Anatolia: Block rotations and listric faulting

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The neotectonic regime of Turkey has started with the beginning of the collision between African-Anatolian plates along the Bitlis-Zagros suture zone. Since then, Western Anatolia has been effected by N-S compression, N-S extension and North Anatolian Fault Zone (NAFZ) shearing. So Western Anatolia is the most deformed area, effected by neotectonic regime, of Turkey.

In this study, volcanic lava samples aging from Oligocene to Pleistocene, collected from 210 different sites were sampled. After demagnetization, just only 18 of them have been rejected because of the unreliability. Rock magnetic studies show that the lavas have a ferromagnetic content dominated by low-Ti magnetite assemblages.

The palaeomagnetic results which have been obtained from Oligocene and Early Miocene aged lavas, show that the Western Anatolia and Greece have rotated ~30° clockwise as a single block. During late Miocene, the mean rotation was anti-clockwise. The changing in the rotation direction can be considered with the starting of the extensional regime. In Pliocene time, some palaeomagnetic sites which are fairly close to the North Anatolian Fault Zone show small anti-clockwise rotation because of the effect of the NAFZ. On the other hand, pure N-S extensional regime can be seen in the southwest Anatolia. After Pleistocene, there is no rotation in the Western Anatolia.

There is no clear evidence of latitudinal movement, due to the dispersion of palaeomagnetic inclinations. The differences between the palaeomagnetic inclinations can only be explained by listric faulting.

Geochronology, geochemistry and palaeomagnetism of Quaternary volcanics in the Niksar pull-apart basin: Implications to tectonics of the North Anatolian Fault Zone, Turkey

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The Niksar basin, sited on the eastern extension of the North Anatolian Fault Zone (NAFZ), is a young sigmoidal pull-apart basin bordered by two non-parallel master faults. The latter were associated with earthquakes in 1939 and 1942. The fault geometry along the irregular ENE margin of the basin is complex and young volcanic rocks reach the surface along pairs of steep strike-slip faults cutting the basin infill. High precision K-Ar dates on volcanics from the Niksar basin yield ages ranging from 542±9 ka and 567±9 ka. Volcanics in a comparable setting on the NAFZ further to the east in the Reşadiye area give ages around 315±7 ka. The Brunhes epoch lavas at Niksar record clockwise rotations of up to ~250º at the eastern margin of the pull-apart basin. Rotation of fault blocks on the scale of up to a few km has occurred at rates in excess of 5º/10,000 years as a result of dextral strike-slip between the master faults bounding the basin. Initiation of this sector of the NAFZ occurred prior to 600 ka, possibly in the Early Pleistocene. Young lavas associated with pull apart on the NAFZ are mainly of alkaline (sodium dominated) composition and include basaltic trachandesite (mugearite) and trachyandesite (benmoreite) with minor sub-alkaline compositions of andesitic dacite-dacite, rhyodacite and rhyolite. Despite the large compositional gap between basaltic and felsic lavas major and trace element distributions indicate co-magmatic origin for basaltic and felsic lavas. Abundances of major oxides and trace elements including the REE vary systematically through the compositional spectrum. Fractional crystallization of the observed phases accounts for the diversity of intermediate and evolved products. Amphibole fractionation in basalts at depth causes the trend towards silica saturation while alkali feldspar fractionation dominated the final stages of crystallization. Significant crustal contamination has occurred in the evolved magmas but contamination is generally minimal or absent in the basaltic parents. Alkaline basic rocks have trace element patterns of OIB affinity characterised by enrichment in LILE, HFSE, LREE and slight depletion in HREE relative to primitive mantle values. Overall geochemical characteristics are a result of the combined effects of different degrees of partial melting, fractional crystallization and variable degrees of crustal contamination.

Late Cretaceous palaeomagnetic data from Strandja, İstanbul and Srednagora Zones: Terrane emplacement and basin formation in the Western Black Sea

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The southwestern border of the Black Sea comprises three major lithostratigraphic tectonic divisions comprising the Istanbul Zone (a division of the Pontide Oregen), the Strandja Zone and the Srednagora Zone, a flysch-volcanic belt separating the Strandja Zone from the Moesian Platform. These divisions were juxtaposed during, and following, consumption of Neo-Tethyan Ocean between Cretaceous and Eocene times. To evaluate the palaegeography prior to this juxtapositioning we have investigated the palaeomagnetism of a range of Cretaceous volcanics. Palaeomagnetic samples from these Late Cretaceous rocks, show contrasting declinations between the three divisions: Group mean result for the Istanbul Zone are D=345°, I=42°, α_{95}=5.9° , Paleolatitude=24.2°N, N=16 , for the Strandja Zone D=26°, I=45°, α_{95}=11.0° , Paleolatitude =26.5°N , N=4 and D=0°, I=59°, α_{95}=2.3°, Paleolatitude =40.0°N, N=5 for the Srednagora Zone. These results imply that the Istanbul and Strandja Zones were nearly at the same paleolatitude during the Late Cretaceous but have rotated in opposite directions since then. The Srednagora Zone was originally sited some 14° (1750±750 km) north of the Istanbul Zone. The results define relative latitudinal motion between these divisions since closure of the Neotethys constrain tectonic models for opening of the Black Sea.

The Geoelectric and Geoelectromagnetic Studies in West Anatolian Grabens

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The electric and electromagnetic data have been measured by several organisations in major grabens in west and northwest Anatolia (Dikili,Gediz, Büyükmenderes, Gökova, Pamukova) mostly by the aim of geothermal prospecting. In this study some of these data sets are evaluated for understanding the structural features under these grabens. The results from our studies and knowledge from the other published data showed that some common structural features can be defined from resistivity distributions in the grabens using the geoelectrical data. The data mainly comes from direct current (DC) resistivity, magnetotelluric (MT) and controlled source audio frequency magnetotelluric methods (CSAMT). MT data from several parts of west Anatolia showed a lower crustal conductor. The depth to this conductor is 25-30 km in north west Anatolia (like in Gölpazarı-Pamukova) and it is 10-15 km in west Anatolia (like Gediz graben). The depth to the lower crust changes in west Anatolia along N-S direction and the depth to this conductor along the main axis of Gediz graben also varies in E-W direction from 7 to 15 km. DC resistivity MT and CSAMT data showed also an undulated character for the shallower layers such as the basement topography under the sedimentary fill of the grabens. The basement depth changes from a few hundred to a few thousand meters along the graben axis for all of the grabens and these can be interpreted as vertical geological contacts (like faults) perpendicular to the main faults forming the grabens.

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