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ABSTRACT BOOK

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PREFACE

The Organizing Committee wishes a warm welcome to all colleagues attending the “7th International Symposium on Eastern Mediterranean Geology” held on the campus of the Çukurova University, Adana, Türkiye from 18 to 22 October, 2010. Eastern Mediterranean region, which is limited by the Apennines to the west, the Carpathian and Caucasus to the north, the Zagros to the East and North Africa to the south, is an area uniquely placed to advance our understanding of the complexities of continental collision, accretion, volcanism, strike-slip faulting, crustal extension, seismicity and other geosciences branches.

Since 1992, the “Eastern Mediterranean Geology Symposium” has been held periodically at venues across Europe and Asia. The Organizing Committee is encouraged by the success of earlier sixth meetings on this theme. From the first conference, which was held in Adana (Turkey) in 1992, the event has been staged in Jerusalem (Israel in 1995), Nicosia (Cyprus – in 1998), Isparta (Turkey – in 2001), Thessaloniki (Greece – in 2004) and Amman (Jordan - in 2007).

Over the years the Eastern Mediterranean Symposium has been a major forum for scientists, engineers and other professionals and has provided many opportunities for experts to exchange their ideas and knowledge on diversified geology of the Mediterranean. During the symposium, the latest research in various aspects on Earth Sciences of the Mediterranean Region will be presented and discussed in an intimate and cordial atmosphere.

As we have stated earlier, the objectives of the symposium are;

- to serve as a center for gathering and updating the information and scientific knowledge and research on the Geology of Eastern Mediterranean Region and,
- to provide an overview of geological research currently being undertaken around the Eastern Mediterranean region,
- to provide a forum for earth scientists to meet and share or exchange their up to date research works and new findings.

We cordially hope that all scientists who have spared their invaluable effort for coming to this symposium or joining the symposium excursions would have the benefit not only from the new findings and friendship among the participants but would also gain the experience from the Turkish culture and hospitality.

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. Keynote lectures given by internationally acknowledged authorities have been scheduled as an introduction to each day's programme. The symposium will consist of three keynote talks and regular presentations. It is our privilege to have three distinguished invited speakers: Prof.Dr. Alastair ROBERTSON from the Edinburgh University, United Kingdom, speaking on the “*Melange Genesis in the Construction of the Anatolian Subcontinent*”, Prof.Dr. Roland OBERHANSKI from the Potsdam University, Germany speaking on “*Peritethyan High Pressure Belts*” and Prof.Dr. Erdin BOZKURT from the Middle East Technical University, Türkiye speaking on “*Synorogenic Eocene Extension and Extrusion Wedge Formation in the Southern Menderes Massif, Southwest Turkey: Insights From U-Pb and ³⁹Ar-⁴⁰Ar Geochronology*”.

The scientific programme has been built around 16 special symposia which will be held as three parallel sessions. The symposium will be attended by over 200 scientists from different countries. Oral and poster presentations are scheduled up to Wednesday. Poster presentations are scheduled during the day between 10:00 and 18:00 and usually follow the oral presentations

for a given symposia or session. Post-Symposium excursions are scheduled on Thursday and Friday. The organizing committee of the 7th International Symposium on Eastern Mediterranean Geology (ISEMG) have provisionally agreed on a special issue on Turkish Journal of Earth Science. The selected original studies which are going to be presented during the symposium, will be published on a Special Issue of Turkish Journal of Earth Sciences.

We hope that the success of this meeting will contribute to a fuller understanding and appreciation of the Geology of Eastern Mediterranean region. We also trust that it will lead to new collaboration among those interested in the geology of this important region. Last but not least, I would like to express my sincere gratitude to the members and supporting staff of the Organizing Committee, the Scientific Committee, the member of 7th ISEMG, various sponsorships, the keynote speakers and each individual who contribute their times and affords for this symposium. Without your significant effort this important scientific activity would not be possible. We wish you a very pleasant, interesting and successful meeting.

On behalf of the Organizing Committee
Prof.Dr. Ulvi Can ÜNLÜGENÇ
President of the Symposium

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KEYNOTES

KEYNOTE: MELANGE GENESIS IN THE CONSTRUCTION OF THE ANATOLIAN SUBCONTINENT

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Melanges can be defined as chaotically deformed blocks with, or without, a matrix and may be of tectonic, or sedimentary origin, or both. Classic examples throughout Anatolia have mainly Carboniferous (Konya-Teke Dere-Karaburun), Late Triassic (Karakaya), Late Cretaceous (e.g. Ankara), Eocene (Pontides) and Oligo-Miocene (Misis-Andırın) ages of formation. The mélanges reflect contractional processes and delineate convergent plate margins or suture zones. Carboniferous melanges record southward (?) subduction of "older Palaeotethys" beneath the N margin of Gondwana. U. Triassic melanges reflect late-stage northward subduction of "younger Palaeotethys" beneath Eurasia. U. Cretaceous melanges record northward subduction of Mesozoic oceanic crust; i.e. Ankara-Izmir-Erzincan ocean in the N (e.g. Domuzdağ Melange, central Pontides; Ankara Melange) and S Neotethys in the south (e.g. Berit Melange). Eocene mélanges in the Pontides reflect final closure of the Izmir-Ankara-Erzincan ocean. Oligocene-Lower Miocene melanges in SE Turkey (e.g. Killan Melange) document later-stage subduction/closure of the S Neotethys. The melanges typically document interaction of *both* tectonic *and* sedimentary processes. Tectonic processes include frontal accretion, forearc subcretion, subduction channel mixing, high pressure/low temperature metamorphism/deformation (e.g. Anatolide mélanges), exhumation; also, re-imbrication to maintain a critical taper. Sedimentary processes include collapse of seamounts/continental margins into subduction trenches (e.g. Carboniferous mélanges), reworking as debris flows in trench/forearc basin settings (e.g. U. Cretaceous Anatolide mélanges), also genesis of large-scale collision-related mega-debris flows, e.g. driven by seamount-trench collision (e.g. U. Triassic Karakaya melange), trench-passive margin collision (e.g. U. Cretaceous Tauride melanges), or continent-continent collision (e.g. Eocene Pontide mélanges and Oligo-Miocene S Neotethyan mélanges). Important controls of the melange genesis include: 1. Subduction setting, either continental margin or oceanic, with e.g. Carboniferous melanges representing near continental margin subduction with high terrigenous input, compared to e.g. some U. Cretaceous melanges that formed in sediment-starved more oceanic settings. 2. Age of subducting oceanic lithosphere: older ocean (e.g. Carboniferous mélanges), was more easily subducted than young, buoyant, ocean (e.g. some U. Cretaceous mélanges); 3. SSZ-type oceanic lithosphere: where present dismembered ophiolites including mantle rocks were accreted (e.g. U. Cretaceous Ankara Melange); 4. Igneous seamounts or continental fragments; where present (e.g. U. Triassic Karakaya melange; U. Cretaceous Ankara melange) large volumes of ocean-island-type volcanics, cover sediments and flank facies were accreted. 5. Large-scale plate dynamics; slab roll-back favoured accretion but slab roll-forward subduction erosion. The normal condition was non-accretion such that melange genesis was skewed to exceptional geological settings (e.g. collision of plume-type seamounts or SSZ-type oceanic lithosphere with subduction trenches). Melanges generally lack incorporated oceanic lithosphere in cases where the subduction décollement was located at a high structural level in the subduction trench.

Keywords: melange, olistostrome, Anatolia, tectonics

KEYNOTE: PERITETHYAN HIGH PRESSURE BELTS

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In Turkey, unlike the Dinarids and Hellenids, ophiolite obduction occurred during the Late Cretaceous rather than in Late Jurassic times, which suggests a major along strike change somewhere between the Cycladic Islands and the Anatolian peninsula. The ways of imbrication of the Anatolides-Taurides tectonics units, are often matter of debate. Particularly, the number and position of former oceans is questioned. Recent studies in the Anatolide Tauride Block show that Alpine subduction-related HP-LT metamorphism is not restricted to the northernmost Tavşanlı Zone, but is actually widespread in the tectonic slices of Tavşanlı Zone, Afyon Zone, Menderes Massif and Lycian Nappes. These blueschist-facies metamorphism occurrences spark the debate on the Alpine evolution of this region. Fe,Mg-carpholite bearing rocks occur not only in its central part of the Afyon Zone, but South of the Central Anatolian Crystalline Complex, all along from the Menderes Massif to East of Kayseri. These occurrences are closely related to the glaucophane- lawsonite-bearing rocks of the Tavşanlı as well as the Afyon zone

The two HP-very LT metamorphic belts occurring in Central Anatolia are separated by an low grade flysch. This flysch and the age difference between HP belts open the question of the number of subduction zones during Late Cretaceous - Early Tertiary in Central Anatolia. A two-subduction model could explain differences in metamorphic grades and ages but would leave the process dynamics open. The dynamic of a one-subduction model could be similar to the Aegean realm today. In this case, subduction roll back should explain the differences between Tavşanlı and Afyon Zone similar as the situation between Rhodopes and Tinos. There, again significant differences in P,T conditions and ages are obvious, while direct observation of contacts is hampered by the seas. Striking dissimilarities are also evident comparing the situation on Leros and in the Lycian realm.

In eastern Anatolia the collision of the Arabian Plate with Eurasia along the Bitlis-Zagros fold and thrust belt lead to the formation of a high plateau in Eastern Turkey. Metamorphic studies in the basement and cover sequences of the Bitlis Massif allow constraining the thermal evolution of the massif by metamorphic index minerals. A regionally distributed LT - HP metamorphic evolution is documented by glaucophane, relics of carpholite in the cover indicating that the Bitlis massif represents a terrane detached from the Arabian indenter that was stacked to form a nappe complex during the closure of the Neo-Tethys. Metamorphic ages for this blueschist metamorphism scatter around 70 to 80 Ma, while eclogites from the basement show ages of 80-85 Ma for the HP metamorphism. North of the plateau again blueschists characterize the Amasia suture zone. The continuation towards the Sanderman blueschist eclogites further to the east remains to be elucidated.

Keywords: Eastern Mediterranean, Neotethys closure, Blueschist metamorphic belts

KEYNOTE: SYNOROGENIC EOCENE EXTENSION AND EXTRUSION WEDGE FORMATION IN THE SOUTHERN MENDERES MASSIF, SOUTHWEST TURKEY: INSIGHTS FROM U-PB AND ³⁹AR-⁴⁰AR GEOCHRONOLOGY

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The southern Menderes Massif in southwest Turkey consists of mylonitic orthogneisses structurally overlying metasediments; both are intruded by leucogranites in the immediate footwall of a regional-scale ductile southern Menderes shear zone (SMSZ). These rocks display two distinct fabrics with differing vorticity: top-NNE thrust-related structures associated with the main Menderes metamorphism and overprinting top-SSW extensional shear bands. Detailed U-Pb LA-MC-ICP-MS geochronology on zircons and titanites and ³⁹Ar-⁴⁰Ar thermochronology on single grains of muscovite and biotite were performed to determine the precise timing of leucogranitic magmatism and extensional deformation in the southern Menderes Massif. A ca. 41 Ma ²⁰⁶U/²³⁸Pb zircon age obtained from a leucogranite is interpreted to mark the initiation of extensional deformation along the SMSZ, much earlier than previously thought. Regional constraints and correlations give evidence for the first time that the sub-massif experienced synorogenic extension which started by the middle Eocene (Late Lutetian). The massif was exhumed by the earliest Miocene (ca. 23 Ma) at the latest, as suggested by the oldest unconformable sediments.

The new ³⁹Ar-⁴⁰Ar mica ages reveal a minimum estimate of 48–35 Ma for syn-metamorphic thrust-related fabrics and 41–23 Ma for extensional structures. The combination of field and structural observations together with the integration of new and previously published age data suggests that top-SSW extension was partly coeval with the top-NNE thrusting during the 41–35 Ma interval. The obvious interplay between contraction- and extension-related fabrics in the massif is attributed to the excisement of the orthogneisses via both top-SSW normal faulting and top-NNE thrusting. In this model, the orthogneisses are bounded by the extensional SMSZ above and a thrust fault below; the thrust herein named as the Büyük Menderes thrust fault (BMTF) and is mapped along the northern margin of the Büyük Menderes Graben. The orthogneisses therefore are interpreted as the northward extruding wedge of remobilized Precambrian granites and their exposures represent the exposed core of a gneiss dome. The SMSZ and MNTF were active synchronously at ca. 41–35 Ma and accompanied the climax of crustal shortening. The intrusion of late middle Eocene leucogranites (ca. 41 Ma) marks the timing of partial melting and magma emplacement, which then weakened the crustal rocks and triggered/facilitated the transition from top-NNE thrusting to top-SSW extension. In this model, the SMSZ is interpreted as a reactivated structure, inversion of which might have occurred as a passive response to the formation of wedge extrusion.

Keywords: U-Pb (LA-ICP-MS) geochronology, ³⁹Ar-⁴⁰Ar geochronology, leucogranite, ductile shear, synorogenic extension, extrusion wedge, Menderes Massif, SW Turkey

ABSTRACTS

OPHIOLITES

GEOCHRONOLOGY OF TURKISH OPHIOLITES: LA-ICP-MS ZIRCON U-PB AGES FROM THE INNER TAURIDE AND BITLIS-ZAGROS SUTURE ZONES

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The Anatolian segment of the Alpine-Himalayan orogen comprises remnants of the Neotethyan oceanic basins, cropping out along E–W trending tectonic zones, between metamorphic massifs and/or platform carbonates. The remnants of the Neotethys, in a structural descending order, are characterized by ophiolites, metamorphic soles and ophiolitic melanges. These ophiolites and related subduction–accretion units were generated during the closing stages of the Neotethyan oceanic basins in Late Cretaceous. Well-preserved Neotethyan ophiolites in Turkey are of suprasubduction zone (SSZ) type. Late Cretaceous ophiolites in Turkey are mainly located in five zones; these are from north to south: a) Pontide ophiolites, b) Anatolian ophiolite belt, c) Tauride belt ophiolites, d) southeast Anatolian ophiolites and e) the peri-Arabian ophiolites. Important questions about the evolution of the ophiolites along the suture zones include: (i) the crystallization ages of oceanic crusts (ophiolites), (ii) the duration of magmatic activity and (iii) the timing of final emplacement.

The peri-Arabian ophiolites (Kızıldağ), the southeast Anatolian ophiolites (Göksun, İspendere and Kömürhan) and the Tauride belt ophiolites (Antalya, Mersin, Pozantı-Karsantı, Pınarbaşı and Divriği) were dated by LA-ICP-MS zircon U-Pb. The peri-Arabian ophiolites yielded 92.7 ± 2.9 Ma from the plagiogranites in Kızıldağ (Hatay) and 86.6 ± 3.2 Ma from the plagiogranites in Antalya. The southeast Anatolian ophiolites yielded 82.2 ± 1.9 Ma from the rhyolitic lavas in Göksun (Kahramanmaraş), 89.9 ± 1.6 to 87.2 ± 3.1 Ma from gabbros and 74.6 ± 4.4 Ma from rhyolitic lavas in Kömürhan (Elazığ). The Tauride belt ophiolites yielded 81.8 ± 4.3 Ma from the gabbros in Mersin, 70.9 ± 3.0 Ma from the gabbros in Pozantı-Karsantı (Adana), 65.4 ± 3.3 Ma from the diabase dikes in Pınarbaşı (Kayseri) and 90.6 ± 4.7 Ma from the gabbros in Divriği (Sivas). The measured ages on different parts of ophiolites along the Tauride belt indicate that the subduction-related magmatic activity started in Turonian and continued until the end of Maastrichtian before their emplacement onto the Tauride platform. Whereas the peri-Arabic belt ophiolites display relatively older ages for the timing of crystallization of the oceanic crust from Cenomanian to Coniacian. The southeast Anatolian ophiolites show crystallization ages of oceanic crust from Turonian to Campanian, that occupies a time span between the peri-Arabic and the Tauride belt ophiolites.

All the data shows that (i) the crystallization ages of the ophiolites are late Cretaceous in general, but display differences from one location to another, (ii) continuous magmatic activities were exist during the closure stages of Neotethyan oceanic basins in SSZ tectonic settings from 92.7 ± 2.9 to 65.4 ± 3.3 Ma, and (iii) emplacement of the ophiolites were in the latest Maastrichtian.

Keywords: U-Pb geochronology, Zircon, gabbro, plagiogranite, Taurides, Anatolia

TECTONIC SETTING OF OPHIOLITIC ROCKS FROM THE HEKİMHAN-KULUNCAK (MALATYA) REGION, SE TURKEY

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Previously little known but regionally important dismembered Neotethyan ophiolites (Kuluncak Ophiolite) are well exposed to the northwest of Malatya city in the Eastern Tauride Mountains. The ophiolites form the exposed basement of much of the area, while the Mesozoic Tauride carbonate platform is exposed to the west. Additional dismembered ophiolites are exposed along the southwestern margin of the Darende Basin ~70 km further west. Overall, the dismembered ophiolite can be restored as a typical ophiolite pseudostratigraphy with, in ascending order: mantle tectonites, ultramafic-mafic cumulates, isotropic gabbros, a sheeted dike complex, plagiogranite, extrusives and pelagic cover sediments. The contact relations between the subunits of the ophiolite are mainly tectonic. Some outcrops are dominated by tectonic melange, commonly made up of blocks of sheared pillow lava, lava breccia and radiolarites set in a matrix of mudstone and sandstone turbidites. The ophiolitic rocks are unconformably overlain by Maastrichtian post-emplacement clastic sediments (Karadere Formation).

The mantle tectonites of the ophiolite are represented by dunite, harzburgite and serpentinite, cut by isolated rodingitised dikes. The ultramafic-mafic cumulate rocks display cumulate structures including igneous layering, cross bedding, graded bedding, isoclinal folding and slump structures. The ultramafic cumulates are dominated by dunite, wehrlite and pyroxenite, whereas the gabbroic cumulates are represented by low-Ti olivine-gabbro and normal gabbro. The cumulate rocks show adcumulate, mesocumulate and poikilitic textures: the crystallization order of the cumulates is olivine±chromian spinel, clinopyroxene, plagioclase and orthopyroxene. Widespread alterations in the ultramafic and mafic rocks includes serpentinization, listvenitization and carbonatization. The major-element composition of the cumulate rocks is consistent with formation in an arc-related tectonic setting. The isotropic gabbros are represented by gabbroic, dioritic and quartz dioritic rocks with granular to ophitic-subophitic textures. The isolated dikes are made up of dolerite and microdiorite with ophitic, intersertal and microgranular texture. Widespread ophiolitic extrusive rocks are basaltic, with associated radiolarite, chert, pelagic limestone and hemipelagic mudstone. The mafic units of the ophiolite are tholeiitic (Nb/Y<1). N-MORB normalized multi-element and tectonomagmatic discrimination diagrams using immobile elements suggest that the ophiolitic rocks formed in a subduction-related tectonic setting.

The dismembered and melange-like nature of the ophiolitic rocks can be explained by subduction, tectonic accretion and southward emplacement over the Tauride carbonate platform during pre to syn (?) Maastrichtian time. The ophiolitic rocks can be correlated with the Pınarbaşı ophiolite to the southwest and with the Divriği ophiolite to the northeast. These ophiolites provide additional evidence of the existence of an Inner Tauride Ocean that was located between the Tauride Platform to the south and the Kırşehir Block to the north during Late Cretaceous time.

Keywords: Inner Tauride suture, Neotethys, Malatya, Ophiolite, Supra-subduction zone

FIRST EVIDENCE OF MIDDLE JURASSIC INTRA-OCEANIC SUBDUCTION GENERATED IN THE İZMİR-ANKARA-ERZİNCAN OCEAN, NORTHERN TURKEY

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The İzmir-Ankara-Erzincan suture zone contains ophiolite-related amphibolitic rocks near Çankırı. Amphibolitic rocks are represented by amphibolite, pyroxene-amphibolite and epidote-amphibolite. All amphiboles from the amphibolites are calcic and can be classified as tschermakite, tschermakitic-hornblende, magnesio-hornblende, pargasitic-hornblende, magnesio-hastingsitic hornblende, edenitic-hornblende to actinolite. The Çankırı amphibolite suite shows major, trace, and rare earth element characteristics of ocean island basalt/within-plate basalt and mid-ocean ridge basalt/back arc basin basalts. The amphibolitic rocks in this region have been dated in this study for the first time. Amphiboles from the amphibolitic rocks yielded $^{40}\text{Ar}/^{39}\text{Ar}$ plateau ages between 177.08 ± 0.96 Ma and 166.9 ± 1.1 Ma. These dates are interpreted as cooling age of the amphibolitic rocks. They differ significantly from ages of amphibolitic rocks (the metamorphic sole rocks) related to Turkish ophiolites. However, similar cooling ages were reported for metamorphic sole rocks of the Hellenic-Dinaric/Vardar ophiolites further west. The metamorphic sole rocks have been generated in intra-oceanic environments via intra-oceanic subduction events. The new age data of the Çankırı amphibolite suite suggest that the İzmir-Ankara-Erzincan ocean was subducted around Middle Jurassic times, i.e. roughly coeval with the Vardar/Pindos ocean. The new age data presented here could imply that Jurassic granites which cross-cut basement rocks of the Pontides are related to the northward subduction of the İzmir-Ankara-Erzincan ocean during Jurassic time.

Keywords: Ophiolite, $^{40}\text{Ar}/^{39}\text{Ar}$ dating, İzmir-Ankara-Erzincan ocean, Hellenic-Dinaric/Vardar ophiolites

THE TEMPORAL EVOLUTION OF ARC MAGMATISMS BENEATH THE TAURIDE ACTIVE CONTINENTAL MARGIN

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The Southeast Anatolian Orogenic Belt (SAOB) records well-preserved remnants of mountain building processes along the Alpine-Himalayan system. The evolution of the SAOB initiated with closure of the southern branch of the Neotethyan Ocean that is located between the Tauride platform to the north and Arabian platform to the south in late Cretaceous, and ceased by the continent-continent collision in Miocene. The tectono-magmatic/metamorphic units cropping out along the orogenic belt are key elements to better understand the evolution of the SAOB, which are located in Hatay-Kahramanmaraş-Malatya-Elazığ regions. These units are, structurally from top to bottom, a) metamorphic massifs, b) ophiolites, c) ophiolite-related metamorphic rocks and d) granitoids. The granitoids, which mark the Andean type active margin formation mainly in Late Cretaceous, crop out in three localities namely the Goksun, Doganşehir and Baskil regions. They intruded the metamorphic massifs, ophiolites and the related metamorphic rocks along the orogen. These granitoids are of typical I-type, calcalkaline Andean type volcanic arc granitoids. The LA-ICP-MS U-Pb zircon ages of the granitoids yielded 81.1 ± 2.2 Ma (2σ) for Esence (Kahramanmaraş) and 82.0 ± 1.2 - 84.6 ± 1.1 Ma (2σ) for the Baskil (Elazığ) localities. These crystallization ages show that the granitoid bodies intruded after the formation of oceanic crust in the southern Neotethyan oceanic basin (~ 90 Ma). Four zircon ages measured from Doganşehir (Malatya) vary between 54.9 ± 1.2 to 45.7 ± 1.0 Ma (2σ). These crystallization ages indicate that the northward subduction was still in progress during Eocene time. The Ar-Ar ages (amphibole-biotite) of the Doganşehir granitoid vary between 54.1 ± 0.99 to 48.3 ± 0.3 Ma (2σ). The Ar-Ar ages (amphibole-biotite-K-feldspar) in the Baskil granitoid vary between 84.0 ± 0.7 to 77.25 ± 0.42 Ma (2σ). The Ar-Ar ages (amphibole-biotite-K-feldspar) in the Esence granitoid vary between 85.3 ± 7.4 to 74.1 ± 0.29 Ma (2σ). All these data support that the granitoids have formed in different episodes and have individual cooling histories. To the west, the Esence granitoid was formed in Santonian and cooled through $\sim 200^\circ\text{C}$ in ~ 10 Ma. To the east, the Baskil granitoid was formed in Santonian and cooled through $\sim 200^\circ\text{C}$ in ~ 6 Ma. In the middle, The Doganşehir granitoid was formed in Early-Middle Eocene (episodic crystallization from Ypresian to Lutetian) and cooled through 300°C in ~ 1 Ma. Apatite Fission Track (AFT) samples were collected from these magmatic intrusions to find out the rate of the collision between Arabian and Tauride platforms. The ages are clustered in two groups, (i) Early-Middle Eocene and (ii) Middle Oligocene whereas one distinct sample yields 16.8 ± 1.8 Ma. The cooling models were made from track length (TL) and age data indicates that these apatite FT ages yield mix ages, whereas three cooling time span from crystallization to unroofing of the granitoids occurred in the region. First cooling phase is Late Cretaceous observed in Esence and Baskil granitoids interpreted as the continuous cooling of the granitoids after a shallow emplacement. Second phase is Early to Middle Eocene time span observed in all granitoids interpreted as the continuous cooling of the Doganşehir granitoid and uplift of the Esence & Baskil granitoids with a high uplift rate during an opening of Maden basin in the region. The last phase is the Late-Middle to Late Miocene time observed in all intrusions interpreted as the initiation and movement of the East Anatolian Fault Zone (EAFZ). The 16.8 ± 1.8 Ma age data collected on the fault zone interpreted as resetting by frictional heating during faulting.

Keywords: Southeast Anatolia, Granitoid, LA-ICP-MS zircon U-Pb, Ar-Ar, AFT, East Anatolian Fault.

TIMING OF PEAK VARISCAN METAMORPHISM OF A NE GONDWANA-DERIVED TERRANE IN THE ARTVIN-YUSUFELI AREA, NE PONTIDES, NE TURKEY: EVIDENCE FROM U-PB LA-ICP-MS DATING OF PARAGNEISS

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The northeasternmost Pontides region is a critical area to unravel the tectonic effects of the Variscan and Alpine orogenies in Turkey. A number of NW-vergent thrust sheets were finally emplaced onto the E Pontide autochthon in this area during Early Cenozoic time. Neotethyan ophiolites and melanges form the uppermost tectonic unit of the regional thrust stack. Beneath this, the thrust stack is divisible into the Lower and Upper Slice Complexes, extending for ~250 km (from Artvin to Bayburt area). The individual thrust sheets within the two slice complexes display coherent stratigraphies of Early Jurassic, Mid-Late Jurassic and Late Cretaceous-Mid Eocene ages, separated by unconformities that record important tectonic events. The Palaeozoic basement of these thrust sheets and the autochthon is made up of schists and cross-cutting Early Carboniferous (~325 Ma) granites. Here, we focus on the Late Palaeozoic basement exposed in one of the thrust sheets (Slice 3) of the Lower Slice Complex, which is represented by granulite-facies paragneiss, schist and migmatite. The unconformable Early Jurassic cover of this basement comprises siliciclastics and condensed, red Ammonitico Rosso pelagic limestones, passing up-sequence into volcanogenic facies. A total of 150 zircon grains were separated from one typical paragneiss sample. Cathodoluminescence images display metamorphic rims surrounding inherited cores. Most of the zircon grains reveal several stages of growth. In contrast, a few individual, rounded zircon grains appear as pale gray, structureless, or weakly zoned grains with Th/U ratios of < 0.1, suggestive of a metamorphic origin. U-Pb dating of the metamorphic rims (79 spot analyses) and individual metamorphic zircons yielded a concordant age of 332 ± 2.2 Ma, interpreted as the age of the peak Variscan metamorphism. The inherited cores of the zircons display oscillatory zoning that is typical of an igneous origin. The Th/U ratios of these zircon cores are > 0.1, compatible with an igneous origin. The ages of the inherited cores (115 spot analyses) range from 450-2700 Ma. Large populations in the data set occur at ~500-680 Ma and ~900-1100 Ma. Mesoproterozoic ages are noticeably absent, while there are a few grains of Palaeoproterozoic age (~1800 Ma and ~2600 Ma). The recorded age distribution suggests a correlation of the East Pontide high-grade metamorphic basement with the Arabian-Nubian shield of NE Gondwana where a similar age distribution has been recorded. We infer that the East Pontide basement represents part of an exotic terrane that rifted from NE Gondwana and later collided with the Eurasian margin where it underwent high-grade metamorphism at ~332 Ma (late Early Carboniferous) in response to closure of the Rheic Ocean. Cross-cutting post-collisional granites of ~325 Ma age could reflect delamination or exhumation processes.

ABOUT THE ORIGIN OF THE EASTERN CARPATHIAN MESOZOIC “OPHIOLITES” AND RELATED ROCKS

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In the Eastern Carpathians (Romania), Mesozoic ophiolitic and related rocks are found connected to Lower Cretaceous Wildflysch formation. These “ophiolites” form centimeter-sized clasts in breccias, as well as blocks ranging from few metres to a few kilometers in size. Lherzolites and harzburgites, FeTi gabbros, dolerites, basalts and andesites are the main lithologies. The volcanics consist of highly depleted basalts/andesites to enriched-type mid-ocean ridge basalts. They include as well as ocean island basalts and calc-alkaline basalts/andesites.

The Eastern Carpathians “ophiolites” were believed (see Săndulescu, 1984, and references therein) to have been formed in the Eastern Vardar Ocean (Main Tethyan Suture Zone). Thus, they should be at least partly time-equivalent to the Middle to Late Jurassic ophiolites and island arc volcanics (IAVs) from the Southern Apuseni Mts. (Saccani et al., 2001; Bortolotti et al., 2002) and from the basement of the Transylvanian Depression (Ionescu et al., 2009). The “ophiolites” were regarded to be thrust on top of the Eastern Carpathians Bucovinian Nappe during the Mid-Cretaceous orogenic events, as part of the so-called “Transylvanian nappes”. Some “ophiolites” were described as olistoliths in the Lower Cretaceous Wildflysch.

By contrast, Kozur (1991), Channell & Kozur (1997) and recently Hoeck et al. (2009) envisaged a Triassic age of the Eastern Carpathians “ophiolites” and a separation from the Southern Apuseni Mts. ophiolites and IAVs. Based on paleontological evidence, a Middle to ?Late Triassic age is assigned to most of the volcanics. Together with the new petrological and geochemical data, this allowed to develop a new model. It accounts for a Triassic ocean connected with the Meliata-Hallstatt Ocean, which would have been formed in Early Triassic and closed most likely in the Late Triassic to Early Jurassic. From this ocean, only an ophiolite complex together with ocean island basalts and calc-alkaline basalts/andesites are preserved. During or/and after the emplacement, the rocks were eroded and transported as blocks into the Lower Cretaceous Wildflysch basin. Subsequently, the sediments of this basin, including “ophiolites” and related rocks, were emplaced as an individual nappe, on top of Eastern Carpathians.

Keywords: Romania, Eastern Carpathians, Ophiolites, Triassic, Jurassic, Meliata Ocean, Vardar Ocean

THE KERMANSHAH OPHIOLITE: AN EXAMPLE FROM OUTER ZAGROS IRANIAN OPHIOLITES

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Ophiolites are on-land tracts of semi-coherent oceanic lithosphere and the tectonic setting that they form in is often controversial. Many studies dealing with the tectonic history of Gondwanaland during Mesozoic time have been undertaken in the past 40 years. Many of these deal with the geological evolution of the Neo-Tethyan Ocean and with discrete continental blocks of the region. Late Cretaceous ophiolites in the Mediterranean eastwards through Iran, Oman and into Pakistan preserve fossil slices of Neo-Tethyan lithosphere. The Outer Zagros ophiolite belt, of central interest to this study, lies along the NE flank of the Zagros fold-thrust belt and preserves a remarkable example of Late Cretaceous subduction initiation on the north side of Neotethys. In particular, the Zagros ophiolites can be subdivided into “inner belt” and “outer belt” ophiolites respectively for the ophiolite belt south of the Main Zagros Thrust Fault (MZT) and along the SW periphery of the Central Iranian block (Stocklin 1977). The Kermanshah ophiolite as a part of the Outer Zagros Iranian Ophiolites consist of mantle harzburgite with pegmatite gabbros pockets, pillow lavas, sheeted dike complex and late Cretaceous overlying pelagic sediments.

The peridotites have high Cr# spinel compositions that mostly plot in the fore-arc field. Al_2O_3 vs. TiO_2 and Cr_2O_3 compositions of basalt clinopyroxenes mostly show affinities to both boninite and island-arc tholeiites, less commonly MORB.

The ophiolitic lavas have nearly flat to slightly LREE-depleted patterns. Extended trace element (spider) diagrams show typical supra-subduction geochemical signatures: enrichments in large ion lithophile and fluid mobile incompatible trace elements and depletions in high field strength elements. Nearly all of the Zagros Iranian ophiolite lavas, including the Kermanshah lavas, fall into both island-arc tholeiitic and boninite fields on a Ti-V diagram, similar to depleted Lasail lavas (V_2 unit) of Oman. In summary, all rock units of Inner and Outer Zagros ophiolitic belts, from harzburgitic mantle to lavas, are characterized by strong supra-subduction zone compositional features. The similarity of ages for igneous rocks and overlying sediments and of geochemical compositions for both inner and outer belt Zagros ophiolites, along with similarity to other Late Cretaceous Ophiolite Belt of SW Asia (in Cyprus, Syria, Turkey and Oman) and position between the Urumieh-Dokhtar magmatic arc and Zagros accretionary prism suggest that the entire ophiolite belt formed as a ~3000 km long tract of fore-arc oceanic lithosphere fringing southern Eurasia, during a subduction initiation event.

Keywords: Iranian Zagros Ophiolites, Late Cretaceous, Fore-arc Oceanic Lithosphere, Subduction Initiation.

DETRITAL SPINELS: THE PETROGENETIC SIGNIFICANCE IN OPHIOLITIC SEDIMENTS (CENTRAL AND SOUTHERN ALBANIA)

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The Albanian ophiolites, situated in the central part of the Dinaric-Hellenic ophiolite Belt are built up by a western MOR-type and an eastern SSZ-type zone, respectively. In central and southern Albania the ophiolites are dominated by large bodies of lherzolite and/or harzburgite. Crustal sections are rare. Sediment piles on top of the ophiolites are common and consist of ophiolitic conglomerates and breccias, sandstones with prevailing ophiolite material and calcareous rocks with ophiolitic detritus. The calcareous sediments are most likely Early Cretaceous in age.

Detrital spinels were sampled from sediments covering the Luniku, Stravaj, Shpati, and Morava massifs. The wide range of Electron Microprobe compositions of spinels in sediments on top of the Luniku massif, with Cr# between 0.85 and 0.50 and Mg# between 0.35 and 0.65, overlap to a certain extent with those of spinels from harzburgites in Shebenik and Shpati massifs. Spinel with lower Cr# and high Mg#, common in harzburgites, are missing in the sediments. The sediments of Stravaj show spinels with a wide variation of the Al₂O₃ content, from 5 to 40 wt.%. Most of them are compositionally compatible with those from harzburgites and possibly lherzolites. Spinel collected from calcareous sediments from the inner part of the Shpati massif show a bimodal distribution. Al- and Ti-poor spinels, with a high Mg# are probably derived from boninites. By contrast, the source of Ti- and relatively Al-rich spinels are most likely the MOR basalts. Finally, the calcareous sediments on top of the Morava Massif contain at least two spinel populations: one with high Cr# and low Ti content and a second one, with Ti > 0.5 wt.%. The former indicates a harzburgitic source, the latter a MORB source. Harzburgites are rare in Morava, but occur frequently in the massif of Bitinska located nearby. The abundance of detrital spinels indicates subaerial weathering of exposed ophiolites. They accumulated as heavy minerals together with mafic and ultramafic clasts in shallow water sediments, most likely in Early Cretaceous.

GEOCHRONOLOGY AND GEOCHEMISTRY OF BLUESCHIST FACIES ASSEMBLAGES IN A NEOTETHYAN OPHIOLITIC MELANGE FROM THE EASTERN PART OF THE CENTRAL TAURIDES

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In the eastern part of central Taurides, five tectonic units that display distinct features in terms of stratigraphy, metamorphism and structures have been recognized in Ereğli (Konya), Ulukışla (Niğde), Karsanti (Adana) and Namrun (İçel) regions. These tectonic units, from bottom to top, are called Geyik Dağı, Bolkar Dağı, Namrun, Aladağ and Bozkır and in terms overlain by Tertiary sedimentary units of the Ereğli-Ulukışla, the Ayrancı-Adana and the Karsanti basins. An ophiolitic melange, belonging to the Bozkır unit, rests tectonically on the top of the metamorphic Bolkar Dağı unit and represented by serpentinite, serpentinitized harzburgite, isolated diabase dikes, volcanics, amphibolite and metacarbonate blocks. The amphibolite that represents a metamorphic sole displays well developed foliation patterns and is intercalated with metacarbonate rocks. The ⁴⁰Ar-³⁹Ar isotopic age determinations performed on amphibole separates yielded ages from 92.29±0.38 Ma to 94.96±0.50 Ma. The metamorphic sole rocks exhibit two distinct geochemical features. The first group is alkaline (Nb/Y=1.43-2.05), whereas the second group is tholeiitic (Nb/Y=0.04-0.58) in nature. The REE patterns, multi-element and tectonomagmatic discrimination diagrams suggest that the protholith of the first group is similar to within-plate alkali basalts, whereas the second group is more akin to MORB-island arc tholeiitic basalts. The isolated diabase dikes are tholeiitic in character (Nb/Y=0.03-0.13). The REE patterns, multi-element and tectonomagmatic discrimination diagrams suggest that the isolated dikes formed in a subduction-related environment. Petrographic studies of the amphibolitic sole and the isolated diabase dike rocks indicate that these rocks display blueschist facies overprinting, represented by glaucophane mineral. All the field and geochemical data show that the ophiolitic rocks formed along the Inner Tauride ocean, bounded by the Kırşehir block in the north and the Taurides in the South. A metamorphic sole developed at the inception of north-dipping intraoceanic subduction during the Late Cretaceous. Subduction-accretion units and the leading edge of the northern margin of the Tauride Carbonate Platform were underthrust, deeply buried and metamorphosed under HP-LT conditions. The metamorphosed rift/passive margin units and the distal edge of the Tauride Carbonate Platform were uplifted and emplaced together with the over-riding ophiolites in Late Cretaceous-early Tertiary. Upper Paleocene to Middle Eocene successions rest unconformably on the top of the above-mentioned units. The LA-ICP-MS zircon U-Pb measurements suggest that the Horozdağ granitoid intruded into all these units at 48-49 Ma.

Keywords: Ophiolite, mélangé, Inner Tauride Suture, accretionary complex, blueschist, Taurides

PETROGRAPHIC CHARACTERISTICS OF BONINITE TYPE VOLCANICS FROM THE EASTERN (SSZ) ALBANIAN OPHIOLITES

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Within the Albanian ophiolites, basalts and dikes with a boninitic affinity are described here from the Eastern (SSZ) – type ophiolite belt. They occur in the volcanic sequence, and sheeted dikes as well as in the gabbro–plagiogranitic sequence and very rare in ultramafic intrusions and in the uppermost part of the ultramafic sequence. Boninitic rocks and high – Mg basalts in the volcanic sequence are restricted to the upper part of pillow lavas, lava flows and volcanoclastites and are interlayered with andesitic basalts, andesites, dacites and rhyodacites. They are fine grained, with gray and dark gray colour and a with a porphyritic, vitrophanitic or vesicular texture. Phenocrysts and microphenocrysts are represented by clinopyroxene, rare orthopyroxene, olivine, cromspinel. Plagioclase phenocrysts are missing. The groundmass is fine grained, microlitic and consists of opx, cpx and plag. Sometimes the groundmass is glassy with a basic to intermediate composition and partially or completely altered. Cromspinel appears as accessory, idiomorphic, poicilitic or sometimes skeletal mineral. Chlorite, carbonate and zeolite occur as secondary minerals. Vesicles are filled with carbonate, chlorite or zeolite. Based on their petrography boninitic rocks in the volcanic sequences are close to the Chichi Jima augitic boninites in Japan (Kuroda et al. 1996). The chemical composition of the clinopyroxene indicates an chrom-bearing endiopside with Wo (38.5 - 43.58), en (50.98 - 53.37); fs (5.12 - 8.69) and Cr2O3 > 0.5%. Phenocrysts and microphenocrysts orthopyroxene are rarely encountered.

The chemical composition of the boninitic rocks shows a low (< 0.45%) TiO₂ content, a low CaO/Al₂O₃ ratio (in average 0.5), a high MgO content (> 7.5%) and low REE concentrations. According to the classification by Crawford et al. (1989) the boninitic type volcanics in the Eastern ophiolite belt are mainly low –Ca, rarely high-Ca varieties. Boninitic type lavas and dikes are associated with high-MgO and low-TiO₂ basalts and with andesite, dacites and rhyodacites forming an association, similar to the Western Pacific arc lavas generated at fore arc settings.

Basalts and dikes with an boninitic affinity within the Eastern-type ophiolites are generated by partial melting processes of a refractory mantle peridotite and mantle-melt interactions. Boninitic dikes in ultramafic intrusions, which an extreme REE depletion, are linked with mantle-melt interaction processes developed during the final stages of magmatic activity of Eastern (SSZ) -type ophiolite.

Keywords: Eastern (SSZ) - type ophiolite, boninite.

FORMATION MECHANISM OF VOLCANIC DOMES IN SOUTHWEST OF ARDABIL, IRAN

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The area under study is situated in southwest of Ardabil. This area contains middle and upper Miocene volcanic rocks succession and Pliocene clastic sedimentary rocks and lower Pliocene epiclastic sediments. Dome shaped volcanic rocks are located in an eruptive caldera. These domes are classified into three types in terms of their formation mechanism. The first type documents magma extrusion in a single stage. These domes are located along the outer boundary of caldera and show dacitic compositions. The second type record multistage magma extrusions. At every stage lava was added to similar lavas from the previous stages. These domes are situated along the inner parts of the caldera rim and show rhyodacitic compositions. The third type of domes also record multistage extrusion but the lava of every stage differ from each other. These rhyolitic domes are located in the center of the caldera. Field observation and geochemical studies indicate genetic relations between the dome forming magmas. Compositional variation is due to differentiation processes between center and rim of the caldera. Chemical composition, viscosity, temperature, amount of volatiles in the magmas and the difference in density between magma and contact rocks are the most important factors determining the mechanism of extrusion and dome formation in this area.

Keywords: Iran, Ardabil, volcanic domes, eruptive caldera

GEOCHEMISTRY OF OPHIOLITIC ROCKS OF THE INNER TAURIDE SUTURE FROM SOUTHERN MARGIN OF THE SIVAS BASIN, EAST CENTRAL TURKEY

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Inner Tauride Suture, believed to be the remnants of the Inner Tauride ocean, is located between Kırşehir and Mendere-Tauride blocks and was evolved from Triassic to Paleocene. In the southern margin of Sivas basin, there are number of tectono-stratigraphic/magmatic units that are important in understanding the geological evolution of the Inner Tauride Suture. These are, from south to north, Tauride carbonate platform, ophiolitic melange, ophiolite and Tecer formation. The Tauride platform is characterized by Upper Triassic-Lower Jurassic-Cretaceous Yılanlıdağ-Çataldağ limestone (Munzur). This unit is tectonically overlain by an ophiolitic melange that comprises sheared serpentinite, radiolarite, pelagic limestone, volcanics and limestone blocks. Then, the ophiolitic rocks rest tectonically on the melange unit and are composed of mainly mantle tectonites, intruded by number of diabase and pyroxenite dikes, cumulate gabbros. Maastrichtian-Paleocene aged Tecer formation unconformably overlies the ophiolitic rocks in the region. The mantle tectonites are represented by serpentinitized harzburgite and dunite that contain considerable amount of chromite mineralization. The mafic cumulates consist of gabro, displaying granular to poikilitic texture. Common mineral assemblages of the gabbros are plagioclase, clinopyroxene, orthopyroxene and opaque minerals. The isolated dikes that intruded mantle rocks at different structural levels in the melange are characterized by diabase, microdiorite and pyroxenite.

Geochemical features of the isolated diabase dikes are used to better understand the geotectonic setting of the ophiolitic rocks in the region. Two types of isolated dikes are defined based on the major and trace element contents. The first group is represented by low amount of TiO₂ (% 0,36-0,66), Zr (7,8-18,7 ppm), Nb (0,2-0,6 ppm), Y (10,2-14,1 ppm) whereas the second group is characterized by high amount of TiO₂ (% 0,87-1,47), Zr (20,5-73,2 ppm), Nb (0,6-1,4 ppm), Y (19,2-31,8 ppm). All the dikes are tholeiitic in nature (Nb/Y=0,02-0,05) and basaltic in composition. The Chondrite-normalized REE diagrams show that the first group display depletion both in LREE and HREE (La_N/Yb_N= 0,19-0,49), compared to the second group (La_N/Yb_N= 0,27-1,13). The MORB-normalized spider diagram of both groups show the similar features such as (a) enrichment in Large Ion Lithophile elements (Rb, Ba, Th, K), (b) enrichment in Sr, (c) depletion in Nb and (d) flat patterns of high field strength elements. As in the REE diagrams, the first group show more depleted patterns in spider diagrams compared to the second group. The geochemistry of dikes suggests that they formed from an tholeiitic melt with different degrees of partial melting in a subduction related environment. All the data suggests that ophiolites formed above a north-dipping subduction zone in the Inner Tauride Ocean between the Taurides in the south and the Kırşehir block in the north during in late Cretaceous and emplaced in latest Cretaceous-Paleocene to the south onto the Taurides.

Keywords: Inner Tauride Suture, ophiolite, mélangé, accretionary complex, dikes, geochemistry

HETEROGENEOUS MANTLE FLOW, EVIDENCES FROM OPHIOLITIC PERIDOTITES OF HARMANCIK, KOPDAGI AND POZANTI AREAS, TURKEY

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Ophiolites in Turkey occupy large territories. Although the complexity of their internal structures and intensive faulting, three large ophiolitic belts have been distinguished and accepted nearly by the all authors: south ophiolitic belt or peri – arabic, intermediate belt and north ophiolitic belt. Anyhow, this classification seems to be more geographical than scientific. Ophiolites as fragments of an old oceanic lithosphere record the most important deformation moments from oceanic spreading up to abduction of oceanic lithosphere over continental crust.

Mantle peridotite is main components of ophiolites of Turkey. Just for this, mantle deformation structures recorded on them show great interest and need special attention to reach to the scientific results on the history of ophiolite development.

Ophiolitic peridotite are derived from a very superficial level of the oceanic mantle, where temperature varies rapidly with distance and depth. Hence the deformation history of ophiolitic peridotite is controlled by their thermal evolution. Microstructural studies allow distinction of structures formed during accretion (high – T deformation at about 1200⁰ C) from those formed after incorporation of peridotites into the lithosphere (Low-T deformation at about 800–1000⁰ C).

The authors have carried out a detailed structural mapping of ophiolitic peridotite last years in the Harmancik (Bursa), Kopdagi (Askale) and Pozanti areas. Based on this, three different models of mantle flow are deduced for those areas. In Harmancik ophiolite an asthenospheric mantle flow is evidenced (deformation structures of high–T), far from spreading center, intersected by subvertical shear zones of lithospheric deformation (low – T deformation).

An upwelling diapiric structure of mantle is evidenced in Pozanti ultramaphic massif. As we know the mantle diapirs usually target the initial center of the oceanic spreading.

In Kopdagi a transition zone composed of clinopyroxene, dunite werhlite, pyroxenite and lherzolite deformed at low–T is evidenced. This transition zone is very rich in chromite ore. Based on the intensity of folding and potential of chromite–bearing Kopdagi transition zone can be considered unique in the world. Its uppermost mantle is composed of mylonitic peridotites, which originate from dunites and hartzburgites by impregnation and tectonic dispersion of melt during deformation occurring at 1000–800°C.

As conclusion we can say that studies carried out up to now, although not enough and at limited areas are, we believe, important for a better understanding of ophiolite developing in Turkey.

Keyword: oceanic lithosphere, continental crust, lithospheric deformation, microstructural studies, mantle.

THE IMPORTANCE OF THE OPHIOLITES OF THE SOUTHERN BRANCH OF THE NEOTETHYS (KOÇALI OPHIOLITIC COMPLEX), IN TERMS OF THE CYPRUS TYPE VMS DEPOSITS

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The studied area is located in the South East Anatolia Thrust Zone comprising the Adıyaman and Diyarbakır regions. The study area comprises from bottom to top, the autochthonous sediments belong to the Arabian Plate, discordantly overlain by the the Koçali Complex and the allochthon units (Terbüzek, Besni, Germav, Midyat Formations) which are tectonically overlaid the Koçali Complex. The mineralizations, skirt along the thrust zone from Hatay to Hakkari, are placed within the Koçali Complex. Koçali Complex was formed as follows; during the end of Upper Cretaceous a North dipping subduction initiated prior to closure of the south branch of the Neotethys Ocean and the allochthonous units moved to the Kastel Basin. The geological survey of Turkey (MTA) reported numerous small and medium scaled Cu mineralizations in this region. The mineralizations are located at the zone of root, stockwork zone, massive ore zone and gossans in the region. The ore formations are settled within the diabase and spilitic pillow lavas, with lens shaped or stratiform structures. Mineralizations are generally observed fracture fillings shaped, massive, rarely stockwork and disseminated. Chloritization, carbonatization, silicification, hematization, limonitization and epidotization alterations are observed in wall rocks around mineralizations. These alteration types are usually seen in seafloor volcanics around globe. Pyrite, marcasite, magnetite, chalcopyrite, bornite, chalcocine, covellite, fahlerz and sphalerite minerals were defined as ore minerals under ore microscopy. The texture of the ore minerals are colloidal, cataclastic and zonal textures. In geochemical studies, all of the ore samples located at Cyprus Type VMS field on Cu-Pb-Zn and Au-(Cu+Pb+Zn)-Ag triangle diagrams. All of the samples akin to Cyprus Type VMS deposits on primitive mantle normalized spider diagrams with similar Pb, Cu, Ag, Au, Zn patterns. Co/Ni content of massive pyrite samples are quite higher than 1, which is the characteristic feature of Cyprus Type VMS deposits.

Along the southeast Anatolian Orogenic belt, numerous massive sulphide deposits including copper ore, are located within the ophiolites. The mineralizations within Koçali Complex proved the importance of prospections in the ophiolitic units in terms of copper ores. It is possible to find economically similar Cyprus Type massive Sulphide deposits in other ophiolitic units in the Anatolian peninsula.

Keywords: Neotethys, Cyprus Type VMS, Koçali Complex, Adıyaman

KAPTINA GABBROIC MASSIF OF “MIRDITA” OPHIOLITE, ALBANIA AND ITS RELATIONS WITH SULPHIDE MINERALIZATIONS.

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Kaptina gabbroic massif is located in northern half of eastern belt of Mirdita ophiolite and is spread up in a relatively vast territory. Geology of Kaptina gabbroic massif area is very complicated in both, variety of rocks and its structure. In this area are also exposed all components of ophiolitic complex, ocean sedimentary cover, Cretaceous sedimentary cover, as well as youngest Neogene-Quaternary formations. Most distributed rocks of the area belong to extrusive and sub-volcanic rocks, represented mainly by andesites, dacites, rhyodacites, and more rarely by basalts; ultrabasic rocks and basic plutonic and intermediate-acid rocks. Sedimentary formations of Cretaceous and those of Pliocene-Quaternary have more limited distribution.

All gabbroic rocks which constitute Kaptina gabbro massif, occupy almost central part of the area. Some of their separated outcrops are encountered in northern and southern ends of Kaptina massif, forming relatively smaller massifs. Such exposures are outcrops of Kunora Mountain, and Bulshari massif, whereas in southwestern end of Kaptina massif, at valley of middle course of Fani i Madh River is encountered a relatively big exposure of gabbroic rocks which form Gojani massif.

Gabbroic massif of Kaptina consists of a series of different rocks, regarding to surface distribution, have various sizes. Most distributed rocks are gabbro-norites, which are found in whole sectors of gabbro (gabbroic) outcrops; close to them are encountered norites and gabbros. These types of rocks are commonly medium, rarely coarse and fine grained. No laws are observed in distribution of these different types of grains. We can point out that, close to the contact of gabbro with volcanic rocks are found mainly small-grained gabbros, but sometimes with them are encountered coarse-grained gabbros. Medium-grained types are most distributed in massif, and are found mainly in its internal parts.

Several small to medium zones of sulphide mineralizations in gabbroid massif of Kaptina are found which are of theoretical and practical significance. The main zones are: Thirra, Gdheshta, Pista, Shemri, Golaj and Nikoliq. These ore deposits have their specific geological and structural features, but also their common characteristics. Based on conditions of location of ore bodies, two type of mineralization are distinguished: (a) Pyrite - chalcopyrite ore type and (b) Quartz - sulphide ore type.

Keywords: gabbroid massif, Mirdita ophiolite, sulphide mineralizations, rocks.

TECTONICS & NEO-TECTONICS

ANATOLIA PLATEAU SOUTH MARGIN:TECTONIC INFERENCES FOR THE MIOCENE TO PRESENT EVOLUTION

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The Neogene Central Anatolia Plateau (CAP), located between the Pontides in the north and Tauride mountains in the south and showing an average elevation of 1.5km, is one of the most interesting geologic features in Europe. The CAP encompasses all characteristics to enhance temporal and spatial plateau-building understanding, which is the main goal of the ESF-sponsored Vertical Anatolia Movement Project (VAMP). As part of the structural branch of the VAMP we aim to quantitatively comprehend the subsidence-uplift mechanisms, as well as, determine the accommodation structures of the south margin of the Anatolia Plateau and its age of growth.

A general north to south description of the study area comprises the following elements; (i) high flat Anatolian Plateau interior, composed by Central Turkey continental basins, (ii) south plateau flank, extensively overlain by Miocene marine basins, (iii) offshore flank continuation in the Cilicia Basin, between Turkey and Cyprus, and (iv) south-verging Kyrenia thrust belt and the Messaoria Basin. The Miocene marine sediments presently found in southern Turkey, which were probably deposited in one single basin that was later divided into Mut, Manavgat and Adana Basins by formation of the Taurides, are essential to determine the main tectonic phases immediately preceding and contemporaneous with plateau development. Laying between Manavgat and Adana, Miocene Mut Basin is a key area to understand the tectonic history that existed in southern Turkey since Miocene.

The present day structures and geometric architecture among the different units of the Mut-Ermenek Basin and surrounding areas are depicted in four E-W and four N-S geological sections stretching from Karaman in the Central Anatolian Plateau interior and from the west of Ermenek to the S and SE Turkish coast. They show a pre-Cenozoic paleotopography in highly-deformed metamorphic basement, unconformably overlain by relatively undeformed marine Miocene sediments. This Oligo-Miocene 2-3 Km-thick relatively undeformed marine infill, some of which were deposited at infranoritic depths, is presently found at altitudes of 2000m in some points. Within the post-Eocene succession two different tectonic periods can be inferred; subsidence of the whole area during Miocene and post-Messinian uplift. Subsidence analyses of the area reveals basin tilting, with sediments emerging first in the northeast and then arising southwestwardly.

In this contribution, using data from previous studies, cross-section data, basin analysis and structural fieldwork techniques, we aim to determine and quantify the character of Miocene to recent vertical movements and deformations underwent by Mut and Ermenek basins and surrounding areas to unravel the structural characteristics of the mountain range-foredeep-subduction system behind the vertical movements underwent by the southern flank of the Central Anatolian Plateau.

Keywords: Plateau, Miocene, Subsidence, Ermenek, Mut.

DEFORMATION AND UPLIFT OF THE SOUTHERN MARGIN OF THE CENTRAL ANATOLIAN PLATEAU

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Orogenic plateau margins are sensitive features for recording the drivers of surface uplift. Cenozoic marine sediments blanket the southern margin of the Central Anatolian Plateau up to >2 km elevation, providing datable reference horizons to track plateau-margin growth. Structural and geomorphological interpretations integrated with new stratigraphic and paleontologic studies improve chronological constraints and help distinguish among geodynamic interpretations of uplift that hinge on precise temporal constraints and analysis of crustal stress regimes.

Along the southern plateau margin, sedimentary deposits of the Manavgat Basin are subhorizontal near the coast, and gradually steepen to almost 30° SW dips at the NE margin of the basin. Close to the Kirkkavak fault at the west end of the basin (~31°E), several small folds with ~NW-SE axes deform the basin stratigraphy. Folding is less prevalent farther east in the basin, where high-angle normal faults create m-scale offset of beds. Dextral offset post-dates the normal movement in several locations. Deformation is likely driven by processes that uplifted the southern plateau margin. This is reflected by longitudinal river profiles across the plateau margin showing convex forms and knickpoints. In the uplifted region farther north, uppermost marine sediments at ~1.4 km elevation are early Tortonian in age based on paleontological analyses and ⁸⁷Sr/⁸⁶Sr stratigraphy.

Farther east (~34°E), the margin is characterized by a single monocline with superposed sinistral strike-slip faults. Minor fluvial dissection implies that surface morphology reflects cumulative deformation. There, Miocene marine sediments rise gradually from the coast over a relatively smooth, convex margin, which peaks at ~2 km elevation ~50 km inland and then drops to ~1 km in the plateau interior. River profiles across the margin show convex-upward forms, indicating that the surface deformation affecting them is relatively recent. This portion of the southern margin coincides with the Namrun segment of the Eçemis fault zone. Although the Namrun segment shows sinistral offset of Miocene sediments, its role in vertical uplift has not yet been investigated. Paleontology and ⁸⁷Sr/⁸⁶Sr stratigraphy suggest that uppermost marine sediments in this region (~1850 m) are late Tortonian or younger.

Several mechanisms can explain the post-Miocene deformation of the southern margin. The margin may have undergone contraction and uplift resulting from counter-clockwise rotation of the eastern portion of Central Anatolia. Alternatively, the Namrun segment of the sinistral Eçemis fault may act as a restraining bend. A final possibility is that slab break-off and upwelling of the asthenosphere into the slab window beneath the southern margin drives regional uplift. Our topographic analyses and timing constraints suggest that each of these mechanisms played a role in building the southern margin.

Keywords: plateau uplift, ⁸⁷Sr/⁸⁶Sr, deformation, river profiles

BASIN FORMATION AND EVOLUTION DURING COMPLEX CONTINENTAL COLLISION: THE DARENDE AND HEKIMHAN BASINS, CENTRAL EASTERN TURKEY

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The Darende Basin and the adjacent Hekimhan Basin in the Malatya Region of central eastern Turkey developed as part of the northern margin of the Tauride microcontinent during collision and suturing of the Mesozoic Tethys Ocean. The Darende and Hekimhan Basins both exhibit a Jurassic-Upper Cretaceous carbonate platform basement overlain by a dismembered ophiolite that was thrust southwards onto part of the Mesozoic Tauride carbonate platform. Sedimentation on the emplaced ophiolites in both basins began in the latest Cretaceous (Maastrichtian), triggered by basin-wide transgression, coupled with tectonic subsidence. Ophiolite-derived clastics accumulated in basin depocentres, followed by Maastrichtian-aged, rudist-rich patch reefs and microbial carbonates on the basin margins and on palaeotopographic highs. An angular unconformity developed in the Darende Basin after the Maastrichtian. Basaltic to andesitic lavas were locally erupted above this. Sedimentation resumed in the Early Eocene in response to flexural subsidence, creating accommodation space. This then filled with various facies that successively record deepening, shallowing and finally emergence during the Late Eocene. In the Hekimhan Basin, Maastrichtian facies are overlain by ~1000 metres of subaqueous basaltic, to trachytic lavas and associated volcanoclastic material. Numerous intrusions cut the lavas including basaltic, to gabbroic dyke swarms, plagiogranite and a syenite body displaying orbicular structures, contact metamorphism, hydrothermal alteration and mineralisation. These lithologies are overlain by latest Cretaceous shallow marine limestones and dolomites. Sedimentation was then continuous from the Late Cretaceous, with a localised pulse of volcanic activity during the Late Eocene, until the Middle Miocene when the basin became emergent.

The following tectonically controlled stages of basin development are inferred: 1) Late Cretaceous extension initiated basin development, possibly related to northward subduction of remaining Tethyan oceanic crust. The lavas and intrusive magma bodies in the Hekimhan Basin also reflect an extensional setting; 2) The Darende Basin became emergent in the Latest Cretaceous, possibly controlled by flexural uplift or sea-level change, while sedimentation continued in the Hekimhan Basin; 3) Early Eocene flexural subsidence, probably caused by crustal loading that accompanied initial collision of the Tauride microcontinent with Eurasia ("soft collision"), forcing the Darende Basin to subside and sedimentation to resume; 4) Late Eocene "hard collision" possibly caused regional uplift and progressive restriction of the Darende Basin, culminating in subaerial exposure. No further marine sedimentation occurred in the Darende Basin after the Late Eocene. In contrast, sedimentation continued in the Hekimhan Basin until it became emergent in the Middle Miocene.

Both basins remain well preserved, although they were affected by post Mid-Eocene, post-collisional suture tightening, followed by predominantly sinistral strike-slip Neotectonic deformation. The excellent preservation of the basins is attributed to their location within a strain "shadow" zone to the east of a large microcontinent, the Nidže-Kırşehir Massif, which acted as a regional-scale indenter between Eurasia to the north and the Taurides to the south.

Keywords: Basin Evolution, Collision, Cenozoic, Turkey.

EVOLVING SUBDUCTION AND COLLISION-RELATED STRESS REGIMES IN THE SOUTH OF CYPRUS DURING MIOCENE – RECENT TIME

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The Neogene basins in the south of Cyprus formed during an Early Miocene (Burdigalian) to Middle Miocene phase of palaeogeographic reorganization that was probably related to the onset of the latest phase of subduction in the easternmost Mediterranean region. Three main basins developed to the south of the Troodos Massif: the Polemi, Pissouri Basin and Maroni-Psematismenos Basins. Another important basin, the Mesaoria Basin, is located to the north of the Troodos Massif. The basin-fill sequences provide temporal and palaeogeographic information to interpret syn-depositional processes and post-depositional structural development. Several phases of neotectonic deformation can be recognised: The Polis and Pissouri Basins in the west originated as Late Miocene (Tortonian) depocentres in response to syn-depositional E-W/WSW-ENE extension. The Maroni Basin in the southeast formed as a Tortonian depocentre related to syn-depositional NW-SE extension. The difference in extension directions between west and south-central Cyprus reflects the curvature of the Cyprus Arc. A Middle - Late Pliocene extensional/transensional phase was then superimposed, resulting in syn-depositional NW-SE extension. A kinematic change occurred at ~3 Ma, attributed to the collision of the Eratosthenes Seamount with an active trench (Cyprus Arc). Early Pleistocene-Recent transpression generated strike-slip faults along E-W trends, along conjugate left-lateral NNE-SSW-trends, and also along right-lateral NNW-SSE-trending (strike-slip) trends. NW-SE- and NE-SW-trending structures were reactivated during the Early Pleistocene-Recent. There was a switch to compression along NW-SE trends during Middle Pleistocene-Recent.

New optically stimulated luminescence (OSL) dating helps to constrain the younger events and shows that the transensional lineaments originated in the early Pleistocene (i.e. Kolossi Fault; between ~ 175 and 75 ka) and are still active today (i.e. Cape Kiti Fault; between ~ 40 and 10 ka). In contrast, the compressional lineaments developed later, during the middle Pleistocene.

Our working hypothesis to explain the tectonic-sedimentary development is that areas to the east of Cyprus (Syria, SE Turkey) were in a continent-continent collisional setting from Mid-Miocene time onwards. In contrast, Cyprus remained in an oceanic embayment (Levant Sea) further west where subduction continued during Late Miocene-Early Pliocene time. Southward extension (trench roll-back) is observed at a high structural level in the south of Cyprus, although compressional processes are assumed to have been active at depth during this time. The collision of the Eratosthenes Seamount with the Cyprus Arc by Late Pliocene time obstructed subduction and initiated rapid uplift of the Troodos Massif. Strike-slip faults and compressional lineaments developed in the south of Cyprus, mainly in response to the attempted tectonic escape from the collision zone south of Cyprus. The over-riding plate in southwest Cyprus appears still to be undergoing gravity spreading outwards from the developing collision zone. This represents a small, but critical, part of the regional collision of the African and Eurasian plates extending from the South Aegean to the Levant regions.

Keywords: Cyprus, faults, Neogene, basins, OSL

MULTIDISCIPLINARY STUDIES ON ACTIVE FAULT ZONES IN TERMS OF DISASTER REDUCTION: ENCOUNTERED PROBLEMS IN THE USE OF SCIENTIFIC DATA BY DECISION-MAKERS

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The North Anatolian Fault Zone is one of the largest currently active strike-slip fault zone in the world, situated along the Alpine-Himalayan Mountain Belt. It forms the most prominent zone of deformation in northern Turkey dominated by strike-slip belt and was responsible for the devastating İzmit earthquake of 1999. The amount, diversity, quality, and density of data collected during the last few years are unparalleled in the history of geological investigations in Turkey and do not have many counterparts in the world (Şengör et al. 2005). Multidisciplinary studies have notably increased in recent years especially immediately after the 17th August 1999 İzmit Earthquake in the western part of the NAFZ, and have mainly focussed in the Sea of Marmara.

Whilst settlements along the North Anatolian Fault Zone are prone to earthquakes, landslides and poor subsoils are common local consequences. The eastern part of NAFZ includes a number of large cities and the area has suffered several large earthquakes and landslides in historical and recent times. Between 1939 and 1999 the fault zone experienced remarkable episodic activity during which a progression of seven westward migrating large earthquakes created more than 1000 km long surface rupture from Erzincan to the Sea of Marmara.

Considering damage to man-made structures caused by natural hazards in Turkey, earthquakes and landslides are the most important hazards. Planning of protective and mitigation measures requires the acquisition of reliable data and with this objective in mind, a large-scale study entitled KABİS Project has been carried out between 2006-2009 along the eastern part of the North Anatolian Fault Zone with the participation of nearly 30 researchers from different institutions in Turkey. The summary of results from this multidisciplinary study utilizing active fault mapping, paleoseismology, geodesy, remote sensing, soil microzonation, borehole data and geochemistry and the encountered problems on the use of these scientific data by local authorities will be discussed.

Keywords: Natural disaster, multidisciplinary study, active faults, North Anatolian Fault Zone, Geographical Information System

THE EFFECT OF SALT ON THE INTERNAL STRUCTURE OF THE KINNAROT PULL-APART BASIN, JORDAN RIFT VALLEY, ISRAEL

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Located south of the Sea of Galilee, the Kinnarot Basin comprises a link in the chain of pull-apart basins that characterize the long dislocation line known as the Dead Sea-Jordan Rift Valley. The basin floor is about -200 m below the msl and the shoulders attain an altitude of a few hundred meters above. Both margins are built of Cretaceous to Neogene sediments interbedded with mostly Pliocene volcanic flows. The sedimentary fill of the basin, which attains a thickness of 5-6 Km down to the Cretaceous rocks, was subjected at the beginning of the 1980's to hydrocarbon exploration. One deep borehole, 4.2 km deep Zemah-1, and several seismic lines are the only source for deep, in basin, geological information.

The unique Neogene stratigraphy penetrated by Zemah-1 borehole includes a massive evaporitic body penetrated by magmatic intrusions. This thick sequence of evaporates and magmatic intrusions, which is referred here as the Zemah Complex, is stratigraphically located between Late Miocene Conglomerates and Pliocene Basalts. Time equivalent formations at the basin margins are more than ten times thinner and showing entirely different facies. According to the borehole findings the upper part of the Zemah Complex is mostly solid salt and magmatic intrusions become more frequent with depth.

New seismic interpretation, based on reprocessing of existing seismic lines, ties the lithology penetrated by Zemah-1 borehole to a basin-wide picture. Furthermore, deeper reflections, considered to be pre-rift formation, were identified throughout the survey.

Results of the current study show that the massive evaporitic body extends throughout the basin dividing it vertically. The structures of the underlying and overlying formations are disharmonic, especially at the central and eastern parts of the basin. The basin floor is dipping northward towards the Sea of Galilee accompanied by normal step faults, showing evidence for extension as expected to be found in a pull-apart basin as the Pliocene Basalt shows extreme folding with a South-North hinge. The relatively even thickness of Pliocene Basalt indicates a fairly levelled surface prior to its deposition however its extreme folding indicates changes in the underlying structure. The current study shows that those changes occur within the Zemah Complex, mostly at its upper, salt rich, part.

Keywords: Salt Tectonics, Pull-Apart Basin, Jordan Rift Valley

SUBDUCTION AND EXHUMATION OF A NEO-TETHYAN MARGIN; METAMORPHIC AND TECTONIC EVOLUTION OF THE SIVRIHISAR MASSIF, TURKEY

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The Sivrihisar Massif (west-central Turkey) forms the eastern continuation of the Tavsanlı Zone and contains well-preserved exposures of a deeply exhumed subduction zone complex of Late Cretaceous age. The NE-SW oriented ~150 km long massif exposes coherent layers of blueschist, marble, quartzite, and calc-schist. Blueschist facies rocks in the northeastern part of the massif contain centimeter to meter scale pristine lawsonite eclogite pods recording metamorphic conditions up to 24 kbar and 580 °C. Kinematic records of high pressure-low-temperature (HP-LT) textures suggest a major component of pure shear recorded in layers, and simple shear in eclogite pods that likely rotated in their matrix during subduction and exhumation. In the SE part of the Sivrihisar Massif, HP-LT units are juxtaposed with medium temperature and pressure (MP-MT) rocks (Barrovian sequence). The nature of the contact between the HP-LT and MP-MT domains is difficult to detect at the map scale due to the continuity of structural style and the same protoliths (mostly marbles) in both domains. Textural and mineralogic evidence at the low-grade end of the Barrovian sequence shows that this region experienced HP-LT conditions before being overprinted; all evidence for blueschist facies metamorphism is erased at the medium- to high-grade end of the sequence. White mica Ar/Ar dates indicate Late Cretaceous cooling ages for the blueschists and Eocene cooling ages for the high-grade Barrovian rocks.

Keywords: Blueschist, Eclogite, Subduction, Exhumation

NEOTECTONIC FEATURES ALONG THE AĞCAKIŞLA-KALECİK (ŞARKIŞLA, TURKEY) SEGMENT OF THE CENTRAL ANATOLIAN FAULT ZONE

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The Central Anatolian fault zone (CAFZ) is thought to be a > 700 km-long sinistral strike-slip fault that cuts across the Anatolian Plateau between Düzyayla in northeast of Sivas to Anamur town in the southwest, and forms the eastern boundary of the metamorphic complexes in central Turkey. It is a young neotectonic structure and is divided into 24 different segments along its entire length. CAFZ displays very distinctive geomorphological features between Ağcakışla and Kalecik located to the north of Şarkışla (Sivas) town along the course of Kızılırmak river. Although no fault exposures observed in the area but the tectonomorphological features such as triangular facets, linear valleys and hills are very clear.

It is argued that the fault may have formed at the southeastern edge of the Central Anatolian Crystalline Complex microcontinent during oblique convergence. It was dominated by left lateral slip in the Late Eocene to Middle Miocene, but became more transtensional/ extensional in the Late Miocene–Early Pliocene (Jaffey & Robertson 2001).

Seismic events occurred around the Ağcakışla-Kalecik segment of the CAFZ in the last 50 years plotted on a digital elevation model (DEM) of the region reveals that the alignment of epicenter locations are quite consistent with the general trend of the shear zone. Linear structures in the area are obvious with their tectonomorphological features especially on the eastern side of the Kızılırmak river. These structures indicate a NE-SW trending fault morphology. The CAFZ at least in this part of its entire length shows low angle, oblique-normal shear system which is also very distinct with the occurrence of normal faults within young sediments located parallel to Kızılırmak River.

Keywords: Geomorphology, Central Anatolian Fault Zone, Neotectonics, Şarkışla, Turkey

LATE CENOZOIC COLLISION VOLCANISM OF THE LESSER CAUCASUS: THE ROLE OF LITHOSPHERE MANTLE AND CONTINENTAL CRUST

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The Late Cenozoic post-collisional volcanism of the Lesser Caucasus of Azerbaijan evolved in two main pulses. The volcanic sequence of the early phase is represented by an intermediate to felsic, calc-alkaline association formed during the late Miocene–early Pliocene. The volcanic sequence of the late phase consists of a mafic to felsic, mildly alkaline association formed during the late Pliocene–Quaternary. The calc-alkaline of the early phase lavas are strongly depleted in highly compatible elements but moderately to strongly enriched in highly incompatible elements (Ba, Th, La, yielding high Th/Yb and Zr/Y ratios). Volcanic units of the late phase define a bimodal series with a silica compositional gap between the felsic lavas (72–76 wt% SiO₂) and mafic ones (48–59 wt% SiO₂). The rhyolites that belong to the early phase have broadly similar trace element patterns to the intermediate lavas of this phase, although troughs in Sr, Ba, P, and Ti are significantly more pronounced. By contrast, their Nb–Ta depletion relative to the LREE is much less pronounced than in the intermediate lavas. The abundances of the REE in the mafic to intermediate lavas from both the alkaline and calc-alkaline series of the Miocene–Quaternary volcanic sequence are very similar, with no Eu anomalies. Compared to the intermediate-mafic lavas, they have higher La/Sm ratios, a slight negative Eu anomaly, and depletion in the HREE, Yb, and Lu. N-MORB-normalized spider diagrams for all mafic to intermediate rocks of the two volcanic sequences are characterized by troughs in Nb, Ta, Hf, and/or Zr that are stronger in felsic rocks of the early and late phases, strong enrichment in Rb, Ba, Th, La, and depletion in Ti, Yb, Y relative to N-MORB. This enrichment in incompatible elements implies that the melt source from which the magmas were derived was a metasomatized lithospheric mantle, enriched in K and incompatible elements. The troughs in Nb–Ta are commonly considered as typical features of subduction-related magmatism. The high La, Th, Ce, and Pb contents of the analysed samples are also consistent with crustal contamination. The geochemical data, particularly the high Th/Nb, Ba/Nb, K/Ti ratios, and low Nb/Y and Ti/Y ratios, combined with the regional geological constraints, indicate that the mantle sources beneath the Lesser Caucasus were metasomatized by ancient subduction events, which provided K-rich and HFSE-depleted aqueous fluids. The late Miocene–Quaternary lavas show a trend that is subparallel to the mantle array but shifted towards higher Th/Yb ratios. This feature indicates a lithospheric mantle source enriched by a subduction component.

In conclusion, the major and trace element characteristics suggest that the magmas that produced the Miocene–Quaternary volcanic sequences in the Lesser Caucasus were derived by different degrees of partial melting of a variously subduction enriched, subcontinental lithospheric mantle. The subduction signature in the melt evolution of these volcanic sequences appears to have diminished through time because of an increased asthenospheric component from the late Miocene to the Quaternary. FC and/or AFC processes were also important during the evolution of these magmas.

THE BEYSEHIR-HOYRAN-HADIM NAPPES IN SOUTH CENTRAL TURKEY: AN EXAMPLE OF MULTIPHASE THRUSTING DURING LATE CRETACEOUS – EARLY CENOZOIC

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The Taurus Mountains, south-central Turkey consist of a series of thrust sheets of Palaeozoic-Early Cenozoic lithologies (Beyşehir-Hoyran-Hadim nappes) that were emplaced over the relatively autochthonous Tauride platform (Geyik Dağ). The nappes consist of discrete tectonostratigraphic units that are interpreted as of carbonate platform, continental slope/basin and oceanic (e.g. ophiolitic) origin. It is generally accepted that the relatively autochthonous Tauride platform and associated thrust sheets restore as a north-facing passive margin, at least during Jurassic–Cretaceous time. However, the timing and style of nappe emplacement are contentious. Cross-sectional profiles through the Beyşehir-Hoyran-Hadim nappes show that the stacking order is laterally variable, with the relative structural positions of proximal, distal and ophiolitic units being indicative of multiphase thrusting. Structural data suggest that the Beyşehir-Hoyran-Hadim nappes were emplaced towards the W/SW/S. The along-strike variability is suggestive of oblique compression during thrusting, assuming regional rotation (unconstrained) of the Tauride units has not taken place since emplacement.

The Bolkar unit, located to the north of the Tauride platform, experienced subsidence and deposition of pelagic sediments during Late Cretaceous (Campanian – Maastrichtian) and was then overthrust, first by melange derived from distal margin and oceanic units, and then by more intact thrust sheets of supra-subduction zone-type ophiolites. Intense deformation of the relatively distal Bolkar platform unit took place during the Upper Cretaceous emplacement onto the leading edge of the Tauride platform, although the Bolkar unit remained part of the regional carbonate platform. Further south the Hadim unit experienced flexural subsidence, with accumulation of a relatively thin unit of pelagic carbonates and ophiolite-derived clastics (e.g. turbidites and debris flows), but was not affected by Late Cretaceous thrusting. A second phase of regional compression occurred during Palaeocene – Eocene time. The Tauride platform then underwent flexural collapse to form a regional foredeep basin, which infilled with siliciclastic turbidites and debris flows. The Hadim and Bolkar nappes and the ophiolites and melange were all thrust southwards over the Geyik Dağ autochthon. Syn-tectonic sediments were also deposited adjacent to tectonic contacts between the Beyşehir-Hoyran-Hadim nappes and were re-thrust during this time. Tectonic imbrication of the Geyik Dağ took place during Palaeocene – Eocene time to the SW of exposed the nappe stack.

Structural and sedimentary evidence suggests that the Tauride platform experienced initial Upper Cretaceous thin-skinned emplacement of ophiolitic and distal margin units during ‘soft’ collision of the Tauride continental platform with an intra-oceanic trench. This drove initial emplacement of deep-sea slope/basinal units and over-riding supra-subduction zone-type ophiolites (Beyşehir nappes). During the Palaeocene – Eocene, thick-skinned emplacement of platform units, together with rethrusting of already emplaced ophiolitic and distal margin units, was driven by ‘hard’ continent-continent collision and ocean suturing. The results of this study caution against assuming simple piggy-back-type thrusting to restore the palaeogeography of areas that have experienced complex multiphase thrusting.

Keywords: Taurides, Tethys, multiphase thrusting, Cenozoic

LATERAL SLIP AND SEISMICITY ALONG THE DEAD SEA TRANSFORM IN DIFFERENT TIME WINDOWS

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Recent advances in the study of neotectonic and paleoseismic activity along the Dead Sea Transform (DST) combined with the regional plate kinematics allow to examine its slip in different time windows. The slip during millions of years represents long term average plate motions. GPS data show a current slip rate of 4-5.5 mm/y, probably representing the last 0.5-1 Ma, indicating slowing from an average rate of 6-7 mm/y in the last 5 Ma. This was associated with an eastward shift of the Euler pole of the Sinai-Arabia motion, continuing a trend apparent since >5 Ma ago.

The short term slip in the last several kyr to tens of kyr is dominated by discrete earthquake-generating slip events that relieve in an irregular manner the shearing of the plate margins due to the continuing plate motions. In the last ca. 2 kyr (not much longer than the recurrence times of the strongest earthquakes) the lateral slip along the DST varied irregularly, and could deviate by up to 50% from the plate motions in that period, and on average may lagged behind the plate motion in that period. Possibly, the magnitude-frequency relation deviated from the Gutenberg-Richter relation. The occurrence of significant aseismic slip cannot be resolved. offset markers show that in time windows of 50 kyr and more the residual short-term variations of the slip become small compared with the total slip. This should be reconciled with the record of sediments disturbed by seismic shaking that suggest considerable variation of the frequency of strong earthquakes.

THE ROLE OF LATE PLEISTOCENE-HOLOCENE FAULTING IN THE LARNACA LOWLANDS, CYPRUS IN THE PULL-APART GROWTH OF THE CYPRUS BASIN AND IMPLICATIONS FOR ACTIVE TECTONICS ALONG THE AFRICAN-ANATOLIAN PLATE BOUNDARY

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The Cyprus Basin lies off the SE coast of Cyprus on the southern margin of the Anatolian plate. The basin is a rhomb-shaped, steep-sided, and relatively deep depression, which occurs between two sub-parallel and sympathetic, left-lateral, strike-slip structures- the Larnaca Ridge-Amanas and Latakia-Tartus fault zones. Published seismic reflection data clearly image the bounding strike-slip faults and also show ~1,100 m of post-Messinian sedimentary fill in the basin, which is >3 times as thick as adjacent areas. Faults that form the western side of the Cyprus Basin are exposed in the Larnaca lowlands on the island of Cyprus. Two NNE-trending, left-lateral, strike-slip transverse fault zones define the boundaries of the Larnaca lowlands. In addition to Miocene and Pliocene deformation, these transverse faults cut Late Pleistocene and Holocene deposits as young as ~3.5 ka at multiple locations. Some linear segments of these fault zones have known micro-seismic activity. Right-stepping restraining bends occur along the transverse fault zones where they intersect E- to NE-trending faults, which are on a deformational trend that connects the Larnaca Ridge-Amanas fault zone with the Arakapas fault zone to the west. A restraining bend at Cape Kiti has uplifted a ~6.5 to 7.0 ka beach deposit ~7 m above present sea level. The history and style of movement on these faults provides insight on the development of the Cyprus Basin, as well as the nature and evolution of the plate boundary.

When strain is partitioned from one strike-slip fault to another sympathetic, sub-parallel strike-slip fault, pull-apart grabens are developed between the faults. The orientation, style, and kinematics of transverse faults in the Larnaca lowlands are identical to transverse faults that form in experimental models of pull-apart grabens. Inference from the history and style of faults in the Larnaca lowlands is that Cyprus Basin is an active pull-apart graben; this is supported by seismic activity around the basin. One signature of a pull-apart graben is a unique surface morphology characterized by steep-sided, relatively deep, rhomb-shaped depressions in the Earth's surface. Thus, active pull-apart grabens are valuable in seismic-hazard research as tell-tale signs of how the Earth's brittle crust is deforming.

If the morphology of the Cyprus Basin is used as a signature of an active pull-apart graben, then another steep-sided, relatively deep, and rhomb-shaped marine basin also can be inferred to be an active pull-apart graben. This second pull-apart graben is off the SW coast of Cyprus and is referred to as the SW Cyprus Basin. It is smaller, but deeper, than the Cyprus Basin and also occurs between two transpressive strike-slip structures- the Paphos and the Florence Rise fault zones. The SW Cyprus Basin is the most seismically active portion of the African-Anatolian plate boundary in the Eastern Mediterranean. Seismicity occurs directly beneath the SW Cyprus Basin at relatively great depths of 40-65 km; measured events exceed M_b 7.0. These inferred pull-apart grabens are consistent with an interpretation of the African-Anatolian plate boundary as a transform structure that curves in a westerly direction from NE to E-W to NW trends; the pull-apart grabens have formed at locations along the plate boundary where the structural trends change to accommodate this curvature.

Keywords: Strike slip, Pull-apart Grabens, Cyprus Basin, Larnaca Lowlands, African-Anatolian Plate Boundary

THE ILICA FAULT, EASTERN SECTOR OF THE ESKİŞEHİR FAULT ZONE, CENTRAL ANATOLIA, TURKEY: ITS STRUCTURAL CHARACTERISTICS AND SEISMICITY

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The right-lateral strike-slip Ilica Fault is located at the eastern sector of the Eskişehir Fault Zone. The fault is around 100 km long and extends in a northwest-southeast direction from Yenimehmetli (70 km southwest of Ankara) to the west-northwest of Tuz Gölü. Its structural characteristics have not been investigated in detail until now.

The fault has been divided into five segments based on the geological and geomorphological data namely, Yenimehmetli, Ilica, İler-Demiröz, Mangaldağı, and Samsam-Gökgöl from northwest to southeast, respectively. The Yenimehmetli segment is characterized by the right-lateral strike-slip fault surface that is clearly observed in the Jurassic-Cretaceous recrystallized limestone and marble. In the Ilica segment, the fault is morphologically distinct between the Pliocene and the Alluvium-Quaternary units. The İler-Demiröz segment shows many structural characteristics of the Ilica Fault, such as steeply-dipping beds, offsetting of stream channels, slickenside surfaces and development of cataclastic zone including breccia and pervasive fracturing. A total of 14 km right-lateral displacement of the Demiröz stream in the İler-Demiröz segment is also compatible with the direction of the fault. The Mangaldağı segment is clearly observed on the satellite images. The subsidiary faults and fractures (R, R', P, and X shears) related to the main fault reflect the right-lateral strike-slip geometry. The Samsam-Gökgöl segment is southeastern continuation of the Ilica Fault and extends to the west of Tuz Gölü. Morphological expressions of the transtensional and transpressional areas are clear along this segment.

The numerous earthquakes having magnitudes between 2 and 4.5 indicate that the area is seismically active. The right-lateral stream offsets and the seismic activity both show that the Ilica Fault is an active structure. Therefore, it should be taken into consideration to the earthquake risk assessment of the capital city Ankara and its surroundings.

Keywords: Ilica Fault, Eskişehir Fault Zone, Central Anatolia, Ankara

THE EAST ANATOLIAN FAULT: GEOMETRY, SEGMENTATION AND JOG CHARACTERISTICS

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Seismically active the East Anatolian Fault (EAF) is one of the major recent tectonic structures of East Mediterranean and together with the North Anatolian Fault it accommodates westward excursion of the Anatolian micro-plate. The EAF, 435 km-long between Karlıova and Türkoğlu, cuts Taurus Orogenic Belt trending NE-SW. The EAF divides into two main strands -southern and northern-, at the western part of Çelikhan. The southern strand extends to Türkoğlu and joins the Dead Sea Fault by the Türkoğlu releasing bend (155°). The northern strand bifurcates as a major splay from the EAF and consists of Sürgü, Elbistan and Göksun faults.

From NE to SW, based on the geometry and jog structures, the EAF is divided into six main fault segments namely Karlıova, Ilica, Palu, Pütürge, Erkenek and Pazarcık. These segments are separated from each other by dilational and compressional jogs. Jogs cause to change the orientation of fault segments. The strike of segments varies from N40°E and N67°E and lengths are between 27 and 86 km. The 2 km wide and 3 km long Gölbaşı releasing step-over formed between Pazarcık and Erkenek segments. The Lake Hazar is the largest releasing step-over along the EAF with a 3 km wide and 10-15 km long. The other jogs between the faults are compressional in character. Of these, the 15 km long Yarpuzlu restraining double-bend locates between Erkenek and Pütürge segments. The 20 km wide Gökdere restraining step-over, which is the largest compressional jog along the EAF, formed between the Ilica and Palu segments. These two large compressional jogs are characterized by uplifted morphology.

During the last two century, six large earthquakes occurred along the EAF except the Pazarcık segment. It is considered that 1866, 1874, 1875-1905, 1893 and 1971 earthquakes were generated from Karlıova, Palu, Pütürge, Erkenek and Ilica segments, respectively. The 8 March 2010 earthquake, the most recent event, occurred in the Gökdere restraining step-over. The latest large earthquake can be correlated with 1513 historical event for the Pazarcık segment. Nevertheless there is no enough data for recurrence interval of the large events for the entire fault zone. However the average slip rate is 8-9 mm/y based on geological and GPS data. Taking into account the elapsed time from the last event it can be speculate that the Pazarcık segment is a candidate to produce large earthquakes in near future. According to the fault geometry and seismological data the Gökdere restraining step-over has the similar moderate-large earthquake potential.

Keywords: East Anatolian Fault, segmentation, step-over, bend

LATE CRETACEOUS-EARLY CENOZOIC TECTONIC DEVELOPMENT OF THE NORTHERN, ACTIVE MARGIN OF THE SOUTHERN NEOTETHYS OCEAN: EVIDENCE FROM SEDIMENTARY GEOLOGY AND BIOSTRATIGRAPHY OF THE KYRENIA RANGE, CYPRUS

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Sedimentary geology and planktonic foraminiferal biostratigraphy shed light on the tectonic development of the northern, active continental margin of the Mesozoic Neotethys ocean (S Neotethys) in the Kyrenia Range. Following regional Triassic rifting a carbonate platform developed during Jurassic-Cretaceous time, followed by its regional burial, deformation and greenschist facies metamorphism. The platform rocks were exhumed by Maastrichtian time and unconformably overlain by locally derived carbonate breccias, passing upwards into pelagic carbonates of mainly late Maastrichtian age. In places, pelagic carbonates are interbedded with siliciclastic or calcareous sandstone turbidites derived from mixed continental-type, basic volcanic, neritic carbonate and pelagic source materials. Two contrasting volcanogenic sequences are exposed in the western and central Kyrenia Range, separated by a thrust fault. The structurally lower of these is made up of a thickening-upward sequence of mainly Maastrichtian-aged pelagic carbonates, silicic tuffs, silicic lava debris flows and thick-bedded, to massive rhyolitic lava flows. The structurally overlying volcanogenic sequence comprises mainly late Maastrichtian and Late Palaeocene basaltic pillow lava, pillow breccia and hyalotuff, interbedded with pelagic carbonates. Additional basaltic lavas exposed throughout the central and eastern Kyrenia Range and the Karpas Peninsula mainly erupted during Late Maastrichtian and Late Palaeocene time. In the favoured tectonic model the Mesozoic carbonate platform of the Kyrenia Range capped a rifted continental fragment within the southern Neotethys. During the Late Cretaceous the Kyrenia platform subducted northwards beneath a larger Tauride microcontinent unit to the north, underplated and then rapidly exhumed, possibly owing to oceanic slab rollback. Pelagic carbonates and sandstone turbidites of mixed, largely continental provenance then accumulated locally along a deeply submerged continental borderland. Both the silicic and basaltic volcanogenic rocks are likely to have erupted in adjacent basinal areas above exhumed Mesozoic continental basement during Maastrichtian time. The probable tectonic setting involved a combination of northward subduction during the Late Cretaceous, followed by Maastrichtian and Palaeocene extension-, or transtension-, related volcanism that was associated with anticlockwise palaeorotation of the Troodos microplate. The contrasting silicic and basaltic volcanic sequences were later juxtaposed, probably related to southward thrusting during Mid-Eocene time, driven by the a later stage of closure of the S Neotethys.

Keywords: Kyrenia Range, Cyprus, Neotethys, Upper Cretaceous-Paleogene; sedimentology, biostratigraphy

PALEOSEISMOLOGY OF THE TÜRKOĞLU-ANTAKYA SEGMENT OF THE EAST ANATOLIAN FAULT ZONE (EAFZ), TURKEY

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The East Anatolian Fault Zone (EAFZ) is among the most important active continental transform fault zones in the world as testified by major historical and minor instrumental seismicity. A paleoseismological exploratory trenching study on the Türkoğlu-Antakya segment was performed during the past 5 years in order to determine its past activity and to assess its earthquake hazard. The segment consists of parallel and subparallel strands getting younger basinwards.

The results indicate that there are three types of Quaternary alluvial deposits, namely Qal1, Qal2 and Qal3, along the segment. They have similar lithology but different deformation and cementation characteristics. The oldest Qal1 and second oldest Qal2 are faulted while the youngest Qal3 is not faulted. Several earthquakes have been encountered in the trenches. The youngest event is the AD 1230 or 1268 event of Sosyal et al (1981). The 1822 and 1872 events ($M > 7$) of Ambraseys (1989) have not been encountered in the trenches. These events may have occurred on a different strand or evidence of the surface ruptures of these events might have been destroyed, which is unlikely for events like these, especially where there is dip-slip faulting, or not discovered in the excavations of this study. The recurrence interval for a surface rupturing large ($M > 7$) earthquake is estimated as minimum 175 and maximum 370 years.

Keywords: active fault; East Anatolian fault zone, Türkoğlu-Antakya segment; paleoseismology; recurrence interval

PALEOSEISMOLOGICAL EVIDENCES ABOUT THE LONG TERM ACTIVITY OF THE NORTHERNMOST DEAD SEA FAULT ZONE, TURKEY

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The Dead Sea Fault Zone (DSFZ) is one of the most active tectonic structures of the Mediterranean region and it extends from the Red Sea in south to East Anatolian Fault Zone in north. The DSFZ enters to Turkey east of Antakya and extends along the western side of the Asi River up to the Amik Basin. Large earthquakes occurred along this fault in historical period and during the 20th century. Although long term historical activity has been documented around Antakya region, it is not clear which segments of DSFZ involved faulting during these earthquakes. Recurrence interval and offset amounts are also uncertain, for this part of the DSFZ.

The recent activity of the northernmost DSFZ is characterized by geological evidence for faulting and offset geomorphological features. Paleoseismological studies were conducted on the fault zone near the Amik Basin. Six different surface faulting events were recognized in the trench study and event horizons were dated by radiocarbon and OSL methods. Comparing trench data with historical earthquake records, it can be concluded that these earthquakes occurred in 115 A.D. 526, 1091, 1408 and 1872 on this part of the fault zone. In addition one more earthquake obtained from trench studies but there is no reliable historical account to correlate this event. On the basis of paleoseismological evidence, it is suggested that the recurrence interval of surface faulting events are 300 - 550 years and the slip rate is 5.2 – 6.5 mm/year on the northernmost part of the DSFZ.

Keywords: Dead Sea Fault Zone, paleoseismology, historical earthquake, Antakya, Amik Basin.

THE EL-KABIR FAULT ZONE: A CRITICAL LINEAMENT LINKING THE CYPRUS ACTIVE MARGIN WITH THE ARABIAN CONTINENTAL MARGIN IN NORTHERN SYRIA

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This important lineament runs south of Cyprus, along the Tartous ridge, through the Nahr El-Kabir basin, to the Ghab graben on the Dead Sea transform fault. The lineament marks the southernmost deformation front separating the African/Arabian and Anatolian plates. Late Cretaceous emplacement of the Baer-Bassit ophiolite was immediately followed by drowning of the northern part of the Arabian shelf. The Paleogene onshore succession reflects subtle uplift and instability of the Arabian margin inland, with generally deepening marine conditions from SE to NW. There is evidence of early lateral offsets along the El-Kabir fault lineament during the Eocene, as seen in excellent coastal exposures (near Latakia). Regional uplift followed, probably as a result of flexural uplift, which accompanied suturing of the Southern Neotethys to the north.

Early Miocene was characterised by marine transgression, followed by subsidence to form the Nahr El-Kabir basin. The sediment infill is dominated by proximal detritus, mainly shallow-marine carbonate and ophiolitic material (e.g. large-scale westerly paleocurrent trending debris flows). The well-preserved southern flank of the basin is marked by extensional, or transtensional faults. In contrast, the poorly exposed northern basin margin was highly fault active during the Late Miocene, continuing into the Plio-Quaternary, as seen in coastal exposures. In the east the basin is truncated by ~N-S faults related to the Dead Sea Transform. The basin infill is interrupted by a Tortonian unconformity, followed by two Messinian gypsum intervals. The Pliocene saw widespread return to open-marine conditions, albeit with restricted depocentres, while the Quaternary was characterised by progressive (or pulsed) uplift.

The onshore stratigraphic and structural development, therefore, involved Maastrichtian ophiolite emplacement, relatively quiescent Paleogene sedimentation, early Miocene subsidence of the Nahr El-Kabir basin, Late Miocene basin infill and Late Pliocene-Quaternary regional uplift. Comparisons with limited available offshore seismic data confirm the long-lived character and critical role of the El-Kabir lineament as the northern boundary of the Levant basin. Overall, the onshore and offshore evidence suggests that the Nahr El-Kabir basin (i.e the traditional Nahr El-Kabir Graben) reflects a small area of crustal extension/transtension within the crustal transition from the collisional area to the north and the pre/syn-collisional deep-sea Mediterranean basin to the west.

Keywords: Nahr El-Kabir graben, Syria, Levant basin, sedimentology, Neogene

A MODEL FOR THE PLATE TECTONIC EVOLUTION OF THE EASTERN MEDITERRANEAN REGION THAT EMPHASIZES THE ROLE OF TRANSFORM (STRIKE-SLIP) STRUCTURES

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The Eastern Mediterranean region has had a complex tectonic history since the early Mesozoic breakup of Gondwana. Between the major plates of Africa and Eurasia, there is a > 1,500-km-wide intervening collage of differing tectonic terranes that is the product of shearing, rifting, subduction, obduction, and contraction over the past 200 Ma. The dynamics of plate interactions is recorded in the assembly of this collage. The Eastern Mediterranean region encompasses the southern portion of the collage and includes its margin with the African plate. Cyprus is located on the southern margin of the Anatolian microplate, adjacent to the African plate boundary. Understanding the tectonic evolution of Cyprus is critical to a better understanding of the tectonic evolution of the entire Eastern Mediterranean region. A model for the tectonic evolution of the Eastern Mediterranean region from Mesozoic to Present is developed from geological, geophysical, and seismological data on and surrounding the island of Cyprus. This model emphasizes the role of major transform structures in accommodating horizontal plate motions, driven from the west by spreading along the Atlantic-Arctic mid-ocean-ridge system and from the east by escape tectonics related to the movement of the Arabian plate.

In particular, this model interprets the African-Anatolian plate boundary in the Eastern Mediterranean as a system of left-lateral transform structures that is approximately 75 km wide and that has been active since the early Mesozoic. In this model, Neotethys spreading and closure (subduction and obduction) occurred north of the transform system. Geophysical data indicate that the Troodos ophiolite dips northward; the vergence direction for all major regional structures is towards the south; these phenomena suggest that subduction was to the north of Cyprus and beneath the Anatolian plate. Southward obduction of the Troodos ophiolite onto continental crust that underlies Cyprus was facilitated by contemporaneous left-lateral horizontal shear during the Cretaceous: this was accompanied by a 90° counterclockwise rotation of the ophiolite. Trench, fore-deep, and accretionary prism rocks were emplaced on Cyprus from the north by transpressive stress in the Neogene.

The northward sequence of 1) a wide zone of shear containing ophiolites; 2) contracted trench and accretionary prism rocks; and 3) a north-dipping subduction zone is similar to the sequence described by others across the Arabia-Anatolian plate boundary, indicating commonality in tectonic evolution.

Keywords: Eastern Mediterranean, plate tectonics, African plate, Neogene, Cyprus

LATE QUATERNARY SEISMIC SEQUENCE STRATIGRAPHY OF NORTHERN CONTINENTAL SHELF AREA OF MARMARA SEA BETWEEN KUMKAPI AND BÜYÜKÇEKMECE

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Influences of tectonics on the Late Quaternary stratigraphy of the shallow subsurface sediments along the northern shelf of Marmara sea have been investigated using high resolution seismic data. Based on reflection characteristics, three major depositional units have been identified in the study area.

Depositional unit 1, at the bottom of the sequence is believed to have been deposited before the initiation of the Holocene ‘Flandrian transgression’, whereas the last two depositional units (2 and 3) were deposited during the Holocene Transgression. From the seismic data, the prominent reflectors “R” that mark the base of the seismic units, respectively, and an acoustic basement (AB) have been identified in the study area. In a distinctly more shallow area to the west, the deformed strata are situated just below the seabed, with only a thin cover of younger sediment. ‘R’ is the only major unconformity to occur within the wedge of unconsolidated sediments forming the inner and outer shelf in this area.

The shallow seismic profiles provide a better resolution of small-scale tectonic features (for example faults and channel) and therefore may contribute significantly to understand the tectonic history of the region. These structures are active since they cut the Late Quaternary sedimentary units. The upper surface of acoustic basement is compared with the coastal geology, it is estimated that this upper surface corresponds to Upper Miocene age sediments between Büyükçekmece and Kumkapı. The Upper Miocene sequence consists of unconsolidated gravel and sand, the base having a variable thickness, and passes through clayey marl-mudstones and muddy limestone towards the top.

Patterns of coastal progradation and/or erosion in the northern coasts of the Marmara Sea may have been affected by regional tectonic conditions and relative sea-level oscillations during the recent Holocene highstand period.

Keywords: Seismic Stratigraphy, Sea Level Change, Holocene, Marmara Sea

AN INCISED VALLEY MARKING AN EROSIONAL UNCONFORMITY AND SHELF MARGIN DURING MAASTRICHTIAN TIME IN HAYMANA AREA OF CENTRAL ANATOLIAN BASIN

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Haymana area of Central Anatolian basin has been studied since late 1950's. All studies have been done for classical stratigraphic work and mapping purposes. Therefore all units deposited in the basin have been considered conformable and gradational. Detailed studies of the basinal sediments indicate that there were many sea level changes that affected the sedimentation pattern and stratigraphic relations resulting in erosion and unconformity. These erosion affected only shelf areas and their extends depended on the amount of sea level drop during that time. One of these sea level drops is marked by an incised valley that was incised into shales and filled by a sequence of quartz sandstone and sandy carbonate levels at the end of Early Maastrichtian. Incision is about 60 meters and topped by a carbonate level with orbitoides and rudist giving the age of Late Maastrichtian. Amount of erosion and extend of erosional unconformity together with facies type indicate that shelf margin was very close to the incised valley (about a kilometer). Incision also confirmed by turbiditic sedimentation. When sea level dropped and reaches below shelf edge sediment load and erosional material from shelf edge directly emptied into basin resulting in the deposition of submarine fan sediments.

Keywords: Incised valley, erosional unconformity, sea level change, sequence stratigraphy, shelf margin

TECTONICALLY INDUCED INCISED VALLEY MARKING AN IMPORTANT SEA LEVEL DROP AND DIRECTION OF LOCAL SHORELINE

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An incised valley about 200 meters was developed before Late Paleocene and exposed today along Koçhisar-Aksaray Fault Zone in the east of Tuzgölü. Incision affected the Early Paleocene, Late Maastrichtian and even pre-Early Maastrichtian continental sediments indicating that a considerable incision had occurred before the deposition of Late Paleocene coarse grained conglomerates and carbonates. When compared the amount of sea level drop from Haymana area and Ulukışla area, this period reflects an important sea level drop and sediments deposited in this period is not observed along the Koçhisar-Aksaray Fault Zone. In the basinal areas, the sediments must be represented by very coarse grained material. Following period also marks a considerable amount of sea level rise that filled more than 200 meters incision and topped the valley fill. Direction of valley indicates that at this locality palaeoshoreline was extending from almost perpendicular to present Koçhisar-Aksaray Fault Zone. This is an important event that we have to consider in order to understand the evolution and palaeogeography of Central Anatolian Basin.

Keywords: Incised valley, sea level changes, sequence stratigraphy, Tuzgölü, Shoreline

OLIGO-MIOCENE SEDIMENTATION IN THE GIRNE (KYRENIA) TERRANE, NORTH CYPRUS

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The Eastern Mediterranean marks the site of the Southern Neotethys Ocean that was created, then largely destroyed near the northern margin of Gondwana. Sedimentary and structural evidence is well preserved in the Girne (Kyrenia) Range, a several hundred kilometre-long, E – W-trending, arcuate lineament that encompasses northern Cyprus and a submarine ridge that links SE Turkey (Misis-Andırın).

Two related Oligocene-Miocene sedimentary basins are separated by an E – W-trending high-angle fault, the Değirmenlik (Kythrea) Fault. The northern basin encompasses the Girne (Kyrenia) Range, whereas the southern basin is located between the Değirmenlik (Kythrea) Fault and the E – W trending Dar dere (Ovgos) Fault Zone, to the south of which is the Troodos ophiolitic massif. The Değirmenlik (Kythrea) Fault is interpreted as a convergence-related thrust fault that was mainly active during the Mid-Late Miocene, creating a submarine ridge that separated sub-basins. The sedimentary sequence in the northern sub-basin unconformably overlies Mesozoic and Late Cretaceous-Palaeogene carbonates with interbedded volcanic rocks. Above basal conglomerates (largely derived from underlying Eocene debris flows), there is a fining-upward siliciclastic turbidite sequence (Late Oligocene), then biogenic calciturbidites and marls (Aquitanian-Langhian). The northerly basin is characterised by thin-, to medium-bedded, pale calciturbidites and marls (Serravallian), overlain by thick-bedded, medium-grained lithic sandstones (Tortonian). The succession in the southern basin, which is strongly deformed by thrusting, begins with poorly dated pelagic marls (Early Miocene?), followed by regularly bedded siliciclastic turbidites with abundant sole structures (Serravallian-Tortonian). Palaeocurrent evidence shows E to W flow for both sub-basins, especially during the Late Miocene. Petrographic and X-ray diffraction studies of sandstones and clay minerals indicate that the Serravallian-Tortonian sandstones of the northern sub-basin are richer in carbonates, while the southern sub-basin contains more siliciclastic and ophiolite detritus. The sediments appear to have been mainly sourced from the Tauride Mountains, northeast of Cyprus in response to Early Miocene closure of the Southern Neotethys and subsequent, Late Miocene suture tightening.

In a regional setting the Oligocene-Miocene evolution of the Girne (Kyrenia) Range reflects the later stages of oblique, diachronous closure of the Southern Neotethys, which included an important phase of southward thrusting during Late Miocene-Early Pliocene time. Uplift of the Girne (Kyrenia) followed during Late Pliocene-Pleistocene time, probably triggered by the collision of Cyprus (by then part of the Eurasian plate) with the Eratosthenes Seamount (part of the African plate) along the Cyprus trench to the south of the island.

Keywords: Southern Neotethys, North Cyprus, Girne (Kyrenia) Terrane, Oligo-Miocene sedimentation, Değirmenlik (Kythrea) Fault.

PLIO-QUATERNARY STRESS REGIME IN ESEN ÇAY BASIN, SW TÜRKİYE

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Southwest Türkiye is one of the complex tectonic areas of Anatolia, situated at the junction of Hellenic and Cyprus arcs. The Plio-Quaternary Esen Çay Basin in southwestern Türkiye plays an important role for understanding tectonic evolution in relation to northward convergence of the African plate towards Anatolia, which resulted in the Hellenic and Cyprus arcs. The inversion of the fault slip vectors acquired from the Pliocene to Quaternary formations in Esen Çay Basin gives normal and strike-slip faulting stress states. The extensional and strike-slip faulting stress regimes, which are characterized by NW-SE and NE-SW trending σ_3 axes seem to contribute to the formation and development of the NNE-trending Esen Çay Basin. The focal mechanisms of the shallow earthquakes occurred within and near the surrounding basins are also characterized by NW-SE and NE-SW T-axes. The stress tensor inversion using these focal mechanisms yields a strike-slip with normal component (transtension) stress state with NW-SE σ_3 axis and also normal faulting stress state with NW-SE and NE-SW σ_3 axes. Our observations suggest that the Esen Çay Basin should have been formed and developed by the NE-SW and NW-SE extensional and transtensional stress regimes since Pliocene. These stress regimes acting from Pliocene onwards in SW Türkiye are attributed to the complex tectonic pattern due to the coeval influence of the superimposed boundary forces in SW Anatolia in relation with the subduction processes along the Hellenic and Cyprus arcs and also to the southwestward escape of the Anatolian block.

Keywords: Inversion, Stress State, Fault-slip vector, focal mechanism, Esen Çay, SW Türkiye.

THE AMBIENT NOISE MULTI-ARRIVAL TOMOGRAPHY OF TURKEY AND SURROUNDING REGIONS

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We present seismic crust and upper-mantle images from Turkey and surrounding regions estimated by the multi-arrival tomographic inversion of Rayleigh wave type Green's functions derived from the Earth's ambient seismic noise. Recent work from Shapiro and Campillo (2004) and Shapiro et al. (2005) showed that by using two seismic stations, it is possible to extract information along the connecting path by cross-correlating seismic ambient noise. This method has recently become an important imaging tool for crustal and upper mantle studies around the globe such as North America (Shapiro et al., 2005; Sabra et al., 2005), Tibet (Yao et al., 2006), New Zealand (Lin et al., 2007), and Australia (Saygin and Kennett, 2009) to name a few among others. Until now, these studies exploit the first arrival of the extracted Green's functions from the ambient noise correlations. For longer interstation distances, one might observe later arrivals of Green's functions, which can be caused by multipathing. Multipathing is a result of focusing and defocusing of seismic waves due to the lateral velocity variations (Stein and Wysession, 2004). Later arrivals due to multipathing carry additional structural information when compared to the first arrivals as their paths differ from the first arrival paths. We invert travel times of the first and later arrivals of Green's functions in a 2 stage approach combining first arrival tomography (Rawlinson et al., 2006) and multiarrival tomography (Hauser et al., 2008). The first arrival tomography uses Fast Marching Method based wavefront tracker (Rawlinson and Sambridge, 2004) for the forward problem and a nonlinear iterative solver; the subspace method (Kennett et al., 1988) for the inversion. In the second step, the result of the first arrival tomography is used with a recently developed wavefront tracking technique combining initial value ray tracing and interpolation in the phase space (Hauser et al, 2008). Inversion is carried out iteratively with the subspace inversion. During each step of the multi-arrival tomography, the expected arrival times of the later arrivals of the Green's functions are predicted and compared with the observed data. The output velocity model is refined step by step in the inversion by incorporating matching later arrivals. The aim of this approach is to increase the number of travel times incorporated in the inversion, therefore giving better coverage and resolution on the velocity models. The primary data come from the 3 component 29 seismic stations of the Eastern Turkey Seismic experiment run during 1999-2001. Other permanent and temporary broadband seismic stations from eastern Greece to western Caucasus were added to the analyses to create a uniform coverage across the region. Our results show the consistent low velocity regions (< 2.8 km/s) in western Turkey for all of the period ranges (5-10 s). These low velocity anomalies are associated with the elevated crust and upper-mantle temperatures or presence of fluids in the crust (Saunders et al., 1998; Akyol et al., 2006). The upper-mantle images from 10 s Green's functions mark the lowered velocities in Anatolian Plateau (eastern Turkey) which is consistent with the suspected partial delamination of the lithosphere in this region (Zor et al., 2003; Gök et al., 2007). The rapid increase in seismic velocities for this period in the south-western Turkey shows the transition from Anatolian Plateau to Arabian Plate (Taymaz et al., 2004, 2007). Another prominent low velocity region in the crust exists in the east Mediterranean Sea which is associated with the presence of thick sediments.

Keywords: Anatolia, ambient noise, multi-arrivals, ray-tracing, tomography

ESTIMATION OF QUATERNARY PERIOD IN THE ALBANIDE

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Albanides as complex real space, along of which extension the new Quaternary depositions, in the fully its knowledge are main issues, about of which are made efforts, no only about their denomination, but for the determination of the elements of the geo-tectonic differentiation. As complex category, Albanides composes elements of the natural landscape, as fundamental base in the transformation of which the human factor determinates the development scale as geo-geographical space. And why these natural elements are representative indicators, with their site, realize regional differentiation, these are only a small part from major group of the natural elements landscape-land-resource. So their fully analyze, is not geological reality, but also and the object of a social role, as determinative for transformation. The study independences of their elements are not only in their inventory, but in the determination of the equilibrium, statistics, dynamics, complexity etc. After collaborations and transforming scale, the natural categories become cultural ones.

Albanides with all their geo-geographical elements are an individualized specific space. With its elements, of the landscape, land and resource category, not only tells the differences, but is differenced clearly from the analogues as in transversal plain also longitudinal one. In a space, in a way, limited are developed almost all categories of the relief, types of the lands, vegetations, complexes of the high mountains and low lands, lithological kinds, structures, tectonics and the communities which live along them. In this frame are and the new Quaternary depositions, with all their geo-economical and geo-environmental estimations.

The Quaternary depositions along Albanides, presented above, compose a geo-natural potential, which from the importance it has, merits many attention and the permanent studies time to time. Its foresight in this book composes a synthetic of their actual state on dynamic, with preliminary estimation of the geo-economical and geo-environmental aspect. So taking in analyze the new depositions, after their lithology, genesis and age, also and some actual geo-tectonic processes of their forming and state, made possible compilation of a map series, that help in administration of the geological setting, in exact planning of the infrastructure also in the determination of the field for treatment of the different contaminants, which associate the human activity. Albanian society in transition to consolidation of the trade economy, confronts every day with many problems, as like as, usage from the man of the land surface, especially for the extension of the urban spaces, the contaminations of all kinds, with rational usage of the ground and the underground, with interpretation of the connections between geological units near of the surface and the agriculture land, with determination of the pollution and the character of the water bearing strata in near of the surface, with the determination of the geological and tectonic setting for the collection, deposition and landfill of the remains, with the determination of the resources of the raw materials, with the determination of the geologo-engeenering features of the geological units near of surface, etc.

And the last, Quaternary depositions, as in first contact with the man and its activity, search attention and special, complex and modern studies compared to the underlying depositions.

Keywords: Albanide, features, society, resources, lithology.

TIME DOMAIN MOMENT TENSOR INVERSION OF ÇAMELI-GÖLHISAR (SW TURKEY) EARTHQUAKES OF 2005-2008

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Western Anatolia is among one of the most active extensional regions in the world. North-South extension in the western and southern part of Anatolia led to the development of numerous fault-bounded basins such as Çameli which is about 40 km wide and 60 km long, Neogen graben located in the vicinity of Denizli (SW Turkey). There are significant tectonic structures such as Fethiye-Burdur Fault Zone, Çameli-Göhlhisar Fault, Honaz Fault, Babadağ Fault and Pamukkale Fault in the study province. Earthquakes with magnitudes ranging $3.5 \leq M \leq 4.0$ occur frequently in the region. However, 24 earthquakes with magnitudes greater than 4.0 have occurred during 2005-2008. The goal of this study is to analyze seismotectonic characteristics and/or source parameters of Çameli-Göhlhisar (Denizli) earthquakes, and further to explain the geometry of active fault structures in the region by using seismological data. For this purpose, we have analyzed 10 earthquakes ($3.5 \leq M \leq 5.7$) occurred between 13.07.2005 and 08.10.2008 in the region. Methodology used in this study developed by Dreger (1992), Dreger and Helmberger (1993), and it is known as Time Domain Moment Tensor Inverse Code (TDMT_INVC). Regional Moment Tensor (RMT) method is commonly used to determine source parameters of moderate earthquakes ($4.0 \leq M \leq 6.0$) recorded at regional distances ($1^\circ \leq \Delta \leq 10^\circ$), and it is widely accepted technique due to availability of number of high quality broad-band stations at a regional and global scale. Normal and oblique fault characteristics are common in the study region as suggested by source mechanism solutions obtained.

Keywords: Active tectonics, Çameli-Göhlhisar (Denizli), earthquake, regional moment tensor, source mechanisms

TIME DOMAIN MOMENT TENSOR INVERSION OF BÂLA-SIRAPINAR (CENTRAL TURKEY) EARTHQUAKES OF 2005-2008

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The goal of this study is to analyse source parameters of Bâla-Sirapınar (Ankara) earthquakes occurred during 2005-2008, and to explain the geometry of active fault structures and seismotectonic characteristics in the region by using seismological data. For this purpose, we have analysed 35 earthquakes with magnitudes ranging $3.5 \leq M \leq 5.7$ occurred between 30.07.2005 and 18.12.2008. Methodology used in this study developed by Dreger (1992), Dreger and Helmberger (1993), and it is known as Time Domain Moment Tensor Inverse Code (TDMT_INV). Regional Moment Tensor (RMT) method is commonly used to determine source parameters of moderate earthquakes ($4.0 \leq M \leq 6.0$) recorded at regional distances ($1^\circ \leq \Delta \leq 10^\circ$), and it is widely accepted technique due to availability of number of high quality broad-band stations. With regard to the earthquake history of the region, there is not clear surface ruptures of active faults which can produce a major earthquake. Nevertheless, the study region has been affected significantly from earthquakes generated by North Anatolian Fault located 120 km to the north and cross-cutting fault zones (splay faults) to the south. We have consequently obtained focal mechanism and moment tensor solutions of 27 earthquakes which have good signal-to-noise (S/N) ratios. According to source mechanism solutions, right-lateral strike slip fault characteristics are common in NW-SE direction and left-lateral strike-slip fault characteristics in NE-SW direction. Some mechanisms include normal faulting components and partially E-W directions exist. It has known that the existence of conjugate fault systems are located both in NW-SE and NE-SW in region. In this respect, plenty of NW-SE directions indicate that common characteristics of 2005-2008 earthquake activity in this region could have represented with right lateral strike slip faulting mechanism and source mechanism solutions are consistent with active tectonics and local geological features.

Keywords: Active tectonics, Bala-Sirapınar (Ankara), earthquake, regional moment tensor, source mechanisms

INVESTIGATION OF MICRO-EARTHQUAKE ACTIVITY IN IZMIR: PRELIMINARY RESULTS OBTAINED FROM LOCAL SEISMIC STATION NETWORK

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A small-aperture, strong-motion array, the IzmirNET (Polat et al. 2009), has been installed in around Metropolitan Izmir (Aegean region of Turkey, Western Anatolia). The network consists of 16 strong ground motion recorders in the frame of a multi-lateral cooperation between Earthquake Research and Implementation Center (DAUM) of Dokuz Eylül University (DEU, Izmir) and Disaster and Emergency Management Presidency of the Prime Ministry of Turkish Republic. Other consortium members are the Ministry of Public Works and Settlement and Greater Municipality of Izmir.

Important purposes of the array are: monitoring future significant events in the region, quantifying spatial variability of strong-motion over short distances, and enlightening the earthquake source processes and parameters. The number of array stations and their arrangement were based on the distribution of the geologic units, settlement density, and industrial developments.

This study about first results of the seismicity of region and focal mechanism solutions. The IzmirNET is operational since the beginning of 2009 and recorded data are investigating to elucidate the local seismicity (focal depths, magnitudes), focal mechanisms and stress tensor. Sufficient number of events have been obtained from the Metropolitan Izmir and its vicinity.

This array is already recording small-scale earthquakes in the Gulf of Izmir and the surrounding area. Using SEISAN S software, located events are expecting low-to-moderate size magnitude, but they eventually play important role to study a future large earthquake or to predict ground motion from a potential future event.

Keywords: Strong motion, Seismicity, Izmir, Earthquake, Seisan

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LINEAMENT ANALYSIS OF ULUKIŞLA PART OF THE CENTRAL ANATOLIA FAULT ZONE

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The study area is located on the Central Anatolian Fault Zone. This zone is one of the largest and most important fault zones after the North Anatolian and East Anatolian Fault Zones in Turkey. The Central Anatolian Fault Zone is 730 km in length, 2-80 km in width; NE-SW oriented, left lateral and active, intra continental strike-slip fault and cut the Anatolian Plate from Anamur to Erzincan. The study area is located in Çamardı-Ulukışla Basin of the Central Anatolian Basins and affected by the Kamışlı segment of the Central Anatolian Fault Zone.

For lineament analysis, the image covering the study area was cut from the 176/34 (path/row) numbered satellite image, and digital elevation model of study area has been obtained from digitization of 1/25.000-scale topographic maps. Lineament analysis were made using single band, RGB composites and principal component analysis applied images, in addition to these, relief gained digital elevation model was also used. Designated lineaments were overlaid as separate layers, and then the associated lineaments were selected. After accuracy analysis, remaining lineaments, and faults were compared with field data and the final map were used for the preparation of rose diagrams. Based on the correlation of the anticipated structures from the strike slip fault zone and lineaments of the study area obtaining from field data and satellite image processing, it is concluded that the study area is under the effect of transtensional left-lateral strike slip fault.

Keywords: Lineaments, Landsat 5 TM, GIS, Çamardı-Ulukışla Basin, Fault Zone

GEOLOGY AND TECTONIC SETTING OF KAMAN-GORKIN POST-EOCENE IGNEOUS ROCKS IN WESTERN ALBORZ, NORTHERN IRAN

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The Cenozoic geological record of Iran is characterized by widespread volcanic activities across central Iranian and Alborz mountains areas, mainly during Eocene times. In the Kaman-Gorkin area, western Alborz, the Middle-Eocene pyroclastic rocks are intruded by calc-alkaline post-Eocene plutonic and volcanic rocks. The Kaman-Gorkin plutonic rocks are largely comprised of dacitic domes and micro-gabbro dikes. The volcanic rocks occur as massive sill- and dike-like bodies ranging in composition from olivine-basalt to andesite and trachyandesite.

The multi-element plots of Kaman-Gorkin post-Eocene plutonic and volcanic rocks normalized to N-MORB show enrichments in “Large Ion Lithophile Elements” (LILE), like Rb, Ba, Th, K, and depletions in High Field Strength Elements (HFSE), such as Nb, Ta and Ti. These features, especially the fact that Kaman-Gorkin post-Eocene rocks are enriched in Th and depleted in Nb, could be interpreted as an association of the rocks with slab-derived fluids and sediments in a subduction-zone environment.

The geological and geochemical evidences all indicate that the Kaman-Gorkin post-Eocene igneous rocks occurred in an active continental margin setting, which is consistent with the model assuming the subduction of Arabian plate beneath the Iranian plate during the Late Cretaceous-Paleocene.

Keywords: Kaman-Gorkin, post-Eocene igneous rocks, Calc-alkaline, subduction zone, , active continental margin setting.

THE AMBIENT NOISE TOMOGRAPHY OF TURKEY: CRUST TO UPPER MANTLE

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We use over 250 3-component broadband stations from permanent and temporary networks in Turkey and surrounding regions to image structure in Turkey with ambient noise tomography from crust to upper-mantle. Rayleigh and Love wave phase and group velocities are used in a nonlinear iterative tomographic inversion. Then the velocity models from the tomographic inversions are used in a joint inversion to create the Moho depth map of the region. The results mark the complex structure of the region. The seismic images from western Turkey show low velocities possibly linked to the elevated temperatures or fluid content. The images for central Turkey show low velocities for shallow depths but seismic velocity increases with depth; this also coincides with the geothermal potential of the region. The complex wave-speed images for eastern Turkey marks the effects of the ongoing geological processes such as the active collision of Anatolian block and Arabian plate.

Keywords: the ambient noise, ray-tracing, tomography, Turkey

HOLOCENE COASTAL NOTCHES IN THE MEDITERRANEAN: PALAEOSEISMIC OR PALAEOCLIMATIC INDICATORS?

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Bioerosion and bioconstruction along rocky coastlines can lead to the development of coastal notches that can be preserved when uplifted or submerged above or below the swash zone. Since these geomorphic features form at sea level, palaeoshorelines can be used to quantify relative coastal uplift and subsidence in tectonically active areas when the sea level history is known. Notches have been dated and measured from around the Mediterranean basin for this purpose since the 1970s but it is only recently that numerical models of Holocene sea-level change have become detailed enough for accurate comparisons to be drawn. Furthermore, there are two main models for the genesis of notch profiles. The first is tectonically driven, with notches forming during relative still-stands of sea-level, where rates of sea-level rise and tectonic uplift are held constant for periods of several hundreds of years; notches are subsequently raised (or lowered) above (or below) contemporary sea-level due to seismic events on local faults. The second model favours a climatic origin for notch formation, where stable periods of Holocene climate allowed enhanced erosion, forming notches that were then uplifted above sea-level during subsequent unfavourable climates; this model assumes that the rate of sea-level rise is lower than the tectonic uplift rate. Here, we explore these two models using a database of Eastern Mediterranean notches that span a wide geographic range. We conclude that the spatial and temporal distribution of the notches favours a dominantly tectonic control on the genesis of these features in this region.

Keywords: marine notches, tectonics, climate, Holocene.

DEVONIAN

AN OVERVIEW OF NON-METHAMORPHIC DEVONIAN IN TURKEY

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The Devonian period is represented in Turkey with non-metamorphic sections of more than 1000 meters, which are parts of almost complete thick Palaeozoic sedimentary successions. These successions are represented in Pontides, Taurides and Arabian Plate and they exhibit varying lithofacial associations.

Devonian in Turkey has been reported relatively early, namely in mid 19th century in Istanbul area. The forthcoming studies in paleontology, stratigraphy, tectonics and field geology resulted in differentiation of Devonian lithostratigraphic units. Depositional environment of respective units and facial properties are also investigated. Although number of conducted paleontological studies is remarkable, biostratigraphical aspects of Devonian successions are only addressed in general terms. Consequently, for lithostratigraphic units ranges of geological age are defined. But, detailed biostratigraphy of Devonian sequences is missing for the most of different Devonian successions. Some very recent efforts towards to fulfill this gap led to the definition of chronostratigraphic units in terms of Devonian stages.

The aim of this paper is to give an overview of the Turkish non-methamorphic Devonian. Hereby, based on the data obtained from previous studies, the geographical distribution, general geological setting, litho- and biostratigraphy, facies characteristics of the Devonian successions will be addressed.

Devonian of the Arabian Plate, observed both on the surface and in several oil wells in Southeastern Anatolia, is either eroded at their top as at the Hazro High, e.g. Upper Devonian is often missing or it overlaps older units, as at the Amanos Mountains and in Hakkari, e.g. Lower Devonian is missing. Respective Devonian sequences on the Arabian Plate consist of lithological associations representing a shallow shelf to tidal flat facies. In Taurides Devonian is represented by a more than 1000 m thick sequence. In general a shallow marine facies ranging from inter- to supratidal during Early Devonian to a deep shelf during Late Devonian is existing. Mainly during Middle Devonian some reefoidal carbonates were also deposited. Devonian in Pontides at northwestern Turkey, represented by the so-called Paleozoic of Istanbul and by the Paleozoic of Çamdağ-Zonguldak area, exhibits remarkable differences. Devonian in Istanbul area clearly indicates a deepening upward sequence from a shallow shelf into a basinal facies from Middle Devonian to Carboniferous, whereas that of the Çamdağ-Zonguldak area suggests a stable shelf environment throughout during the entire Devonian.

Keywords: Devonian, Turkey, Lithostratigraphy, Biostratigraphy

THE DEVONIAN COASTLINE OF NORTHERN GONDWANA: SEDIMENTARY SIGNATURES OF DEPOSITIONAL ENVIRONMENTS AT THE LAND-SEA TRANSITION (TAURIDES, TURKEY)

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In the Devonian of the Eastern and Central Taurids sedimentary sequences of 900 to 1200 m thickness have been deposited in shelf to coastal environments. The present study focuses especially on the formation and facies characteristics of sediments in extreme coastal settings which allow a detailed reconstruction of the respective environmental conditions.

In the northernmost **Halevikdere Section** Devonian sedimentation starts with proximal to distal siliciclastic shelf deposits (Lochkovian-Pragian) of various lithologies, reflecting fluctuating energy levels, strongly varying input of sediment material from the hinterland, as well as minor sea-level changes. Continuous deposition of carbonates started in the upper Lower Devonian with a deepening-upwards sequence of coastal dolomites, cross-bedded bioclastic limestones grading into nodular limestones, and dark shales. A long phase of very stable shallow shelf environmental conditions follows, where a thick sequence of bioclastic carbonates of typical framebuilding organisms frequently intercalated by colonization horizons was formed. This phase terminates in a threefold shallowing-upwards reef cycle (Frasnian) with each of the cycles starting with thin-bedded medium-grained siliciclastics. The micr ofacies is dominated by grainstones to rudstones. Baffle- and bindstones are composed of corals, stromatoporoids together with encrusting algae, microbial mats, and bryozoans. The matrix in all facies is dominated by biopelmicrite. Diagenetic alteration is low, early diagenetic dolomitization is common.

The **Kocadere Section** starts with coastal deposits of ?Lower Devonian aeolian dunes overlain by approx. 500 m of dolomites which are interpreted as sabkha deposits indicated by the frequent occurrence of biolaminites, teepee-structures, breccias, ooids, oscillation ripples, and cellular dolomites. This basal sequence shows an intercalation of inter- to shallow subtidal reef-related bioclastic carbonates of Givetian age. The Middle/Upper Devonian carbonate production by local reef growth and deposition of bioclastic deposits is frequently interrupted by the input of siliciclastic material from the hinterland onto the shallow shelf. The alternation of siliciclastic deposits of varying grain size with thin bedded bioclastic carbonates ends at the D/C boundary.

The base (Emsian) of the studied southernmost **Eceli Section** is formed by shallowing-upwards shelf deposits consisting of sandstones alternating with micritic to bioclastic limestones. Continuation of this shallowing trend is marked by inter- to supratidal deposits in a lagoonal to sabkha environment. The Middle Devonian is characterized by a 600 m thick carbonate sequence starting with a 17 m thick mud mound overlain by well bedded micritic limestones. Again, a shallowing-upwards trend is recorded by inter- to supratidal deposits in a lagoonal to sabkha environment, indicated by e.g. biolaminites and breccias. Towards the top, carbonate production is characterized by less restricted environmental conditions: Inter- to shallow subtidal bioclastic carbonates with local reef growth occur, partly intercalated by sabkha-type dolomites.

Keywords: sabkha, biolaminites, aeolian deposits, dolomitization, reefs

STRATIGRAPHY, FACIES DEVELOPMENT AND GLOBAL EVENTS IN DEVONIAN SEQUENCES OF THE CENTRAL AND EASTERN TAURIDES (TURKEY)

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In the frame of a bilateral Turkish-German cooperation project (DEVEC-TR) three Devonian key sections of the Central and Eastern Taurides have been studied. Each of the sections is several hundred meters thick. After some biostratigraphical data from the Eastern Taurid region have been reported a few years ago (GÖNCÜOĞLU et al., 2004 and literature therein), many more productive samples from that area (Halevikdere and Kocadere sections) and newly from a Central Taurid section (Eceli) revealed more detailed stratigraphic assignments (WEHRMANN et al., 2010). The sections, situated at the northern margin of the Gondwana Supercontinent were also investigated with respect to sedimentology and facies development. A whole array of different environmental conditions have been recognized ranging from coastal to shelf settings. Although the detailed facies development differs from one section to the other, general trends of changing environmental regimes, however, can be traced in all of them: siliciclastic dominated lower parts, carbonate dominated middle parts, mixed siliciclastic/carbonate upper parts. In some places – especially in the Kocadere Section – levels of global events can be recognized. The now available biostratigraphical data allow for a sound subdivision of the sections on the stage scale and their approximate correlation and comparison to the regional lithostratigraphy. The palaeobiogeographic distribution of various fossil organisms indicates only a comparatively narrow seaway (Rheic Ocean) between Laurasia and Gondwana/Peri-Gondwana during the Devonian.

Keywords: biostratigraphy, North Gondwana, palaeobiogeography, palaeoenvironments, sedimentology

DO PALYN OFACIES AND MINERALOGICAL SIGNATURES REFLECT HINTERLAND PROCESSES? IMPLICATIONS FROM DEVONIAN SEQUENCES IN THE CENTRAL AND EASTERN TAURIDES, TURKEY

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Devonian sedimentary sequences in the Central and Eastern Taurides (Turkey) have been studied in the framework of the interdisciplinary Turkish-German project DEVEC-TR. The sequences consist of siliciclastics, limestones, and dolomites and have been mainly deposited in a shallow marine but highly differentiated environmental system.

Three Devonian sections (Eceli, Halevikdere, and Kocadere) have been investigated by sedimentological and palynological methods. Whereas the entire Eceli section and especially the biolaminates are very poor (or even sterile) in organic-walled microfossils (OWM), shales and marls from the middle and upper parts of the Devonian succession (Givetian to Frasnian) in the Halevikdere and Kocadere sections contain well-preserved and diverse OWM (spores, acritarchs, chitinozoans). Furthermore, an assemblage of Lower Devonian (Lochkovian/ Gedinian) spores and acritarchs has been identified from the Halevikdere Section. However, the ratio between terrestrial (spores) and marine (acritarchs, chitinozoans) OWM differs within the sections and points to variable depositional environments and/or source areas.

Information about processes and environments of the hinterland (i.e., weathering, climate, tectonics, bedrock lithology and provenance) can be also transferred from specific signatures of the sedimentary sequences in the three sections. In the Eceli and Halevikdere sections, the upper part of the siliciclastic phase is characterized by minor amounts of detrital rutile and Na- to K-feldspars. In the Kocadere Section, detrital rutile is missing. Reworked metamorphic quartz grains occur together with feldspars in the siliciclastic lower part of all three sections. Additionally, reworked opaque grains are associated with rutile and feldspars in the Halevikdere Section. All these constituents can be assigned to physical erosion of metamorphic (to magmatic) rocks in the respective drainage basins of the hinterland, thus its provenance should be the interior of a craton. This would imply a source area south to southeast (i.e., North Gondwana) of the deposition centre. The hinterland environment can also be characterized with respect to climatic conditions. The different depositional environments in the Lower Devonian of the sections based on lith ofacies as well as numerous sedimentological structures, point to a semiarid climate as indicated by conglomeratic gravel beds, aeolian dunes, sabkha deposits, algal mats and desiccation cracks. The Middle Devonian is dominated by the formation of reefs, biogenic build-ups, biolaminites and sabkha deposits indicating arid, subtropical to tropical climatic conditions. Around the Middle/Upper Devonian boundary, recurrent influence of hinterland processes is indicated by the increased input of siliciclastic material alternating with carbonates. The occurrence of chlorite clay minerals and ferruginous cements in the higher parts of the Halevikdere and Kocadere sections again indicates weathering under semiarid to arid conditions.

The aim of this integrated study is to figure out the potential of palyn ofacies and sedimentological signals for palaeoenvironmental and palaeoclimatic reconstructions.

Keywords: spores, minerals, provenance, palyn ofacies, palaeoclimate

UNUSUAL FACIES IN THE DEVONIAN OF THE CENTRAL TAURIDS

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The 1200 m Devonian at Halevikdere (Central Taurids) start slightly above the S/D-boundary and ranges up into the Famennian. It appears threefold on the major scale with a basal, more siliciclastic-dominated unit roughly corresponding to the Lower Devonian part. In the middle, there is a carbonate-dominated unit which is subdivided by faulting but nevertheless comprising most of the Middle Devonian and Frasnian. The upper part of the section is again represented by a more siliciclastic-dominated unit.

The upper part of the lower unit is characterized by a distinct type of grey silt- to fine-grained sandstones typically showing light brown weathering. Internally, they are highly bioturbated and rarely show remnant bedding, but they are riddled by a highly characteristic type of sinusoid burrows (“*Vermiculites*”). Lithology and bioturbation indicate a distinct shelf environment which dominated for some time in the upper part of the Lower Devonian.

Some of the Frasnian carbonates are characterized by the almost monotypic occurrence of vermiform to slightly funnel-shaped calcareous fossils with a length between less than 5 cm and 15 cm and a diameter of few mm to >1 cm. They are internally chambered in a longitudinal direction. On the outside they are carrying characteristic monocrystalline spines. The systematic assignment of these organisms is still unclear, but there are some indications in favour of hypercalcified demosponges.

Keywords: Devonian, Taurids, facies, trace fossils, demosponges

SEDIMANTOLOGY &
SEDIMENTARY BASINS

TECTONO-SEDIMENTARY EVOLUTION OF THE UPPER CRETACEOUS – MIDDLE EOCENE CENTRAL ANATOLIAN BASINS

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In central Anatolia, a strand of the former northern Neo-Tethys Ocean subducted northwards under the Pontide active margin during Late Cretaceous – Early Cenozoic time. Subduction was associated with the generation and emplacement of accretionary complexes and supra-subduction zone-type ophiolites onto former passive margins of microcontinents. The resultant suture zones contain Upper Cretaceous to Middle Eocene basins (the "Central Anatolian Basins") including: 1) the Kırıkkale Basin; 2) the Haymana Basin; 3) the Tuz Gölü Basin (Şereflikoçhisar area) and; 4) the Çankırı Basin (Sungurlu and Bayat areas). These basins are distinct from others further south (e.g. the Ulukışla Basin), which developed on ophiolites after their latest Cretaceous emplacement onto the Tauride margin. Using stratigraphic logging, igneous geochemistry, palaeontology and provenance studies, we have tested two end-member models of basin evolution. In one model, the basins formed on obducted ophiolitic nappes following closure of a single northern Neo-Tethys Ocean. In the other model, northern Neo-Tethys involved two oceanic strands, the İzmir – Ankara – Erzincan Ocean to the north and the Inner Tauride Ocean to the south, separated by the Niğde – Kırşehir Massif. In this scenario, the basins developed as forearc/syn-collisional-type basins, associated with north-dipping subduction which persisted until the Middle Eocene when continental collision occurred. The basements of the Central Anatolian Basins comprise the Ankara Mélange, a mainly Upper Cretaceous accretionary complex and the western/northern margin of the Niğde – Kırşehir Massif. New geochemical data from the composite basement of the Kırıkkale Basin identify mid ocean-ridge basalt (MORB), here interpreted to represent relict Upper Cretaceous Neo-Tethyan oceanic crust. During the latest Cretaceous, the Kırıkkale and Tuz Gölü Basins initiated in deep water above relict MORB crust, bordered by the Niğde – Kırşehir microcontinent to the east where marginal facies accumulated. Further west, the Haymana Basin represents an accretionary forearc-type basin constructed on the Ankara Mélange. The Çankırı Basin developed on accretionary melange, bounded by the Pontide active margin to the north. Palaeocene sedimentation was dominated by marginal corallgal reef facies. Latest Palaeocene – Middle Eocene facies include shelf-type Nummulitid limestone and shallow-marine deltaic pebbly sandstones. We propose a new model of basin evolution in which two north-dipping subduction zones were active during the late Mesozoic within northern Neo-Tethys. In the south, ophiolites formed above a subduction zone consuming the Inner Tauride Ocean until the southward retreating trench collided with the northern margin of the Tauride continent emplacing ophiolites and mélange. In the north, subduction initiated outboard of the Eurasian margin triggering genesis of supra-subduction zone ophiolites; the subduction zone rolled back southwards until it collided with the Niğde – Kırşehir Massif, again emplacing ophiolites during latest Cretaceous time. Neo-Tethyan MORB still remained to the west of the Niğde – Kırşehir microcontinent forming the basement of the Kırıkkale and Tuz Gölü Basins. Latest Palaeocene – Middle Eocene regional convergence culminated in crustal thickening, folding, uplift and strike-slip faulting which represent final continental collision and the assembly of central Anatolia.

Keywords: central Anatolia, Neo-Tethys, subduction, Upper Cretaceous, basin evolution

MIOCENE MIXED CARBONATE-SILICICLASTIC SEQUENCES OF THE GULF OF SUEZ: CONTROLS IN SYN-RIFT DEPOSITION BY SEA-LEVEL CHANGES AND TECTONIC MOVEMENTS

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In the Gulf of Suez crustal extension started during Late Oligocene, causing large halfgraben structures. These are differentiated by listric faults into antithetic tilted blocks of different hierarchic order. During Early to Middle Miocene, marine mixed carbonate-siliciclastic sediment sequences were deposited along uplifted block shoulders on both sides of the graben axis. The depositional subenvironments of these sequences were mainly controlled by (i) sediment supply, (ii) biogenic carbonate production, (iii) tectonic movements and (iv) sea-level changes. Caused by these processes a more than 300 m thick formation of Late Burdigalian to Early Serravalian age has been deposited. This formation can be subdivided into 4 sequences. These sequences correlate with sea-level changes proved by biostratigraphic data and tectonic movements. Each sequence shows the characteristics and internal structure of system tracts, sets of parasequences, sequence surfaces and boundaries.

Keywords: extensional tectonic, Red Sea, biogenic sedimentation, warm-temperate carbonates, hinterland processes

QUATERNARY CALCRETE DEVELOPMENT IN THE MERSIN AREA, SOUTHERN TURKEY

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In the Mersin area, Quaternary calcretes are widespread and occur in a variety of forms. Several distinct calcrete profiles are recognized in the area, and subdivided into two major groups of mature and immature profiles. The mature calcrete profiles comprise a generally isolated calcrete horizon at the base and hard laminated crust at the top, and rarely pisolithic crust in the upper-most part. The immature calcrete profiles consist mainly of an isolated calcrete horizon which is rarely overlain by laminated crust in localised areas. In the field, calcrete forms represent three main stages of development: (i) a mottled or plugged horizon, comprising isolated calcrete forms such as powdery, nodule, tube, and fracture-fill; (ii) calcareous crusts, including laminar and hard laminated calcrete crusts; and (iii) a pisolithic crust which is very restricted. The plugged horizon, in which calcite precipitated from downward moving percolating water, reduces the permeability of the host-rocks or sediments. Later, the plugged horizon leads to the horizontal movement of percolating water so that calcareous crusts formed. Finally, a pisolithic crust forms by down-slope movement of the grains and their accumulation in troughs between dome-like structures. XRD, ICP–AES and SEM analyses show that calcrete samples are composed predominantly of calcite, and palygorskite is closely associated with them as a minor constituent. Calcite $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ isotope values of calcrete samples vary between -4.31 to -6.82 and -6.03 to -9.65 ‰ PDB, respectively which indicates formation from percolating meteoric water at or near the surface setting supporting a thin column of soil. Abundance of beta fabric constituents and negative calcite $\delta^{13}\text{C}$ values suggest a pedogenic origin for the calcretes.

Keywords: calcrete, hardpan, nodule, pedogenesis, Quaternary.

BIOSTRATIGRAPHICAL CONSTRAINTS ON THE NEOGENE EVOLUTION OF THE MESAORIA BASIN, CYPRUS.

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The island of Cyprus is located in an area tectonically affected by the interplay of movements of the African, Arabian, Anatolian and Eurasian plates and is itself an accretion of three tectonic terranes: Kyrenia in the north, Troodos in the centre and south, and Mamonia in the south and south-west. The Neogene to Recent age Mesaoria Basin is located in central-north Cyprus, between the Kyrenia Mountains to the north and the Troodos Mountains to the south, and is cut by a major structural suture between the Kyrenia and Troodos terranes – the Ovgos Fault Zone. The high seismic hazard potential of the area and of the city of Nicosia in particular, was the subject of a United Nations-sponsored multi-organizational project to assess risk, which involved mapping, drilling and trenching to evaluate the structure and stratigraphy of the area. Dating of the Neogene-Recent sedimentary sequences was crucial for understanding structural relationships and the timing of movements and was achieved by a combination of radiogenic, isotopic and biostratigraphical methods. The purpose of this paper is to present the biostratigraphical results used to give a timeframe for the lithostratigraphy and so constrain the tectonic/neotectonic evolution of the Mesaoria Basin.

Key words: Miocene, Pliocene, Quaternary, planktonic foraminifera, calcareous nann ofossils

EVIDENCE OF THE MEDITERRANEAN EARLY ZANCLEAN FLOODING IN THE ADANA BASIN

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Following the complete closure of the seaway connection with the Atlantic Ocean via the Gibraltar Strait at the end of the Messinian Salinity Crisis (MSC), the Mediterranean area experienced brackish- and fresh-water environments (Lago-Mare event). Starting from about 5.6 Ma, Lago-Mare bi ofacies consisting of Paratethyan immigrant fauna (ostracods, molluscs and dinocysts) characterized all the sub-basins of the Mediterranean area until the base of the Pliocene (5.332 Ma). At the end of the MSC, rapid inflow of seawater from the Atlantic Ocean (Pliocene flooding) gave rise to the deposition of epibathyal early Zanclean clays just above Lago-Mare late Messinian marls and clays. According to the literature, the Adana Basin recorded the Pliocene stage with the deposition of shallow marine to fluvial deposits (Handere Fm). Our micropaleontological analyses of samples from the southern margin of the Adana Basin, near Avadan village, reveal late Lago-Mare bi ofacies in the upper part of the section, with Paratethyan ostracod assemblages pertaining to the *Loxocorniculina djafarovi* zone. South of the Avadan uppermost Messinian Lago-Mare deposits, a very short section of grey clays was sampled for a total thickness of 3 m. The continuous occurrence of *Reticul ofenestra zancleana* and the base of the *Reticul ofenestra pseudumbilicus* paracme have been identified in the calcareous nann ofossil assemblages of the Avadan section. This latter bioevent occurs diachronously in a time range spanning from the 4th to the 6th precessional cycles of the Pliocene. These results point to a very early Zanclean age (MNN12a subzone) for the studied section (5.332-5.199 Ma). The planktonic foraminifera assemblages of the section are characterized by Early Pliocene fauna. The occurrence of *Sphaeroidinellopsis* spp., which is common in some samples, the presence of *Neoglobobulimina acostaensis* dx, and the absence of *Globobulimina margaritae* allow us to constrain the sampled section to the basal Zanclean (MP11). The ostracod assemblage is characterized by the presence of *Krithe compressa* and *Argilloecia acuminata*, pointing to epibathyal and bathyal environments. Similar paleodepth indications with disaerobic conditions come from the benthonic assemblages characterized by *Cibicidoides* sp., *Planulina ariminensis*, *Sphaeroidina bulloides*, *Uvigerina rutila*, and *U. peregrina*. ⁸⁷Sr/⁸⁶Sr measurements on ten foraminifera samples gave ratios ranging between 0.709006 and 0.708979, with an average value of 0.708998, for estimated ages falling within the lower Zanclean. In particular, taking into account the 3-point running mean through data from the Indian Ocean (ODP site 758; Farrell et al., 1995) the average ⁸⁷Sr/⁸⁶Sr value from the Avadan samples point to the following estimated ages: 5.0, 5.2, and 5.3 Ma.

Although the Messinian/Zanclean boundary doesn't crop out in the Adana Basin, the occurrence in the Avadan section of epibathyal to bathyal early Zanclean mic ofossil association (MNN12a and MP11) close to the outcrop of late Messinian Lago-Mare bi ofacies suggests that in the Adana Basin, the Messinian/Zanclean transition parallels conditions reported throughout the whole Mediterranean Basin.

Keywords: Messinian salinity crisis, Adana basin, Zanclean flooding

PALAEOMAGNETIC AND ISOTOPIC STUDY OF THE DENİZLİ TRAVERTINES: IMPLICATIONS FOR THE ENVIRONMENTAL CHANGES

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This study aimed to determine the records of environmental changes in travertines. Isotopic and palaeomagnetic analyses of travertine samples collected from the Denizli region were performed. All travertine samples except one show normal polarity. Fieldwork sampling in the Denizli region was conducted primarily in 7 quarry exposures in bedded travertines. The aim of the palaeomagnetic study here was to determine the changes in recorded magnetic field direction up through successions of travertine and see whether these accurately recorded secular variation of whether their magnetic field was a long time average. If the latter is the case it will show that the porous bedded travertines are subject to profound later diagenesis and therefore that they integrate long time records of behaviour rather than short term changes that might be correlated with secular variation.

Magnetic susceptibility measurements show positive values due to input from the atmospheric magnetic dust. This is an important result indicating the presence of environmental signatures in bedded travertines. Petrographic studies within isotopic works on the travertine samples show that the layered travertines completely disintegrate with diagenesis because having porous structure. The results of the petrographic investigation were to find that the bedded travertine is thoroughly altered by diagenesis. This is not surprising because the tufa-like deposits laid down by the geothermal waters spilling out at the surface are highly porous and susceptible to later waters seeping down through them. This indicates that the isotopic systems will be homogenised over long intervals of time and cannot record a short-term environmental signature. This negative conclusion means that we have not been able to pursue isotopic studies on bedded travertines in the Denizli region.

Keywords: Travertine, Climatic and environmental changes, Palaeomagnetism, Denizli, Pamukkale

STUDY OF NATURE, ORIGIN, MOVEMENT AND EXTENSION OF SAND DUNES BY USING SEDIMENTOLOGICAL ASPECTS AND REMOTE SENSING TECHNIQUES IN BAIJI AREA, NORTH IRAQ

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The migration of sand dunes in Baiji area of northern Iraq are causing many problems, such as accumulation of drifted sand on the railways and the roads, moved sand and dust storms which affect and causes pollution for civil constructions and industries in the area, and as well as, increasing desertification of this and surrounding areas.

This study aims to explain the morphology, origin, grain size and movement of the sand dunes in Baiji area. The study includes detail field study of the sand dunes and investigation of the future effect of extension and increasing the desertification in the area within time. Using of remote sensing and geographical information systems in the study of desertification by Multitemporal data which including (maps and Landsat Thematic Mapper (TM) images) provided best understanding of the distribution of sand dunes and other aeolian features in the area of study.

Keywords: Sand dunes, sand sheets, desertification, Landsat TM images, Arc View GIS.

OLIGOCENE ALLUVIAL SEDIMENTATION IN THE NORTHERN OF ACIGÖL BASIN, SW TURKEY: FACIES ANALYSIS AND PALAEOGEOGRAPHICAL EVOLUTION

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The NE-trending Acıgöl Tertiary basin located in between Menderes metamorphic massif to the north and Lycian nappes to the south. The northern part of Acıgöl basin filled by dominantly of clastic sedimentary rock units deposited between Eocene and Pliocene period. The Oligocene sedimentary sequence divided into two units due to their sedimentary constituents. These are in ascending order; (1) the Armutalanı and the (2) Çardak formations.

The Oligocene rock units cropping out in the northern of the Acıgöl depression comprise conglomerates gradually passing into sandstones and mudstones towards to the northern of basin. These clastics belong to the Armutalanı and Çardak formations and originated monogenic-conglomerate alluvial fan that fed almost entirely from ophiolitic-rocks such as diabase, gabbro and harzburgite belong to Lycian nappes and large polygenic-conglomerate fan which derived from mostly limestone and ophiolitic-rocks belong to Lycian nappes, respectively. Their lithological, textural and geometrical features, in combination with sedimentary structures have been subsidiary to establish lateral and vertical relationship and distribute of the main features for each type of depositional system throughout time.

The Armutalanı formation represents greenish grey coloured conglomerates which are poorly sorted, nonstratified, moderate-well rounded pebbles and matrix-supported. The cross-bedding is merely observed internal sedimentary structures in sandstone lenses. These coarse sediments can be formed by debris flow related with alluvial fan deposits when fine sediments are less in the source area. The composition and nature of alluvial fan sediments is controlled mainly by the local source of the debris rock and weathering processes. On the other hand Çardak formation is characterized by greyish blue coloured, matrix-supported, large scaled cross-bedding, scarcely imbrication, very poorly sorted cobblestone, boulders and gravel with subordinate amounts of sand, silt and some clay. In both fining-upward trends are related to onlaps and record the retrogradational stages of the alluvial fans. The stratigraphic and sedimentological studies permit to establish the palaeogeographical evolution of the area during Oligocene time. According to sedimentological assessments and field observations, the Oligocene alluvial fan deposits derived mainly from southern source rock units of the Pre-Oligocene Lycian nappes.

Keywords: Alluvial fans, Acıgöl Basin, Oligocene sediments, facies analysis

PETROGRAPHIC AND SEDIMENTOLOGICAL STUDIES OF THE COAL-BEARING NEOGENE UNITS (SINANPAŞA-AFYON), CENTRAL TURKEY

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Neogene units with coal seams are exposed in the road-cut outcrops along the main road of Afyon-Sandıklı in which coal seams are 20-70 cm thick and repeated several times through the 150 m of the total thickness. Spore and pollen groups determined indicate that the unit is Middle Miocene in age. Measured sections start with mass flow deposits (15-20 meter thick) which are composed of coarse pebbles and blocks of metamorphic rock fragments, which interdigitated with palaeosol (Depositional Package 1). Coal-bearing layers are characterized by grey-coloured mudstones encompassed poorly sorted conglomerates along with cross-bedded and channel-fill lensoidal conglomerates (2-5 meter thick) (Depositional Package 2). Mudstones are interbedded with thin palaeosol layers (10-20 cm thick) and mineralogically consist of clay minerals belonging to caolinite group, feldspar, quartz, and gypsum. Coal seams completely disappeared within the overlying depositional package. Where allocthonous coal fragments, (particullary coalified woods) are dispersely present in place of the autocthonous coal seams. Dominant lithology is mudstone, sporadically fringed by wedge-shaped conglomerates (Depositional Package 3). The unit is terminated with a red-coloured and thick conglomerate (≥ 10 m) with erosional basal boundary. (Depositional Package 4). In the microscobic studies, the coal seams are mainly determined as macerally humminite minerals, in which liptinites and inertinites seem to be subordinate minerals respectively. Intensive oxidation of the coal samples indicate that their depositional environments became very shallow that temporarily underwent atmospheric exposures. Inorganic composition of the coals are generally high with respect to standart coal beds. Volumetrically from high to low, they are represented by clay, calcsit, gypsum, and Fe-minerals (framboidal pyrite).

The studied unit is a typical example for deposition of a fluvial-lake system. Matrix-supported conglomerates were a result of alluvial fan-dominated-grain flow deposition (Depositional Package 1). Lake deposits initiated in a transition environment from lake flat to swamp with coal formation. Maser and lithotype analysis also supported that the deposition took place under very shallow conditions (Depositional package 2). Mudstone-dominated depositions reflect deeper lake conditions and the channalized conglomerates point out local and small fan delta systems in which allocthonous woody coal fragments were acuumulated. (Depositional Package 3). Thick conglomeratic units and large scale cross-beds resting on the lake deposits with erosional boundary indicate a transition from lake deposits to braided river deposits (Depositional Package 4).

The lateral and vertical facies changes in a short distance from fluvial-lake to fluvial suggest a fault-induced basin margin existed during Middle Miocene period.

Key Words: Lake deposits, SinanPaşa, Coal, Miocene.

GEOLOGICAL AND STRUCTURAL ASPECTS OF WESTERN YAZIHAN AREA (MALATYA) WITH ADDITIONAL REMOTE SENSING SUPPORT

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Landsat 5 TM satellite images are widely used for lithological mapping. In this study, the formations cropping out around Yazihan (Malatya) area have been mapped and the mapped area has also been supported with the 5 TM satellite images. Following the application of geometric image correction processes, single band enrichment processing has been applied to the image. In addition, n-channel multi-spectral images reduced to n-channel smaller amount of bands for the aim of providing easier analyses to reduce the repetitions, thus, principal component analysis was applied to the images. The data obtained with the help of statistical results and field work studies about the lithologies of unit, single bands PC5, PC2 and triple-band combinations of 542, 741, 321, TBA235, TBA135 and TBA134 in the code of RGB were chosen. The geological map that prepared by interpreting these combinations compared with the one prepared in the field shows great compatibility each other. Tectono-stratigraphy of some part of the Yazihan-Hekimhan basin within the eastern Tauride belt around Yazihan and its surroundings area has been investigated in this study. Regarding the data obtained from the investigated area, 14 different formations ranging in age from the Upper Jurassic to Quaternary have been determined. These units are as follows; Upper Jurassic-Lower Cretaceous age Horasançal formation forms the basement rock unit of the area. Hocalıkova ophiolite, which probably thrust into the area from North to the South during and after late Campanian, tectonically overlies the Horasançal formation. Hekimhan formation transgressively deposited during late Campanian-early Maastrichtian time to the edge of the tectonically controlled basin (shallow marine-shore line sediments). Paleocene age Medik formation overlies this unit with angular unconformity to the South of the basin. Middle-Upper Eocene age Tohma formation that generally deposited in lagoon, beach and shelf environments covers the Medik formation with an angular unconformity. Tohma formation is cut and unconformably covered by the volcanic activity of late Eocene age Leylek volcanic. Aquitanian age Çavuş formation unconformably covers the Leylek volcanic. Burdigalian age Ansurçay formation rests on the Çavuş formation with angular unconformity. Lower Miocene age Akyar formation overlies the Ansurçay formation with angular unconformity. Middle-Upper Miocene age Yamadağ volcanic unconformably rests on the older units. Middle Miocene age Parçikan formation, which deposited in a lacustrine setting presenting soft sediment deformations indicating tectonically active areas, are seen on the Yamadağ volcanic. Plio-Quaternary aged Mısırdere formation unconformity rest on the Parçikan formation. Quaternary age alluvial fan, terrace and alluviums are the youngest sediments of the area and unconformably rest on all the older units.

Keywords: Malatya, Yazihan, stratigraphy, Malatya–Ovacık Fault Zone.

THE APPLICATION OF ARTIFICIAL NEURAL NETWORKS FOR THE CLASSIFICATION OF DIFFERENT LITHOLOGICAL FORMATIONS IN REGION OF PORTO ROMANO, ALBANIA

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The area around the former chemical plant in Porto Romano is contaminated by high-risk chemical components composed by Lindan, Sodium Bichromate, accumulated in tailings. They have the ability not only to pollute the water, but also are easily absorbed by agricultural cultures. The two chemicals are pollutants at high risk for the health of nearby residents, because they cause cancer in the liver, nervous system and lung of human being.

The important place in the studying of tecnogen pollution spreading around the region of Porto Romano have occupied the following methods: Applying Electrometry with resistivity method, electrical sounding array-Schlumberger, with AB up to 1000 m; Well Logging with observations of electrical resistivity and spontaneous polarization into the drilling and the Geochemical method of soil samples of the Quaternary deposits with sampling density every 250 m, in the 5 and 40 cm depth.

Through the use of geochemical-geophysical methods complexity is achieved to be determined: depth, thickness and lithologic composition of Quaternary deposits, chemical elements as pollutants and is consequently judging above the risk of spreading and distribution of pollution in surface and in depths of geological environment.

In this study has become the mathematical modeling of electrometrical data, obtained from conducting of surveys in situ by MATLAB s software, which uses numerical modeler methods. One of these directions is the application of artificial neural network to classify the different lithological formations of the region of Porto Romano, Durres, which comes to help study for the distribution of tecnogen pollution in surface and in terms of depth. For this purpose, are used neural nets and various algorithms of their training to make it possible to find the optimal network, to better solve a given task.

Finding of optimal networks makes possible the accurate determination of the lithological formations through the evaluation of electrical resistivity, in the intermediate parts of the depth of study, for which no quantitative information of performed VES data. This processing will help in obtaining of the information in terms of depth for each VES carried out in pr ofiles of this region, in the absence of performed geological drilling.

Keywords: Tecnogen pollution, Chemical elements, Eectrical sounding, Neural networks.

DELINEATION OF THE DEEP-SEA SEDIMENTS DISTRIBUTION WITH USING THE LANDSAT TM IMAGES

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Submarine fan sediments may be observed in shallow to deep marine (abyssal plain) environments. They contain coarse- to fine-grained sediments in a range of different sub environments. Gravel and sand-sized sediments may be found in the main feeder and connected distributaries channels. They may also be found in the slope environment as a disorganized debris flow. Slope environments may also include slumped units comprising of mostly claystone with occasional sandstone beds. Deeper marine plain environment in front of the slope are initially dominated by mostly sandstone and to a lesser extent claystone, followed by mostly claystone with sandstone alternations. Distribution of these sediments is highly controlled by basin morphology that is shaped by structural alignment. Distribution of these facies therefore can change over short distances. Accurate mapping of these sediments may obstructed by bumpy morphology and absence of roads. The Miocene-aged Kahramanmaraş Peripheral Foreland Basin includes variety of deep-sea sediments. This basin is bounded by structural alignments that also affect the basin centre. After detailed field investigation, Landsat-5 Thematic Mapper (TM) satellite images were used to delineate deep-sea sediment distribution in outcrop. Results from the image enhancement process (such as colour composites, band ratios, and principal component analysis) were investigated in detail. Lithological boundaries are most visible in RGB 7-5-1 (detail studied) and RGB 7-4-2; TM band ratio RGB 5/7-5/1-4; and principal components PC6 1-4-5. Images gathered after the principal component transformation supplied the best view due to more vivid colour content. Band ratio images give detailed information on hydroxyl and iron oxide bearing mineral areas. These minerals can be found in the alteration zones of older rocks and depositional area of younger deposits (mostly Miocene). Thus, this band ratio gives some clues about source rock and transportation path of the sediments. Mapping of the lithological boundaries, structural alignment, and determination of areal distributions of compositionally different deep-sea sediments can be successfully undertaken using the Landsat Thematic Mapper image. This method may provide operatives with gain of time and low cost results instead of the physically hard field working.

Keywords: Landsat 5 TM, Deep-sea sediments, Kahramanmaraş Peripheral Foreland Basin, Miocene

CHAOTIC SEDIMENTATION IN THE SOUTHERN MARGIN OF ULUKIŞLA AREA OF CENTRAL ANATOLIAN BASIN INDICATING PROBABLY SEISMICITY DURING SEDIMENTATION

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Ulukışla area is an important part of Central Anatolian Basin. It has many features that may shed light on the evolution of the basin. First sediments overlying Bolkar metamorphics is red coloured conglomerates and mudstone filling irregular topography and showing lenticular geometry suggesting that alluvial fan deposition and steep slope. This unit is overlain by pelagic sediments of probably Cretaceous age. While pelagic sediments directly overlying Bolkar metamorphics, shallow water carbonates of Late Maastrichtian age exposed along the Bolkar Mountain. Debris of the same shallow water material with fragments of rudist are found in the pelagic globotruncana bearing limestone in the basin also indicating that shallow water facies deposited during Maastrichtian time. Ophiolitic melange of Late Cretaceous age is overlain by red coloured continental sediments and these sediments are overlain by Late Paleocene Limestones. In these areas, Late Cretaceous or Early Paleocene sediments are not seen indicating a sea level drop or uplift along the margin of the basin. During Late Paleocene time and Early Eocene large masses of material were transported into basinal areas and deposited along base of slope areas. Large masses of pelagic limestone of Late Cretaceous, ophiolitic melange and other debris flow deposits dominate the sequence suggesting that during this period seismicity was intense. During the same period, away from the marginal areas the basin fill is dominated by volcanics and volcaniclastics with thin pelagics, but it is difficult to define the seismicity within the volcanics and volcaniclastics due to intense deformation.

Keywords: Chaotic sedimentation, seismicity, sea level changes, sequence stratigraphy, basinal sediments

SEDIMENTARY STRUCTURES AND DEPOSITIONAL ENVIRONMENTS OF THE ASHIN FORMATION IN NAKHLAK AREA, CENTRAL IRAN

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Middle to Upper Triassic (Upper Ladinian to Carnian) deep-sea sedimentary rocks crop out across a large area west of Nakhlak village, Central Iran and have been named Ashin Formation. The up to 304m thick, turbiditic, siliciclastic Ashin Formation consists of alternating turbiditic, thin- and medium-bedded calcareous sandstones, purple, fine-grained volcanoclastic sandstones, and mostly green and violet, very thin-bedded volcanoclastic shales that can be subdivided into three members. Ammonoids collected from members 1 and 3 of the Ashin Formation associated with radiolarians, pelecypods and foraminifera indicate a Late Ladinian to Carnian age for the formation. These alternations fine upwards and exhibit sedimentary structures such as graded bedding, parallel lamination (with parting lineation) convolute bedding, small-scale cross-bedding, load casts, groove casts, prod casts, flute casts, bounce casts, chevron casts, brush casts and chips and protraction traces indicating A to E parts of the Bouma cycle. Septarian nodules occur repeatedly. The lower surfaces of sandstones contain abundant trace fossils belong to the deep-sea *Nereites* ichn ofacies. Numerous signs of strong current activity such as groove casts, flute casts and prod marks associated with trace fossils such as *Paleodictyon*, *Protopaleodictyon*, *Megagraption* and *Lorenzina* indicate that the Ashin Formation represents a deep marine environment. The field and petrographic studies show that the Ashin Formation was deposited in distal parts of submarine fans, on the continental slope to abyssal plain.

Keywords: sedimentary structure, Triassic, Ashin Formation, Nakhlak, Central Iran

RECENT COASTLINE CHANGES AND PALAEOGEOGRAPHIC EVOLUTION OF THE FETHIYE DELTA, SOUTHERN TURKEY

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The Fethiye Delta is one of several small deltas along the Aegean coast of Turkey that evolved or was significantly modified during the Holocene rise in global sea-level. Most of these deltas are fed by short, high-gradient, commonly ephemeral rivers originating within the adjacent tectonically active Taurus Range.

Our novel methodology involves integration of digital information, derived from airborne and satellite imagery over specific time intervals, with data obtained from historical and geoarchaeological sources to create a GIS database that can be interrogated, enabling changes in the coastal configurations over several past millennia to be calculated. This study demonstrates that over the past century the surface area of the Fethiye Delta has increased by some 122,000 m² (around 0.02% of total area) but the pattern and rates of local coastline accretion (and retreat) have been erratic.

Geoarchaeological data shows that almost 40% of the current area of the Delta had accreted by around 3000yrs BP, with a further 36% added in the succeeding centuries up to the early Byzantine period (1500yrs BP). From then to the early 20th century a further 23% was added to the surface area of the delta and its environs. Overall progradation continued in the first half of the 20th century but a net loss of around 0.01% of total delta area has occurred over the past few decades, manifested mainly by coastal retreat in the heavily populated southeastern sector.

We conclude that this recent retrogradation results from a combination of natural and man-made factors: (i) Increasing sea-level, the more energetic wave-climate and compaction-related subsidence; (ii) anthropogenic restriction of the sediment supply, through soil retention and flood control measures (in the hinterland and on the delta), together with rapid expansion of the built environment on and around the delta.

Unless effective remedial measures are taken in the very near future, the process of localized deltaic retreat seen in recent decades is likely to continue and may accelerate with a further rise in sea-level.

Keywords: Delta-evolution, Turkey, geoarchaeology, anthropogenic influence

VOLCANIC STRATIGRAPHY AND PALEOSOL DEVELOPMENT OF CAPPADOCIA, CENTRAL ANATOLIA

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Upper Miocene (11-3 Million years ago) is composed of catastrophic explosive volcanic eruptions occurred in Cappadocia, central Anatolia. These eruptions resulted from local deposition of voluminous pyroclastic flows such as ignimbrites, each has 10 to 100 m thick that form the Nevşehir Plateau, and are famous for their scenic erosional landscape. These units interlayered with lacustrine sediments and sequences of paleosols and calcrete on lahar deposit. The lacustrine environments are restricted to the North for most of the section (Ürgüp Basin, South of the river Kızıl Irmak) and almost cover the complete volcanic plateau at the end of the profile (in the Pliocene). Mineralogical composition of pumice levels (fall out), paleosol and calcrete between Cemilköy, Gözdeles and Kızılören ignimbrites and their lateral and vertical distribution are determined. Petrographically the paleosol, calcrete and ignimbrites are composed of altered feldspar, devitrified volcanic glass, iron oxidized of pyroxene, degraded pumice and rock fragments, where the sparitic calcite cement is developed in dissolution voids and fractures. Minerals including feldspars, quartz, opal-CT, calcite, and amphibole (hornblende) were observed throughout the profile. In addition, serpentine, talc, pyroxene, gypsum, and zeolite (analcime) were detected in some levels of the profile. Clay minerals including smectite (montmorillonite) chlorite and illite were commonly found throughout the profile. Trace palygorskite and sepiolite accompany the clay minerals in certain horizons of the profile. Calcite and clay abundances show marked reverse relation. The paleosols are most common in the central part of the plateau Ürgüp-Şahinefendi-Soğanlı. They are archives of the climate changes that occurred several million years ago because of the formation of their characteristic mineralogical composition depended on humidity and temperature, e.g. development of carbonate nodules, palygorskite and gypsum. The interval represented by paleosols and calcrete in Cappadocia is of special interest, as it included the total time of the Upper Miocene phase of extreme aridity (the Messinian crisis), which is marked by widespread salt deposits in the Mediterranean Basin indicating the Mediterranean Sea fell dry.

Keywords: Cappadocian volcanic province, paleosol, calcrete, Upper Miocene, paleoenvironment, clay minerals,

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OBSERVATIONS OF MORPHOLOGICAL CHANGE, AND GRAIN SIZE AND HEAVY MINERAL DISTRIBUTION ON MODERN BEACHES FROM THE TURKISH COASTS

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Studies of heavy mineral placers and sediment transport processes along the microtidal coasts of Turkey showed the importance of sediment sampling strategies to obtain reliable and representative results. From 2000 to 2010, large number of sediment samples were obtained from shoreline/foreshore and backshore environments of the beaches and many photographs were taken to understand the role of coastal geomorphology during sampling. Part of sediment samples were washed to remove marine salt and other organic/biogenic materials to carry out grain size and heavy mineral analysis using technical procedures in sedimentary petrography. Brom oform was used to separate heavy mineral fractions of bulk sediments.

Three major types of beaches were recognized based on grain size distribution. These include pure gravel beaches, sand beaches and mixed sand and gravel beaches. Some gravel beaches are composed almost entirely of lithogenous material whereas others could bear appreciable amounts of shelly remains of biogenic materials. These gravel beaches have mostly steep slopes and gravel berms which seemed to be not appropriate to provide a satisfactory explanation for longshore sediment transport and heavy mineral studies. Mixed beaches constituted gravel components either shoreline aligned or occurred at patches with sand. Due to hydraulic sorting here, smaller heavy minerals are deposited with larger lighter grains. Sand beaches if contained a wide range of fractions from very fine to very coarse sand, were ideal for hydraulic sorting of grains. Not only slope gradient of beaches but also width of foreshore and backshore areas have significant influence on grain size. Mean grain size, sorting, skewness, kurtosis values of sediments were interrelated each other but correlating results were significant only in short distances.

This study demonstrates that transport, deposition, and resuspension of sediments, variations in coastal morphology/beach profile and rates of terrigenous/riverine input together with intensity of alongshore and crossshore currents under wind/wave forcing are a combination of complex processes to understand the texture and composition of beach sediments.

Keywords: Turkey, Beach, Sediment, Grain Size, Heavy Mineral, Morphodynamics

GEOMORPHOLOGICAL EVIDENCE OF BOTTOM-WATER DYNAMICS IN THE KAFIREAS STRAIT, CYCLADES, GREECE

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The Cyclades plateau is a morphologically complex marginal platform, dividing the relatively shallower Central Aegean Sea from the deeper South Aegean Sea. The Kafiareas Strait (Cavo Doro) is located between Evia and Andros and is especially famous due to the very rough seas and the prevailing strong north winds. The surface currents in the wider area, although not studied in detail, are variable and have been measured to be up to 1.6 knots.

A marine geophysical survey together with seabed sampling, which was carried out during 2008, revealed the presence of morphological features that imply strong near bottom current activity and are discussed in this contribution. The seafloor in the study area was divided in five morphological units named Evia shelf and slope, Evia-Andros valley and Andros slope and shelf. The maximum water depth in the study zone is about 530 m, although the depth in the Strait reaches the 580 m.

The Evia shelf develops up to the 180-185m, exhibits along its biggest part a highly irregular relief due to the presence of rocky areas/ridges and steep paleocoasts and consists of sands to cobbles. The Evia and Andros slopes are very steep (locally more than 30°) and along their upper parts are barren of sediments and rocky ridges appear on the seafloor. The deeper parts of the slopes as well as the Evia-Andros valley are covered by muddy sands to sandy muds. The surficial sedimentary cover of the Evia-Andros valley wedges out eastwards, indicating the prevalence of non-depositional conditions due to current activity. The eastern floor of the valley is covered by almost E-W trending megaripple-type bedforms, whose height is estimated to be less than 0.5 m. The overall thickness of the surficial sedimentary layer decreases to the south indicating a southward increase in the current speed.

The Andros shelf develops shallower than ~250m and has an uneven relief due to the presence of bedforms, rocky areas and biogenic mounds. Along the outer shelf the seabed is fashioned by sand waves of an almost NW-SE direction, creating a relief of about 1.5m. Erosional surfaces create locally morphological steps up to 2m in height. Megaripple fields, about 0.5m in height, with a WNW-ESE to ENE-WSW direction are found locally towards the inner part of the shelf. During previous surveys sand-ribbons and sediment streaks, which are oriented NNW-SSE to NNE-SSW, were also found in the wider area.

Indications of strong near-bottom currents of short period in the Kafiareas Strait come from local fishermen, who declare that during winter their nets are found destroyed and transported over large distances. The acoustically observed bedforms in the Strait imply powerful near bed currents of the order of 40-100cm/s. Their configuration mostly suggests a southward flow direction. Their development is probably related to the formation of the dense Cretan Deep Water in the area during seasonal (winter) water cooling or to the passage of this water mass (coming from the North and Central Aegean Sea) through the Kafiareas Strait.

Keywords: Kafiareas Strait, Bottom Currents, Bedforms, Sand Waves and Megaripples, Cretan Deep Water

SOURCE ROCK CHARACTERISTICS, ORGANIC MATURITY AND HYDROCARBON POTENTIAL OF THE EOCENE DEPOSITS IN BLACK SEA REGION, NE TURKEY

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Type of organic material, thermal maturity, depositional environment and source rock potential of Eocene aged clastic rocks of Eastern Black Sea Region were evaluated by using Rock-Eval pyrolysis and gas chromatography analysis. The total average organic carbon (TOC) contents of the sequences in Kelkit (Gümüşhane), Akduran, Örence and Çalidere (Bayburt) are 1.89%, 0.43%, 0.64% and 1.57%, respectively. Based only on TOC values Eocene aged clastic rocks of Gümüşhane region can be classified as medium-good oil source rocks and Eocene aged clastic rocks of Bayburt region as poor-good oil source rocks. Average HI and PY values of Kelkit, Akduran, Örence and Çalidere samples are 202 mgHC/gTOC, 29.2 mgHC/gTOC, 46.4 mgHC/gTOC, 111.4 mgHC/gTOC and 7.2 mgHC/g rock, 0.21 mgHC/g rock, 0.34 mgHC/g rock, 1.13 mgHC/g rock, respectively. Samples of Akduran and Örence (Bayburt) sections contain Type III, Çalidere (Bayburt) section Type II, Type III and Kelkit (Gümüşhane) section a mixture of Type I-Type III kerogen. In gas chromatograms of samples of both which two regions, n-alkanes distribution of samples are unimodal n-alkanes with low and high numbered carbons exhibit a similar abundance distributions. Pr/Ph ratio of samples in Gümüşhane region is calculated as 2.01 and of samples in Bayburt region as higher than 5 from gas chromatograms. CPI_{1,2} values of samples Pe-6 (Kelkit), C-13, C-19 (Çalidere) are higher than 1 and those of samples C-16, C-23 (Çalidere) lower than 1. Calculated Pr/n-C₁₇ ve Ph/n-C₁₈ ratios of samples Pe-6 and Pr/n-C₁₇ ratios of samples C-13, C-16, C-19, C-23 are calculated as higher than 2, while Ph/n-C₁₈ ratios of samples C-13, C-16, C-19, C-23 are lower than 0.50. Average T_{max} values of samples of Kelkit, Akduran, Örence and Çalidere sections are 439°C, 446 °C, 452 °C ve 453 °C, respectively. Based on these values, Eocene aged clastic rocks are thermally mature. Since analysed samples are clastic rocks, and as they contain both marine and terrestrial type organic material and as the water column during the deposition process was oxic, a transitional marine depositional environment is considered for the sequence. According to these data, Eocene aged clastic rocks of Gümüşhane and Bayburt regions show poor source rock characteristics.

Keywords: Northeastern Turkey, source rock, TOC, GC, depositional environment.

EVALUATIONS RELATED TO MINING ARCHAEOLOGY (GEO-ARCHAEOLOGY) IN AMASYA CITY

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In the study, two ancient mines were investigated that were located in different areas of Amasya city, northern Turkey. These ancient mining ventures are situated in Gümüşhacıköy district (Gümüş town) and Merzifon district (Bakırçay Derealanı site). Gümüşhacıköy ancient mine is located in Upper Jurassic-Lower Cretaceous rocks of Amasya group and Campanian-Maastrichtian Artova ophiolitic mélangé, whereas the Bakırçay-Derealan ancient mine is situated in scarn zone of the contact between Upper Eocene Tavşandağı granodiorite and marble. In Gümüşhacıköy district, the prehistoric gallery traces were found within the operating galleries of the Ottoman period. A stone muller concerning ancient mining, an Ottoman ceramics and a ceramic relating to 2000 B.C. years were found at Gümüş town. The Carbon-14 (¹⁴C) analysis of a wooden piece finding in the study area yields 130 years. The ²⁰⁶Pb/²⁰⁴Pb, ²⁰⁷Pb/²⁰⁴Pb, ²⁰⁸Pb/²⁰⁴Pb, ²⁰⁷Pb/²⁰⁶Pb, ²⁰⁸Pb/²⁰⁶Pb and ²⁰⁴Pb/²⁰⁶Pb isotopic ratios are similar and range between 18.5-18.8, 15.5-15.7, 38.1-38.49, 0.833-0.838, 2.03-2.06, and 0.0530-0.0538, respectively. The evaluating results of this data show that the mining proceedings begin at prehistoric period in Gümüşhacıköy and continued in Rome and late Ottoman periods. In the Merzifon district, in the Bakırçay area, numerous ancient structures has been found. These are three ancient operating galleries, eight ancient slag stacks, three miner settlements and ceramic samples related with time from 2000 B.C. to Byzantine and Ottoman periods. As a result of all studies, it can be suggested that the mining processes began at prehistoric period and continue until late Ottoman periods in Bakırçay area.

Keywords: Mining Archaeology, Geo-Archaeology, Ore Deposit

UPPER MIOCENE-PLIOCENE LACUSTRINE EVAPORITES OF THE BOR-ULUKIŞLA BASIN (NİĞDE, TURKEY)

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The Bor-Ulukışla Basin located in the south-eastern part of the Tuz Gölü Basin, Central Anatolia underwent a significant evaporitic sedimentation in non-marine settings during the Upper Miocene-Pliocene. The evaporitic sedimentation formed in the central part of the basin as a shallow, saline lake system, where abundant halite and Ca-Na sulfate deposits. Detailed mineralogic and petrographic properties of lacustrine sediments were examined by X-ray diffraction, scanning electron microscopy and thin section. Samples collected from field and from six deep cores. Thickness of evaporite levels varied between different drilling wells. Three interconnected subenvironments or zones—inner, intermediate and marginal are differentiated in this saline lake system. In the inner zone, alternation of halite, Ca-Na sulfates (gypsum, anhydrite, glauberite, thenardite, mirabilite), Mg-sulfates (epsomite, bloedite), clay minerals, carbonate minerals (i. e. dolomitic and magnesian). The minerals showed laminated to each other suggesting a seasonal regime. The composition of some levels was nearly pure, consisting of one or two evaporite minerals, i.e., halite, anhydrite, while clay minerals, evaporite, zeolite and other silicate minerals are found together in some levels. In the intermediate zone, carbonate (dolomitic), clay laminae, and gypsum, anhydrite nodules and micronodules formed. In the marginal zone, alternation of lacustrine limestone, claystone, green-red sandstone, siltstone including fibrous gypsum band accumulated. Generally quartz, feldspar, mica and detrital clay minerals are present at the margin of the basin. Detrital chlorite, Ca-smectite, kaolinite and illite reflect compositions of the older formations in the paleodrainage areas. Clay minerals are also found in the upper levels of evaporites. The main clay mineral assemblage consists of Ca-Na-montmorillonite, sepiolite, palygorskite, illite, chlorite and kaolinite. Six evaporite facies, identified from the mineralogical data, reflect variable brine chemistry throughout the history of the playa. In the playa sediments, alternation of the evaporite facies reflect fluctuations in salinity level induced by climate change. Both the evaporitic mineralogy and evaporite/carbonate lithofacies suggest that arid and semiarid conditions prevailed in this basin during the accumulation of the evaporite units.

Keywords: Evaporites, Halite, Na-sulphate, Bor-Ulukışla Basin, Central Anatolia

SEDIMENTOLOGY AND GEOCHEMISTRY OF MODERN BEACHES FROM THE MERSIN GULF, SE TURKEY

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Grain size distribution, total heavy mineral contents and some major elemental compositions of sediments from modern beaches of the Mersin Gulf were investigated to understand sediment transportation processes in interrelationship between marine and terrestrial conditions. In addition to field observations sediment samples were collected from the upper swash zone of beach surface both in foreshore and backshore areas. Grain size analysis were performed with a set of sieves ranging in mesh size from very fine sand to gravel. Heavy liquid bromoform was used to separate heavy minerals from the sediment mixture. ICP-MS technique was applied to determine concentrations of some elements.

Sand is the prominent grain size in bulk sediment and mean grain size ranged from 1.25 to 2.77 Φ (avg. 2), covering grain size class from fine sand to medium sand. Grain size sorting varied between Φ 0.46 and 0.99 (avg. 0.7) medium to well-sorting. Total heavy mineral contents ranged from 1 to 72 % of bulk sediment with a tendency to increase in the northeastern section of the gulf having values more than 20 %.

Grain size, heavy mineral and major element parameters were interrelated. Although studies are going on, recent data suggest combined terrestrial and marine effects controlling grain size and heavy mineral distribution in beach sediments. These factors include; variations in coastal morphology (width and slope of beach profile), fluvial regime (proximity to river mouths and nature of rivers), types of source rocks for river sediments, anthropogenic impact for coastal use, wave and current regime.

Keywords: Mersin Gulf, Beach, Sediment, Grain Size, Heavy Mineral

ENGINEERING GEOLOGY &
NATURAL HAZARDS

QUANTIFYING SEISMIC HAZARD FOR THE ANTAKYA AREA OF SOUTHERN TURKEY USING A NOVEL GEOMORPHIC ANALYSIS.

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Quantifying the extent to which geomorphic features can be used to extract tectonic signals is a key challenge in the Earth Sciences. Here the drainage patterns, geomorphic impact and long profiles of bedrock rivers that drain across and around normal faults in a regionally significant oblique-extensional graben in Southern Turkey are analysed. The Hatay Graben has been mapped geologically, but there are poor constraints on the activity, slip-rates and Plio-Pleistocene evolution of basin-bounding faults. By comparing the presence, size and distribution of long profile convexities, we demonstrate that the northern margin of the graben is tectonically quiescent, whereas the southern margin is bounded by active faults. Our analysis suggests that rivers crossing these latter faults are undergoing a transient response to on-going tectonic uplift, and this interpretation is supported by classic signals of transience such as gorge formation and hill-slope rejuvenation within the convex reach. Additionally, we show that the height of long profile convexities varies systematically along the strike of the southern basin-bounding faults, and we argue that this effect is best explained if fault linkage has led to an increase in throw rate on the faults through time. By measuring the average length of the original fault segments, we estimate the throw rate enhancement along the faults, and thus calculate the range of times for which fault acceleration could have occurred, given geological estimates of fault throw. These values are compared with the times and slip-rates required to grow the documented long-profile convexities enabling us to quantify both the present-day slip-rate on the fault and the timing of fault acceleration. Not only do these results enable us to constrain the tectonic evolution of the graben through time, the results have substantial implications for predicting earthquake hazard in this densely populated area suggesting that the seismic moment magnitude (M_w) of a potential rupture along the southern boundary fault could exceed $M_w = 6.0$ with an estimated peak horizontal ground acceleration of 0.34 g at 10 km from the fault. More widely, these results demonstrate that geomorphic analysis can be used as an effective tool for estimating fault slip rates over time periods $> 10^6$ years, even in the absence of direct geodetic constraints.

Keywords – seismic hazard, normal faulting, tectonics

NEW VIEW TO SEISMIC HAZARD ASSESSMENT: THE SYRIAN EXPERIENCE

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According to the existing requirements of seismic hazard assessment, the potential M_{max} of a seismic zone is estimated by two ways. First, M_{max} may be derived from magnitude–number of earthquakes plots. Second, M_{max} may be calculated using empirical relationships between earthquake magnitude and the length of an earthquake fault. This estimation yields the upper limit of possible M_{max} in the fault zone. Due to clear manifestations of active tectonics, abundance of archaeological objects and early beginning of written registration of strong earthquakes, Syria provides a possibility to study the last 2500-years seismicity by combined analysis of historical, archaeoseismological and paleoseismological data. 20 earthquakes with $M_s \geq 6$ were registered in the southern and central parts of the El Ghab segment zone (Syria) of the Dead Sea Transform (DST) for the last 2100 years. The temporal distribution of released seismic energy demonstrates a cyclic recurrence with the interval of 300–400 years. At the same time, the energy release was low in the first half of the I millennium AD, increased in the second half, reached maximum in the XII century, and then was gradually decreasing towards the present minimum. The period of recent relative quiescence can be interpreted differently: (1) prolonged accumulation of elastic deformation will realize in super-strong earthquake; (2) the next peak of seismic cycle will be probably characterized by earthquake with $M_s < \sim 6.5$ and anyway will not reach $M_s = 7.7$, characteristic for the XII century. The second scenario seems to be more reasonable because of the following data. Over the Middle Pliocene–Quaternary and the Holocene time, accumulation of elastic deformation was realizing in sinistral motion on the DST fault zone at the average rate of ~ 5 mm/a. Three campaigns of the GPS measurements around the discussed part of the El Ghab segment, carried out in 2000–2008 independently by the USA–Syrian and Russian–Syrian working groups, revealed 2–3 mm/a of the rate of elastic deformation accumulation. The 12-m offset of the Roman aqueduct near the village of Al Harif (built in the I century BC – I century AD after 63 BC) gives ~ 6 mm/a of the average rate in the southern part of the El Ghab segment for the last two millennia. If the present 2–3 mm/a rate is characteristic for the last several centuries, the average rate had to be more than 6-mm/a for the previous centuries. We assume that variation in rates of elastic deformation accumulation controlled and was in proportion to variation in magnitudes of earthquakes in the fault zone and the released seismic energy for the same period. So, variations of rates of elastic deformation accumulation are important for seismic hazard assessment in the region

Keywords: Syria, Dead Sea Transform, variation of strain accumulation rate, seismic hazard.

QUANTITATIVE LANDSLIDE RISK ASSESSMENT BETWEEN MERSIN AND ERDEMLI REGION (SOUTHERN TURKEY)

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Landslide risk is defined as the expected number of lives lost, persons injured, damage to property or disruption of economic activity due to a particular landslide hazard for a specified time period within a given area. In this study, quantitative landslide risk maps were prepared, between Mersin and Erdemli region extending for 1600km², considering landslide hazard, vulnerability and economic value of elements at risk. 1285 and 338 residences were either collapsed or heavily damaged in Mersin city, due to the landslides triggered by excessive rainfall in 1968 and 2001, respectively.

In order to determine the spatial probability of landslide occurrence, susceptibility maps were prepared for particular time periods using statistical relationships between landslides and landslide conditioning factors. Temporal probability of landslides was determined by considering the triggering factors from rainfall – frequency relationships. The exceedance probability of landslides occurrence in 5, 10, 25, 50 and 100 years time intervals were calculated. The probabilities of landslide size (extent) were obtained from frequency – size distribution of multi-temporal landslide inventory maps prepared after interpretation of four sets of aerial photographs. Then, landslide hazard maps for different landslide sizes (>0.1km² and >0.01 km²), that will occur having exceedance probabilities for 5, 10, 25, 50 and 100 years periods were obtained. The elements at risk were considered only for roads (2916km), houses (13780) and agriculture lands (169 km²). Vulnerability was assessed by comparing losses with the actual economic value of the elements at risk and simply expressed as 1 for roads and houses, and 0.6 for agriculture lands.

Landslide risk maps were prepared by multiplying landslide hazard, vulnerability and actual economic values of elements at risk. The results indicate that the total expected economic losses for 50-year period of landslide sizes greater than 0.01 km² and 0.1 km² is about 243 million \$ (%23 of total economic value) and 50 million \$ (%5.5 of total economic value), respectively. It is suggested that the risk maps produced by this study would help to perform effective landslide risk mitigation strategies of the region.

Keywords: landslide hazard, landslide risk, vulnerability, elements at risk, Mersin.

CORRELATION STUDY BETWEEN POINT LOAD TEST AND UNIAXIAL COMPRESSIVE STRENGTH AND TENSILE STRENGTH OF SOME SEDIMENTARY ROCKS IN MOSUL CITY

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The point load test is highly practical and inexpensive test to obtain intact rock strength indexes when logging core samples in either a field or laboratory setting. In order to estimate the uniaxial compressive strength, indirect tensile strength (Brazilian and 4-point bending) of the rocks, index to strength conversion factors are used to involve three types of the most popular sedimentary rocks in Mosul city, which are Limestone, Sandstone and Gypsum in both dry and wet condition.

The results showed that conversion factors of (14.55 and 15.9) can be used to predict uniaxial compressive strength for both limestone and gypsum rocks in dry and wet conditions respectively. In addition, conversion factors of 1.4 and 2.6 may be preferred the three rocks in Brazilian and Bending tests in dry condition.

Keywords: Point load strength, Uniaxial compressive strength, Conversion fact

INVESTIGATION OF THE SOILS COMPACTION: ULTRASONIC (P-WAVE VELOCITY) METHOD

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Soil compaction is one of the most important part of earthfill projects. Tightness of the fill is defined by the dry unit weight of the compacted soil. The maximum dry unit weight (γ_{d-max}) and the optimum water content (w_{opt}) obtained from standart Proctor test, describe the best compacted state of the earthfills. The Proctor test consists of three steps. First includes the determination of the maximum dry unit weight of soil. Second, the contractor is imposed to achieve the specified percentage of this value during the construction in the field. Finally, a sand cone test, a drive cylinder test or a nuclear density test can be performed to assess the degree of compacted fill in the field.

In this study, the changes of the P-wave velocity (V_p) in relation to soil compaction was investigated. The standard Proctor test was applied to eight different soil types. The P-wave velocity of the compacted soil in the mold was measured by the portable ultrasound device after compaction. The statistical relationship between the P-wave velocity and the dry unit weight (γ_d), and the water content (w) was investigated by the simple regression analysis and a high corelation coefficient was obtained between the V_p and the γ_d ($r = 0.93-0.99$). Results show that a new compaction assesment method using ultrasound technique can be proposed. The new method is considered to be more practical and simpler than commonly used similar methods.

Keywords: Compaction, P-Wave Velocity, Soil, Ultrasound

THE EFFECTS OF BIOLOGIC WEATHERING ON SURFACE CHARACTERISTICS OF ARMOURSTONES

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Several physical, chemical, and biological agents can positively or negatively change coastal rocks (both natural and transported). Shallow marine and marginal marine environments (between the continental and marine environments such as delta, beaches) create suitable habitats for different type of organisms. Boring, burrowing, grazing, feeding, and other activities of the some organisms may cause weathering (disintegration and decomposition; destructive process) of the coastal rocks. Many types of the organism remnants or secretions of them can create hard ground (supply a protection against the sea wave) on the outer surface of coastal rock. So, the organism type is one of the important controlling factors on the biological weathering. Rock composition and rock strength are the other important factors of the biological weathering.

Plio-Quaternary conglomerates, gravelly sandstones, and sandstones form the Mediterranean coasts near the city of Mersin. Mostly Miocene reef limestone, occasionally Mesozoic limestone, and Quaternary calccrete blocks have been used for the construction of Mersin port and several recreational parks. Worms (*Phoronida* sp.), mussel (*Brachidontes pharaonis* (Fischer P. 1870)), and *Patella* sp. are abundantly living in and on those armourstone blocks. They are creating maximum 3 cm thick organic cover and maximum 4.5 cm thick weathered section inside the armourstone blocks. The organic cover protects the armourstone from the sea wave action. The degradation activities of organism cause to strength weakening of the armourstone. In addition, destructive activities of organism are destroying the Plio-Quaternary clastics (conglomerates, gravelly sandstones) because of the penetration through the matrix sandstone. As a result of this process, finer-grained materials are transported to the open sea, while gravels of clastics are transported to the shore region and form gravelly beach.

Keywords: Bioerosion, Bivalve, Draga, Limestone, Sandy Conglomerates, Mersin Bay (S Turkey)

EVALUATION OF STANDARD PENETRATION RESISTANCE AT A SUBSECTION OF ESKİŞEHİR CITY USING ANFIS MODEL

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In the last decade, advances in computer technologies and software's, soft computing methods have been widely used in geotechnical investigations with a limited data. The obtained data from Standard Penetration Tests (SPT) are frequently used by determining the bearing capacity and liquefaction potential of soil layers. Therefore, the usage of most proper method in the prediction of SPT results plays an important role.

In this study, 1955 SPT data, obtained from 334 boreholes which were drilled at a subsection (especially southern part) settlement area of Eskişehir city, were evaluated using Adaptive Neuro-Fuzzy Inference Systems (ANFIS) method. For the purpose, only the boreholes penetrated through the alluvial soils were evaluated. Depths of SPT, soil class, the existence of groundwater in the depth level of SPT were used as input data and SPT was used as output data in ANFIS. In this way, depth was used as is due to its numerical values. On the other hand, soil class and ground water were linguistic data. Therefore, they had to be classified by subgroups and defined using numerical values in order to construct ANFIS model. Soil classes were separated into four subgroups and these were assigned as follows: first group, (CH, MH and CH-MH) High Plasticity Silt-Clay; second group, (CL, ML and CL-ML) Low Plasticity Silt-Clay, third group, (SC, SM and SC-SM) Clayey-Silty Sand and the fourth group, (SW, SP, GW, GP etc) Sand-Gravel. Besides, the groundwater was assigned as available (1) and none available (0).

The 2/3 of the whole data was used for training process and the remaining 1/3 of them were used for testing process in order to construct the ANFIS model. In this manner, different ANFIS models were developed. The performance of the developed models was compared to each others using the RMSE, R^2 ve MAPE values as the criteria. The model predictions and performance values were evaluated to obtain the most adequate ANFIS model.

Finally, the employment of ANFIS method, for modeling and predicting SPT values, was discussed by considering the model prediction values. Accordingly, the most efficient effect on the prediction ability of the developed ANFIS model can be concluded as the existence of some linguistic inputs. The relationships between SPT values and these linguistic inputs seem to be low. In this case, it causes to uncorrelated relationships between the inputs and the SPT output in the prediction of SPT values, and it leads to the prediction values beyond the real values obtained from the SPT results. This conclusion can be drawn from the prediction values of both training and test processes. Consequently, the developed ANFIS model is reliable and ANFIS method can be employed to predict SPT values.

Keywords: ANFIS, SPT, Prediction, Eskişehir, Alluvial soils.

EFFECT OF STEEL FIBERS ON MECHANICAL PROPERTIES OF LIME STABILIZED SOIL

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Recently, many attempts were made to use steel fiber reinforcements to improve some soil properties. In this research, the effects of fibers on the compaction and mechanical properties of lime stabilized soil was studied. Variables such as type of steel fibers and amount were studied. Results indicated that the addition of fibers lead to increase in the maximum dry unit weight. On the other hand, a maximum values of unconfined and tensile strength were obtained with the addition of 0.5 % short fiber (FS) and 1.5 % long fiber (FL) respectively. The load-deflection curves indicates that a brittle manner failure for the unreinforced samples and samples prepared with little amount of fibers 0.5% (FS) and (FL).

Keywords: Soil Stabilization, Tensile Strength, Lime, Steel Fibers

GEOTECHNICAL INVESTIGATION OF MARLY LIMESTONE ROCKS AND RELATED RESIDUAL SOILS IN EKBATAN DAM SITE (WEST IRAN)

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Mechanical and physical characteristics of rocks and soils are generally fundamental information for engineering purposes, such as assessing foundation support for facilities, instability of artificial and natural slopes, and other engineering works. Since marly limestone rocks in South-East region of Hamadan has a relatively large spread in area, and the residual soils due to weathering of the rocks, studies of physical and geotechnical properties of these soils into development activities is most important. In this paper, the characteristics considered include soil mineralogy, soil texture and other common soil tests. Laboratory studies of yield strength, stress-strain characteristics, elastic properties, slake durability and Los Angeles test have been conducted on rock samples. The effects of weathering are shown in rock sections. The following study shows a significant relationship between the engineering geological characteristics of residual soils and the petrographic characteristics of the rocks.

Keywords: marly lime stones, Geotechnical Properties, Residual Soils, Hamadan

THE REASON FOR UNREALISTIC BOUNCE-HEIGHTS OF THE ROCKFALL MODELLING STUDY ON THE STEEP-HIGH SLOPES: AN EXAMPLE ERMENEK (KARAMAN-TURKEY) DISTRICT

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Ermenek is surrounded by Karaman-Hadim from north, Gülnar-Mut from east, Anamur-Gazipaşa from south and Sarıveliler-Başyayla districts from west. The study area has a rugged topography with altitudes ranging from 1250 m to 1850 m in north-northwest side of Ermenek district. The slope angle is almost 90 degrees and the height of the slope is approximately 300 m in this region. Rockfall movements, which have occurred in the northern part of the Ermenek district and its vicinity, are mostly due to a sudden increase of elevation, unfavorable geological and engineering properties of the rock units, and climate of the region.

To assess the relative stability and potential for future rockfall, in-situ tests were conducted and rockfalls were modeled using commercial software packages such as RocFALL. When determining the coefficients of normal (R_n) and tangential (R_t) restitution, the weight of the block is not used. On the other hand, the weight of block, coefficients of restitution and topographic profile are used in the modeling study. As a result, unrealistically, a 10-ton block jumped up to 70 meters along the profile in the modelling study. In this study, the reason for this unrealistic bounce-height values were evaluated.

Keywords: Ermenek; Rockfall; Bounce-Height; Coefficients of Restitution

RELATIONS BETWEEN THE FACIES AND MATERIAL PROPERTIES OF THE UPPER CRETACEOUS LIMESTONE OF THE KARABURUN PENINSULA, IZMIR WESTERN TURKEY

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Petrographic and physico mechanical properties of limestones are dependent upon their textures which reflect their deposition environment. Change in the environmental and diagenetic conditions during the deposition period, is generally reflected in the petrographic and physico-mechanical properties of the limestone. A detailed study has been carried out on the Upper Cretaceous Karahasan Limestone unite of Karaburun Peninsula in Western Turkey to determine the relation between their facies and physico-mechanical properties.

The Karahasan Limestone unit is Campanian-Maestrichtian aged and has been used for bloc marble production in the Karaburun Peninsula in western Turkey. This unit is located in the upper part of the Mesozoic carbonate sequence and outcrops in north west of the Balıklıova town. The limestone sequence is about 116,5 m. thick in the Balıklıova limestone quarry. There is about 15 m. thick lithic conglomerate bed at the base of the limestone squence, 84,7 m. thick large beige packstone-grainstone deposited at the slope foreshore on top of conglomerate and the limestone squence continues with beige and pinkish packstone and pinkish red packstone-wackestone levels. This packstone-wackestone level is divided into three zones in the area as;

-5,3 m thick deep sea and deep sea margin facies containing pinkish-beige planktonic foraminiferaous packstone

-3.5 m this deep sea margin facies containing pinkish beige sponge spicule packstone

-8 m thick deep sea facies containing red planktonic foraminiferaous noduler wackestone.

The SiO₂/CaO ratio of the Karahasan Limestone unit has been found to be facies dependent. The SiO₂/CaO ratios have been found to increase with depening of the deposition environment .

Finding have shown that while there is a relatively moderate correlation between the SiO₂/CaO ratios and the physical properties of the Karahasan Limestone, high correlations have been found with their mechanical properties. These founding are important in assessing the limestone deposits as a source for building stone or other purposes.

Keywords : Karaburun Peninsula, Upper Cretaceous Limestone, Facies, Material Properties.

COMPACTION CHARACTERISTICS OF CALICHED SOILS IN ADANA REGION

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Laboratory determination of the compaction characteristics of soils is a vital operation for use in earth fills. The purpose of compaction is reduction in settlement and increase in shear strength. In this study, caliched soils which are known as problematic geo-materials were evaluated in view of compaction characteristics. Caliche are described as secondary carbonate formations and calcareous, semi-consolidated aragonite or early diagenetic calcite forming in loose materials such as pebble, sand, silt, and soil under semi-arid and arid climatic regimes. Caliche deposits contain different levels based on physical properties, strength and deformability. In this study, nine disturbed caliched soil sample are taken from various location in the study area, and tested for various soil mechanical tests, including grain-size distribution, liquid limit, plasticity index, specific gravity of soil solids, maximum dry density of compaction, optimum moisture content, and CBR (California Bearing Ratio) following ASTM standard procedure. The test results of caliched soils samples were as follows: percent retained on US sieve #3/4": 0-6.16; Percent passing US sieve #3/8": 8.12-18.92; Percent passing US sieve #4: 14.36-26.74; Liquid limit: 34.50-53.50%; Plasticity index: 19.60-36.12%; Specific gravity of soil solids: 2.54–2.61. Maximum dry density and optimum water content values are within range of 1.53-1.73g/cm³ and 16-27%, respectively. CBR values varies from 5.39 to 48.75. Relative desirability rating for core and compacted earth lining was determined to be very high level of desirability according to the Engineering Use Chart (after Wagner, 1957; Attawel and Farmer, 1976) for CL-ML group caliched soils. However, desirability of caliched soils is lower level for filling of foundation (seepage important) and roadways. Caliched soils is an excellent filling geo-materials if used with in dry conditions.

Keywords: caliched soils, compaction, Adana

GEOLOGICAL AND GEOTECHNICAL PROPERTIES OF THE AVSAR CAMPUS AREA OF KAHRAMANMARAS SUTCU IMAM UNIVERSITY

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This study comprises determination of the geological and geotechnical properties of the Avsar Campus of Kahramanmaras Sutcu Imam University (KSU). The campus area includes the six faculty buildings, dormitories, and shopping centre. The investigated area is located in first-degree earthquake zone. Geologic properties, soil classifications, allowable bearing capacity values, and risky area for constructions were determined.

The Yenice kale formation (Miocene) and Quaternary alluvial deposits crop out in the study area. 1/5000 scaled slope index map was prepared. The campus area has 30-40° percentage at the southern slopes, 10-20° percentage at the western slopes and 0-5° percentage at the northest slopes. Sixteen drillings of 10 m depth were opened in eight-construction site. Undisturbed samples were taken from the different depths of each borehole. Water content, specific unit weight, sieve analysis, Atterberg limits, and uniaxial compressive strength values of each sample were determined in laboratory.

It was determined that the allowable bearing capacity of Avsar Campus varies between 1.10-1.53 kg/cm². Conglomerate member of the Miocene formation was fixed as a most suitable place in the Avsar Campus (KSU) for construction. The alluvial grounds are the most risky area for constructions.

Keywords: Soil Classification, Bearing Capacity, Geotechnique, Avsar Campus.

EFFICACY OF AFŞIN-ELBISTAN FLY ASH ON AXIAL STRENGTH OF A COHESIVE SOIL

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The study was aimed to evaluate efficiency of utilizing a self-cementing fly ash derived from combustion of lignite at Afşin Elbistan thermal power plant in stabilizing a fine grained clayey soil (CL). Grain size and Atterberg limits analysis, compaction and uniaxial compression tests were carried out on the clayey soil (pure soil) and soil mixtures added various percentage of fly ash. The samples used for uniaxial compression test were prepared mixing fly ash with soil at optimum moisture contents determined by standard proctor test and cured for 18 months.

The test results indicate that the axial strength of soil increases considerably with addition of fly ash. Axial strengths of pure soil, the soil sample added 5% fly ash and pure fly ash was determined as 376, 1.735 and 10.348 kPa, respectively. Addition of 5% fly ash into the soil and fly ash mixture caused about 22,4 percentage (approximately 263 kPa) increment on the mixtures.

Moreover, the fly ash treatment brings also soil in more granular nature due to flocculation of the clay particles by puzzolanic activity. The results state that Afşin Elbistan power plant fly ash is a very convenient material as a soil stabilizer for cohesive soils.

Thermal Power plants in Turkey combust about 55 million tons of coal and lignite annually, which result in more than 15 million tons of fly ash. Some disposal facilities in Turkey involve a risk of filling to their design capacity. Afşin Elbistan Thermal Power plant is one of these, which annually produce approximately four million tons fly ash as a waste by-product.

Usage of Afşin Elbistan fly ash in soil stabilization seems to be one of many acceptable answers for handling the fly ash waste problem as well. Utilization of fly ash in soil stabilization will have a positive influence on the environment and the economy because much more fly ash disposed of rather than utilized, making more productive use of fly ash would have considerable environmental benefits, reducing land, air and water pollution.

Keywords: fly ash, soil, axial strength, soil stabilization

MAIN TECHNICAL ROCK CHARACTERISTICS OF ACTIVE QUARRIES IN SERBIA, USED IN ROAD CONSTRUCTION, IN ACCORDANCE WITH THE NATIONAL AND EN STANDARDS

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The rocks used in road construction in some country depend on the geological history of that country. The standards for rock and rock aggregates are national standards or EN standards for countries that are members of CEN (European Committee for Standardization). In Serbia, country of the Balkan Peninsula, which is not member of CEN, research of rock and rock aggregates take place in conformity with national (SRPS) standards, which are an integral part of national technical requirements for the quality of materials for road construction. In Belgrade, the Highway Institute's accredited laboratory investigates technical characteristics of different rock types that are used in road construction, building and for decorative purposes. But only a small number of rock types are widely used in road construction; such materials are from active quarries whose material quality has to be proven by six-month certificates. For the road construction in Serbia are used limestone, dolomite and crushed gravel of sedimentary rocks for the base course, binder and wearing course (up to medium traffic). Dacite, andesite, trachyte and diabase are igneous rocks in use for binder course and wearing course (for all traffic intensities) since their use in the lower layers is too expensive. Dolomite marble of metamorphic rocks so far has greater application for base course, binder course and wearing course (up to medium traffic). Technical properties of rocks are shown in the tables in the form of interval variation and arithmetic mean values taken from a database of active quarries. In order to ease understanding of data presented, in tables are given marks of national (SRPS) standards by which the testing is done and EN or ASTM standards which are consistent in the recipe testing. The natural stone were interpreted with following properties: petrographic research, compressive strength, abrasion resistance (Böhme), particle density, water absorption and frost resistance; crushed aggregate: resistance to abrasion (LA), polished stone value (PSV), crushability by compression in cylinder, wear resistance (micro -Deval) and water absorption. In accordance with national technical specification, possibility of using these rocks in road construction is given. Considering the increasing use of European standards in the neighbouring countries, in Serbia we pointed out the need for testing the technical properties of these rocks from the active quarries according to EN standards. Based on these tests, a national technical specification will be prepared depending on the quality of rock mass in Serbia. Much of the testing equipment for stone and aggregate was acquired, and some tests were started. In this work of great help would be comparative testing with accredited laboratories for rock and rock aggregates among neighbouring countries of Serbia, and other members of CEN. Also significant is the collection of EN national technical requirements CEN-member countries in one place for easy mutual comparisons and performed road works in Europe's countries and the candidate countries for EU membership. This is particularly important for holding companies that have quarries in several countries, and works performed by the technical conditions of the host country.

Keywords: technical properties - Serbia - road construction - EN technical specification.

POTENTIAL ENVIRONMENTAL RISKS RELATED TO THE NATURAL GAS EXPLORATION/EXPLOITATION WORKS AT S.N.G.N. ROMGAZ S.A. MEDIAŞ (ROMANIA)

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S.N.G.N. ROMGAZ S.A. Mediaş is the main natural gas producer in Romania. The areas of interest concern both inner (Basin of Transylvania) and outer (Moldavia) Carpathian regions. The exploration and exploitation works focus on the Middle Miocene sands. The natural gas exploitation history has been, by far, longer in Transylvania than in Moldavia, the first gas discovery being recorded in April 1909 at 2 Sărmăşel well. In 2009, the works were carried out on over 140 gas fields in the afore mentioned areas. The total amount of natural gas extracted was about 6 million Scm. The natural gas from Transylvania is among the worldwide purest, with over 99% methane. In time, a considerable number of wells have exploited natural gas. As a matter of fact, several environmental risks in point of the exploration and exploitation works have to be taken into consideration:

- i. the risk of soil pollution could appear while drilling, separating, collecting and carrying away the formation water, handling and using fuels and lubricants, managing waste, when there is some leakage from the siphon conduit and during workover jobs in the wells.
- ii. the surface and underground waters may be polluted while drilling, testing the wells, during methane extraction, workover jobs in the wells, gas compression process, gas transportation through pipes, various activities carried out in the production units.
- iii. the air can be polluted only in unusual situations, during free gas eruptions or because of unsealed valves.
- iv. there are no harmful impacts on the water and terrestrial ecosystems. They might be damaged only for short periods during drilling, well tests and workover jobs.

In 2009, the total investment of the company was of over 200 million Euros, 2 million being allocated for the environment protection. In these circumstances, in the last years, there have been no harmful environmental events.

Keywords: Romania, natural gas, environment protection.

INVESTIGATION OF EFFECT TO EXCAVATION DEPTH AND FOUNDATION WIDTH OF THE RECTANGLE SHAPED SHALLOW BUILDING FOUNDATIONS IN THE SEISMIC ACTIVE REGIONS DUE TO EARTHQUAKES (A CASE STUDY IN BURDUR)

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The shallow foundations are foundation type most widely used in several countries for different geological units. These foundations are widely used in the seismic active and inactive regions of Turkey. According to investigations, causes damage to buildings due to occurring earthquake in seismic active regions are related to incorrect calculations of foundations parameters (excavation depth and width) and earthquake resistance and to incorrect selection of foundation types.

The parameters of shallow building foundations are determined with several natural factors. One of the factors is seismicity of regions to project of building foundations. The foundations parameters are calculated using natural soil properties and static loads transferred to foundation from building by civil engineers. Unfortunately, soil properties and loads transferred to foundation are changed during earthquake in short time, and thus calculations which are made with static loads are inadequate for new situation.

In the study, earthquake against resistance of foundations of industry and social facilities which are located Burdur city where found silty, sandy, clayey soils (CH-ML) originated from volcanic units within first degree earthquake zone of Turkey and were investigated. The soil properties of the study area were determined in soil mechanics laboratory of Suleyman Demirel University and foundations properties were selected to present buildings in Burdur city. For calculation of earthquake resistance of building foundations, a method which is suggested by Foundations and Soil Research Institute (Pr of. Dr. Stavniser) and widely applied in Russia are used. According to this applied method results, the shallow foundation parameters rectangle shaped (for MSK 12 bal scale) which are calculated to natural factors and static loads should be taken 1.5-2.0 times for able to resist of present industry buildings within the study area to earthquake having to 7-8 bal power.

Keywords: Burdur, Earthquake, Soil, Foundation, Static Load

ENGINEERING GEOLOGICAL INVESTIGATION OF FOUNDATION OF CHAMSHIR DAM SITE BY USE OF DMR CLASSIFICATION (IRAN)

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DMR (Dam Mass Rating), is proposed -as an adaptation of RMR by Romana (2004) that giving tentative guidelines for several practical aspects in dam engineering and for the appraisal of dam foundations in preliminary studies (overall stability against sliding, needed depth of excavation for the foundations, consolidation, grouting treatment, possible consequences of excessive relationship following Rocha concepts- between the deformation modulus of the dam and of the rock mass foundation) taking into account of the effects of rock mass anisotropy and of the water saturation. The formulae for estimation of the rock mass deformation modulus E_m are also discussed. Using RMR classification method, Chamshir dam site have a favorable stability condition against sliding. But some landmass movements occurred in dam site. So in this article, the dam site stability was studied using DMR Classification. The Chamshir dam on the river Zohreh is located about 20 km south-east Gachsaran city in the south-west of Iran. The dam is now under study. The Chamshir dam has been designed as a concrete dam (Gravity-Arc dam). The dam and its associated structures are mainly founded on Mishan Formation (Lower Miocene age). Mishan Formation in Chamshir site are two different facies, facies limestone (biohermy limestone) and second facies include, marl and coconoid limestone layers alternately. These rocks are affected by jointing and faulting especially in the surface. Eight boreholes drilled at the dam axis. Total length of drilling is 811 meters. Obtained Average RQD is 95% for left and right abutments. In this paper by use of borehole samples, desk studies and laboratory works, geotechnical properties of dam foundation is estimated. By studying of engineering geology and use of DMR classification on rocks, quality of rocks mass (related to the dam stability against sliding) were determined. DMR values obtained show more unfavorable condition than RMR values.

Keywords: Chamshir, Engineering Geology, Dam, DMR Classification

EFFECT OF TEXTURAL CHARACTERISTICS ON GEOTECHNICAL PROPERTIES OF ROCKS (HORNFELS CASE STUDY)

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Considering that the geotechnical properties of rocks affected by their textural features, always been tried to communicate between textural characteristics and geotechnical properties. The authors evaluate the impact of textural characteristics on geotechnical properties of rocks (hornfels case study) with 6 types of hornfels, which has been gathered from different regions of Iran. Then for each sample, some thin section was prepared and then 6 digital photographs were taken from each section. After this, all imaged were digitized using AutoCAD s software. Then, area, perimeter, longest diameter and shortest diameter were assigned. After all above stages, geotechnical properties of have been tested in laboratory. Finally, relationships between textural characteristics and geotechnical properties of hornfels have been evaluated and the related mathematical equations have been presented.

Keywords: Rock Texture, Textural Characteristics, Geotechnical Properties

STUDY OF GEOTECHNICAL PROPERTIES OF HORNFELS ROCKS AND RESIDUAL SOILS DUE TO WEATHERING (CASE STUDY IN SOUTH-WEST OF HAMEDAN)

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The physical and mechanical properties are depend on the mineralogical and textural characteristics of the rock. The purpose of this study is to apply correlation analysis to investigate the relationships between petrographical and engineering properties of hornfels rocks and the residual soils due to weathering of these rocks. Since metamorphic rocks (hornfels) in South-West region of Hamadan has a relatively large outcrops, and the residual soils due to weathering of the rocks, studies of physical and geotechnical properties of these units for development activities is important. In this paper, the development of residual soil pr ofile weathering from a hornfels is described. The characteristics considered include soil mineralogy, soil texture and other common soil tests. Laboratory studies of yield strength, stress-strain characteristics, elastic properties, slake durability and Los Angeles test have been conducted on rock samples. The effects of weathering are shown in thin sections. The study shows a significant relationship between the engineering geological characteristics of residual soils and the petrographic characteristics of the rocks.

Keywords: hornfels, residual soils, geotechnical properties

DEPENDENCE BETWEEN GEOTECHNICAL PROPERTIES OF GRANITIC ROCKS AND RESIDUAL SOILS DUE TO WEATHERING OF THE ALVAND BATHOLITH

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Decomposed granitic soil is widely used as the construction material in Hamadan. And granitic rocks show a variety of engineering properties that may affect quarrying operations, tunneling, mining, slope stability and the use of rock as a construction material. Since granitic rocks of the Alvand batholith and the residual soils due to weathering of the rocks in have a relatively large outcrops spread in South-West region of Hamadan, studies of physical and geotechnical properties of these soils into development activities is important. In this paper, the development of residual soil profile due to weathering of these granitic rocks was described. The considered characteristics include soil mineralogy, soil texture and other common soil tests. Laboratory studies of yield strength, stress-strain diagram characteristics, elastic properties, slake durability and Los Angeles test have been conducted on rock samples. The effects of weathering are shown in rock thin sections. The study shows a significant relationship between the engineering geological characteristics of residual soils and the petrographic characteristics of the rocks.

Keywords: granite, Alvand batholith, residual soils, geotechnical properties

INVESTIGATION THE AFFECTS OF DIFFERENT FACTORS IN DEVELOPMENT OF KARST TERRAINS, USING OF REMOTE SENSING AND GIS (CASE STUDY: SOUTHWEST OF IRAN)

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Several factors are significant in karstic phenomenon and development of water resource in carbonate formations. In this study, attentions have been paid to the significant influential factors in karstic development in the Shirin Bahar territory in the north-east of Khuzestan province Iran. Therefore, the lithologic information, slope, topography earth level (surface), lineament density, precipitation and temperature layers were prepared and have been analysed in GIS media. Different informational layers, with applying expert judgement and cross-country inspection, were classified as criteria map and combined with the method of weighted integration by an appropriate combination weight which shows the degree of importance of each factor. Finally, after combining the layers, the area was classified in terms of the amount of karstification into five groups including very low, low, medium, high and very high. The results indicated that the maximum amount of karstification was in the zone with high fracture agglomeration due to severe tectonic of the region.

Keywords: Rate of Karstification, Remote Sensing and GIS, Imaging Satellite, Shirin Bahar Region

LANDSLIDE SUSCEPTIBILITY ASSESSMENT OF GOZNE REGION (MERSIN-TURKEY)

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Gozne region is located 30 km north of Mersin, on the southern flanks of the Bolkar Mountain Range. Due to the rainfall induced landslide events in 1968 and 2001, 196 residences were either collapsed or heavily damaged in the region. In order to identify the spatial distribution of landslides, detail aerial photo interpretation and field verifications were conducted. Total landslide affected area was identified as 27.7 km² which refers 7 % of the entire study area. Landslides are characterized mostly by rotational and complex type of movements. The most susceptible units are Mersin ophiolite and Ophiolitic melange units that cover almost 50 % of the area preserving 72% of the all landslides. Landslide susceptibility assessments were performed using logistic regression analyses to identify other potential landslide prone areas in the region. 47 independent geoenvironmental variables were considered such as DEM derivative terrain classifications, geological and morphological units. Landslide inventory datasets were randomly divided into two groups as 80 % for the training and 20 % for the test datasets. Same procedure was repeated five times and logistic regression method was applied for each dataset. Considering the training and test data sets, 78-81% and 65-80% of the landslides were found in high to very high susceptible zones, respectively. Additional validation approaches were also evaluated in order to determine the prediction capacity of the susceptibility maps using ROC curves, Cohen's Kappa index and prediction and success curves. According to ROC curves, AUC scores obtained between 0.76-0.79 and Cohen's Kappa index range between 0.431-0.480 which refer acceptable discrimination and moderate classes, respectively. These results suggest that the adequacy of the method and of the maps obtained is reasonably acceptable.

Keywords: Landslide inventory, landslide susceptibility, ROC curves, Cohen's Kappa index

GEOGRAPHIC INFORMATION SYSTEMS (GIS) BASED MICROZONATION FOR ESENLER TOWN (ISTANBUL)

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Turkey is located on an active tectonic structure and has a suitable topography for natural disasters. It is necessary to prepare the microzonation maps and determine the better soil sites in settlement areas. Esenler town is located on European part of Istanbul province. In this study we aimed to form the GIS (Geographic Information Systems) based microzonation maps of Esenler town. For this purpose nearly 100 drilling data and nearly 50 seismic refraction data transferred to numerical domain. We carried out a data analysis for the database and eliminated the faulty data. The SPT (Standard Penetration Test) values belong to 1,5 m, 3 m, 4,5 m, 6 m and 7,5 m, shown on GIS based maps and observed the variation on SPT values along with the depth rises. The seismic velocity maps are also formed by GIS and investigated the harmony with the SPT maps. The study area consists of five geological formations and some artificial filling zones. The Lower Carboniferous aged Trakya formation consists of sandstones and covers large fields in the northern part of the study area. These fields have high SPT values and high seismic velocities as seen in all microzonation maps. The southern parts of the study area have complex geologic structure. Therefore, SPT values and seismic velocities showing variations, according to age and firmness of the geological formations. Generally there was not found groundwater level on drilling applications in the study area. All the maps show that the northern parts of the study area have better soil parameters. The scientists claim that in nearly 30 years, a big earthquake will be happen and affect Istanbul and its environment. Thought that the building stocks and population, it will cause great damages. It is necessary to make reinforcement for buildings which are especially located on several fields that have low SPT values and seismic velocities in the study area. It will be useful to make precaution such as drainage, excavation and ground improvement before construct a building in artificial filling zones and alluvial fields at the study area.

Keywords: GIS (Geographic Information Systems), Drilling, Seismic Velocity, Microzonation, Esenler

INVESTIGATION OF THE USEFULNESS OF İÇMELER (MERSİN) LIMESTONES AS CONCRETE AGGREGATES

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Limestones having different advantages compared to other industrial material types have been used commonly as concrete aggregates in structures due to technological developments. Developments in the construction sector in Turkey and increasing demand for good quality concrete have resulted in the increase of demand for good quality crushed stone.

In this study, the usage properties of limestones as concrete aggregates obtained from the stone quarries in Mersin are examined. Samples are taken from Camili village quarries.

The chemical properties of limestone were analyzed first to determine their chemical composition. Secondly, unit weight, density, porosity, rate of flat material determination, water absorption by weight and volumetric methods of physical properties were tested. Also, Schmidt hammer hardness index, Los Angeles abrasion loss, Freezing and thawing after mass loss, Alkali aggregate reactivity, amount of organic matter, uniaxial compressive strength, and point load of limestone mechanical properties and petrographic description were determined for the samples used. The rock was classified based on its uniaxial compressive strength, point load index, porosity and Schmidt hammer hardness test method. The results of the evaluations show these samples meet the standards with regards to features. It was determined that İçmeler limestone passed limit values for being used as concrete aggregates in structures.

Keywords: İçmeler (Mersin), Limestone, Aggregate, Concrete

EFFECT OF GYPSUM CONTENT ON SOIL-WATER CHARACTERISTIC CURVE FOR CLAYEY SOILS

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This research work studies the effect of the addition of varying percentage of gypsum content on the behavior of soil-water characteristic curve (SWCC) for clayey soils. Tests were conducted to determine SWCCs covering nearly the entire range of soil suction ($0 - 10^6$) kPa, for two soil samples selected from MOSUL city: Al-Jammia, (J) and Al-Yrmook (Y). Results indicated that the shape mode of SWCC remained the same for all the studied cases with the occurrence of a change including an increase in the water holding capacity and air entry value due to varying initial water content. On the other hand, the effect of addition of various gypsum percent to the natural clayey soils on their SWCCs behavior was impalpable. Finally, a mathematical model for SWCC was found for all studied cases using (Fredlund & Xing, 1994) equation Model, with aid of FORTRAN program, the parameters of mathematical model were analyzed statistically, the values of R^2 ranged from (0.99868–0.99955), and SSR (0.1.4434–7.7205).

Keywords: Gypsum content, Clayey soils, Soil suction.

AMBIENT NOISE MEASUREMENTS FOR SITE EFFECT CHARACTERIZATION IN URLA, IZMİR

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In Turkey, Urla is one of the most cultural and important tourism region, where considerable seismically active areas of Western Anatolia, the microtremor horizontal-to-vertical spectral ratio (HVSr) method was applied to a 500 m dense grid of free-field measurements over an extended area and to a 250m dense grid in the town area in order to assess the fundamental frequency of the sediments. Density of the settlements and distribution of the geological units have been considered during the finalizing of the measurement points. Added to these, İzmirNET (Polat ve diğ. 2009) Urla strong motion station records have been also used.

In addition of this study, the effects of wind and artificial noise on the reliability of the results were analyzed. In order to study the effects of the surface geology on seismic ground motion in more detail and in view of the fact that no subsurface geological and geophysical information is available that would allow a modeling approach, we decided to perform a study for investigating of soil characteristic of the Urla, based on the microtremor Horizontal-to-Vertical Spectral Ratio (HVSr) method.

In conclusion, dominant period, frequency and amplification values have been contoured according to the criterias defined in SESAME convention and engineering seismology classification. Preliminary results indicate low frequency values in quaternary aluvium deposits at the North, with respect to conglomerate-tufa-aglomerate units at the Northwest, and Miocene aged thin-mid layered marl and Urla limestone at the South.

Keywords: Ambient Vibrations; Microtremors; Horizontal-to-Vertical Spectral Ratio (HVSr); Site Effects

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GEOCHEMISTRY &
ORE DEPOSITS

GEOLOGY OF KALKAFI GRANITOID INTRUSIVE BODY: A POSSIBLE PORPHYRY COPPER-MOLYBDENUM DEPOSIT, ANARAK, IRAN

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Kalkafi granitoid intrusive body is located in 76 km northeast of Anarak, Isfahan province, Iran. The studied area is situated in central Iran structural zone. According to field observations and petrographical and XRD examinations, three major alteration zones were distinguished in the studied area including potassic, phyllic-argillic, and silicic alteration zones. Potassic alteration is characterized by orthoclase + secondary biotite + quartz \pm sericite assemblage. Phyllic alteration is composed of sericite + quartz + pyrite + clay minerals \pm calcite. Argillic alteration is characterized by kaolinite + dickite + sericite + quartz + hematite + limonite + goethite. Phyllic alteration is the most important and widespread alteration type in the studied area. Chondrite normalized rare earth elements (REE) patterns of unaltered intrusive bodies show a strong LREE differentiation but a weak HREE differentiation. Lower content of total rare earth elements in the altered samples of the studied area indicate their mobility in hydrothermal environments. Higher depletion of total rare earth elements in silicified samples which is different from other kinds of alteration indicates the higher mobility of rare earth elements in silicic alteration environment.

Two major ore mineralization were distinguished in the studied area: (1) Cu-Mo mineralization and (2) Au-Pb-Zn mineralization. Cu-Mo mineralization which is mostly related to porphyry quartz monzonites and granites is of more importance. Microthermometric analysis of the fluid inclusions of the studied area indicates that salinity of mineralizing fluid ranges from 1.74 to 53 NaCl equivalent wt%. Homogenization temperatures confirm the existence of at least two generations of fluid inclusions or mineralizing fluids in this area. According to this study, Kalkafi Cu-Mo deposit is very similar to other porphyry Cu (-Mo) systems of Iran (e.g., Sarcheshmeh and Sungun).

Keywords: Granitoid, alteration, rare earth elements, fluid inclusion, Kalkafi

GENESIS OF BERYLLIUM IN THE MIOCENE KIZILCAÖREN FLUORITE-BARITE-REE DEPOSIT AND BERYL WITHIN SURROUNDING SEDIMENTS, ESKİŞEHİR, NW TURKEY

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The Kızılcaören fluorite-barite-rare-earth-element (REE) complex ore deposit, associated with alkali phonolite, trachyte and diabase overlying metamorphic units, is located southeast of Eskişehir, and developed within Miocene volcanic sandstone, graywacke, agglomerate and tuff units. Beryllium-containing solutions – products of alkaline volcanism – coexisted with the F, Ba and REE of the Kızılcaören ore deposit. This deposit comprises fluorine (11.4-40.2 %), barium (31300-237600 ppm) and REEs (total REE of 11028-43172 ppm), and is accompanied by appreciable amounts of beryllium (13-92 ppm). However, the beryllium contents (6-31 ppm) of the phonolite and trachyte units are relatively depleted. The depletion of beryllium resulted in the formation of euhedral green emerald and light bluish-green aquamarine-type beryl crystals, having crystal sizes of ~35 µm, hexagonal structure, and refractive indices of $n_o = 1.568$ and $n_e = 1.584$, which have also been recognized in detrital sediments derived from the metamorphic rocks. Geochemically, the depletion of REEs in the ore deposit is due to fractionation of amphibole and feldspar, and the presence of a fluid phase. Also, rocks in the ore deposit are characterized by positive Eu anomalies, revealing an oxygen-rich environment that resulted in a crystallization temperature possibly below 200°C. It is concluded that beryllium was concentrated hydrothermally in the complex fluorite-bearing ore deposit and in relatively lesser amounts in Al-bearing crystals within the phonolite, trachyte and diabase units. This hydrothermal injection along upthrust faults and fractures weakly affected the metamorphic unit resulting in the development of beryl crystals.

Keywords: Beryllium, Beryl, Genesis, Geochemistry, Kızılcaören Fluorite-Barite-REE Complex Ore Deposit.

PRELIMINARY STUDY OF GEOLOGICAL AND PETROGRAPHICAL INVESTIGATION IN INKAYA (SIMAV-KUTAHYA) CU-PB-ZN MINERALIZATION, WESTERN TURKEY

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The study area is located in the western part of Anatolian tectonic belt, in southern part of İzmir-Ankara zone, and in northern part of Menderes Massive and part of the Inner West Anatolian of Aegean region. In the region, at the base, Pre-Cambrian Menderes Massive Metamorphics (Kalkan formation, Simav metamorphites, Saricasu formation, Arikaya formation) is situated. Menderes Massive is overlain by Upper Jurassic-Upper Cretaceous aged Budagan limestone. This unit is overlain by Dagardi Melange with a tectonic boundary.

The Cu-Pb-Zn mineralization is situated in Simav metamorphics represented by quartz-muscovite schist and quartz-biotite schist including metabasic-metaultrabasic lenses. Grano-lepidoblastic textured quartz-micaschists have 29-45% quartz, 25-34% muscovite, 7-15% biotite, 10-15% chlorite, 2-10% plagioclase, 1-7% garnet, 2-5% opaque mineral, 2% amphibole, 1-2% apatite, 1% epidote and 1% tourmaline. Dunite that is cropped out in around of the Inkaya Cu-Pb-Zn mineralization, comprises of 70-73% olivine, 10-14% serpentine, 3-5% clinopyroxene and 5-8% opaque mineral (magnetite, chromite). The biotites in the quartz-micaschist turned partially or completely into chlorite in consequence of retrograde metamorphism. In plagioclase, commonly inclusion and rarely albite-carlsbad twinning were observed. Generally hypidioblast-xenoblast garnets are colourless-yellowish. In phase with similar size except garnets, micas with basal cleavage and quartz with shape of circular are alternation with each other.

Mainly ore minerals are galena, sphalerite, chalcopyrite, pyrite, fahlore (tennantite-tetrahedrite), and accompanied by minor amounts of serusite, anglesite, digenite, enargite, chalcocite, covellite, bornite, limonite, hematite and goethite. The pyrites that have coarse grain, cataclastic structure, idiomorphic and allotriomorphic, have spongy texture in many samples. The galena was converted to serusite and anglesite throughout its fractures, fissures and cleavages under the surface conditions. As well as serusite and anglesite, chalcocite and covellite are observed throughout its fissures. Fahlore have extensively been in mineralization. It was thought that the fahlore have composition of tetrahedrite/tennantite in mineralization. Brown-reddish internal reflections in sphalerite that is observed idiomorphic show Fe concentrations and high temperature characteristic. In the Cu-Pb-Zn mineralization, succession is pyrite, chalcopyrite, sphalerite, fahlore and galena. Based on the preliminary microscopic studies these deposit was formed under hydrothermal phase of magmatic ore deposition.

Keywords: Petrography, Cu-Pb-Zn mineralization, Simav, Inkaya, Western Turkey.

NEW DATA ON THE OLIGOCENE–QUATERNARY BASALTIC VOLCANISM IN SYRIA, APPLIED TO ITS ORIGIN

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New data on the geology and 21 K-Ar dates of the Late Oligocene – Quaternary basalts in Syria, and a combination of new and previous analyses are used to reconstruct the volcanic history and its tectonic events. Volcanism began at the end of Oligocene (26–24 Ma) and was most intensive in Late Oligocene – Early Miocene along a N-trending zone stretching from Jebel Arab (Harrat Ash Shaam) up to Kurd Dagħ and southern Turkey. Activity waned in the Middle Miocene (17–12 Ma), but restarted along the same zone in the Tortonian and increased during Messinian and Early Pliocene (6.3–4 Ma), when volcanism spread to the Shin Plateau and its coastal extension. The geodynamic changes in the Shin area led to structural rebuilding in the northern Dead Sea Transform (DST) zone and caused temporal geochemical changes in the composition of the erupted basalts. After a brief hiatus, corresponding to structural rebuilding ~4–3.5 Ma, volcanism became still more intensive and spread from the N-trending zone to the east into the northern margin of the Mesopotamian Foredeep and to the west into the DST zone. Additional eruptions continued into the Holocene. Volcanism lasted >25 million years in the Jebel Arab Highland and >15 million years in the Aleppo Plateau. The long duration of volcanism in specific parts of the moving Arabian plate and absence of records of one-way migration of the activity signify that the magmatic sources moved together with the plate, i.e., they were situated within the lithosphere mantle. Coincidence of the tectonic and volcanic stages of the Arabian plate development proves that volcanic activity depended on the geodynamic situation, caused by the plate motion. Situated within the lithosphere, magmatic sources within this transverse zone were possibly caused by thermal and mechanical influences of the asthenospheric flow that moved laterally from the Ethiopia–Afar deep superplume. The flow possibly eroded the Arabian plate deep interface, and magmatic sources were formed within decompressed sites of the lower lithosphere. As the potential of the sources was supported by the sub-lithosphere lateral flow, the sources produced basaltic eruptions at the same areas over a long time. At the same time, eruptions were only possible, when the geodynamic setting favoured initiation and activity of channels for magma passage. In Miocene, the flow penetrated into the inner zones of the Alpine-Himalayan collision belt up to the Great Caucasus and contributed to the Late Miocene–Quaternary volcanism there.

Keywords: Syria, Late Cenozoic basalts, K-Ar dates, tectonics, magmatic sources.

MINERALOGIC AND GEOCHEMICAL PROPERTIES OF CALCRETES IN ANKARA: INDICATORS OF THE PALEOCLIMATIC CONDITIONS

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Calcretes are among the major components of subaerial exposure surfaces. They are generally associated with semi-arid climates where annual rainfall is around 500mm. The formation of calcretes is dependent on the past climatic conditions; therefore, they can be used as good proxies for paleoclimate interpretations.

Although calcretes of the Ankara region have widespread occurrences, studies related with them are very limited. Two different successions were selected for the study from the Bala and Karahamzalı-Gölbaşı areas near Ankara. Although those calcretes have widespread occurrences, they have taken little attention so far. Their ages are suggested to have been as Pliocene-Pleistocene according to their stratigraphic positions. Morphologically similar successions including red swelling clay paleosols with calcrete nodules, tubes and powders were compared according to their mineralogic and geochemical properties. Both sections indicate almost the same calcrete profile development from powdery to nodular form. They are semi-mature stage II calcretes. In Karahamzalı section, they have high gravel contents revealing their massive accumulation characters. On the other hand, calcretes in Bala section have almost no gravels. Mineralogically they are completely different. Calcretes in Bala section are pure calcite but those in Karahamzalı have very high dolomite content as carbonate mineral. Also, scanning electron microscope studies reveal that dolomite included samples have palygorskite formed during the pedogenesis of mudstone. The host of the calcrete nodules in both sections shows very similar mineralogical and geochemical characteristics. They are reddish brown in color with thicknesses 1.5 m at most. Paleosols in both sections show subangular blocky to blocky structures. Floating grains, carbonate glauubules, circumgranular cracks, alveolar texture, porosity rimming, dog-tooth cement, secondary carbonate infilling within the voids, voids left from biological activities and MnO₂ coatings imply that those studied calcretes show both alpha and beta calcrete characteristics. Geochemical analyses reveal that the mudstones represent paleosol properties with their almost stable clayness, calcification, base loss, and leaching ratios. Having the same field occurrences and geochemical signatures but different mineralogical compositions is likely to imply that both sections indicate semi-arid conditions with seasonal wetting and drying; however, their diagenesis stages are different. Bala section shows early diagenesis whereas dolomites in Karahamzalı section reveals their middle diagenetic origin.

Keywords: Calcrete, Ankara, Mineralogy, Geochemistry, Paleoclimate

C, O, S ISOTOPE STUDIES OF LATE CRETACEOUS ELAZIG MAGMATITS RELATIONSHIP MINERALIZATION IN EAST TAURUS, TURKEY

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The study area is located at the Elazığ area in the East of Anatolian district, where much more mineralizations related to Elazığ Magmatic rocks is observed.

Three different types of mineralizations were determined in the study area. These are skarn type mineralizations (Aşvan, Çöteli, Meşeli and Birvan), massive sulfide mineralizations (Helezür and Pul) and vein type mineralizations (Kızıldağ and Karakaş). $\delta^{32}\text{S}$ of pyrite; $\delta^{18}\text{O}$ of biotite, amphibole, garnet, quartz; $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ of carbonates were analyzed to determine the source and the system of these mineralizations.

Oxygen isotope studies show that the $\delta^{18}\text{O}$ values of biotite, amphibole, garnet and quartz are ranging between 6.9 and 18.5 ‰ (SMOW). The mineralizations, which are related to magmatic activity show that the $\delta^{18}\text{O}$ values change in the range of 6.9-11.3 ‰. However, $\delta^{18}\text{O}$ values of the mineralizations related to recrystallized limestone (Karakaş and Çöteli) increase up to 28.7‰. While $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values (0.4-1.5 ‰) are positive, $\delta^{32}\text{S}$ values (between -5.9 and -7.0‰) are highly negative. These data show that sulfur values decrease as heavy oxygen and carbonate values increase due to crustal contamination.

The preliminary data of the study show that $\delta^{18}\text{O}$ values of the Kızıldağ, Aşvan, Meşeli samples are within felsic magmatic limits and related to magmatic activity; and also Çöteli and Karakaş mineralizations may be formed by circulations in metamorphic rocks of the hydrothermal fluids.

Keywords: Elazığ Magmatic rocks, carbon-oxygen-sulfur isotopes, Fe, Cu, Pb mineralizations

ALPINE SUBDUCTION-RELATED GEODYNAMICS OF WESTERN TO CENTRAL TURKEY: INSIGHTS FROM PETROLOGY OF HP METASEDIMENTS AND ⁴⁰AR/³⁹AR GEOCHRONOLOGY

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In Western to Central Turkey, the closure of a Neotethyan oceanic branch resulted in the accretion of a Gondwana-related continental fragment, known as the Anatolide-Tauride Block, to southern Eurasia. As a result, the northern continental passive margin of the Anatolide-Tauride Block was tectonized and metamorphosed between the late Cretaceous and the early Cenozoic. Based on differing lithostratigraphy and metamorphic histories, several metamorphic units, referred to as Anatolides, are generally considered as follows. From north to south, they are the Tavsanlı Zone, the Afyon Zone, the Menderes Massif and the Ören Unit. From the Aegean Coast to Cappadocia, blueschist-facies mineral assemblages were reported in coherent sedimentary series from all these units. Moreover, the Cycladic Blueschist Unit, which crops out mostly in the Aegean, is also recognized west of the Menderes Massif.

The timing of the subduction-related metamorphism is variously constrained from one unit to the other. Radiochronologic studies (using Ar/Ar and Rb/Sr on phengite and glaucophane) showed that HP metamorphic event occurred in middle Late Cretaceous (88-82 Ma) in the Tavsanlı Zone, and in Eocene (40-45 Ma) in the Cycladic Blueschist Unit. In contrast, no radiometric but only vague stratigraphically-constrained metamorphic ages, were published for the HP metamorphism in the Ören Unit, the Menderes Massif cover and the Afyon Zone while accurate ages would constitute strong clues for understanding the evolution of Western and Central Turkey and its correlation with the Aegean Domain.

At the 7th International Symposium on Eastern Mediterranean Geology (Adana, October 2010), we will present new results of ongoing Ar/Ar geochronologic and metamorphic petrological works from the Anatolides HP belts, and discuss their implication in understanding the evolution of the Eastern Mediterranean.

Keywords: Western Turkey, Neotethys, HP metasediments, Ar/Ar geochronology

HYDROTHERMAL FLUID INFILTRATION EFFECTS ON CHEMICAL AND ISOTOPIC COMPOSITION OF SUSURLUK SKARN DEPOSIT, NW TURKEY

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During the contact metamorphism fluid composition is the most important control mechanism on skarn mineralogy, texture, chemical and isotopic compositions. The skarn zone between the Çataldağ granitoid and carbonate units at east of the Susurluk area (Balıkesir) is represented by both endoskarn (plagioclase-pyroxene) and exoskarn (garnet-pyroxene-vesuvianite-wollastonite) zones. Products of only prograde stage were developed in association with granitoid intrusion at Susurluk. Crystallization of the Çataldağ granitoid at shallow depths resulted in changes of fluid composition, promotion of fluid-rock interaction and prolongation of metasomatic reactions.

Garnets in proximal and distal zones have compositions of $\text{And}_{3-74}\text{Gr}_{23-91}\text{Prs}_{0-12}$ and $\text{And}_{15-26}\text{Gr}_{72-81}\text{Prs}_{0-8}$, respectively. Pyroxenes were determined to have compositions of $\text{Hed}_{3-44}\text{Diy}_{56-96}\text{Joh}_{0-2}$ in the proximal zone and $\text{Hed}_{9-38}\text{Diy}_{64-91}\text{Joh}_{0-1}$ in the distal+vein zone. Andradite content ($X_{\text{And}}=0.68$ to 0.95) and Fe^{+3}/Al ratio (1.0 to 55.0) of zoned garnets increase from core to rim. Increasing of andradite content in zoned garnets and compositional changes in mineralogy reflect high oxidation conditions of granitoid as well as changes in fluid composition in the hydrothermal system, which are also detected by increases in REE contents. REE concentrations in skarn zones are extremely increased in comparison to the Çataldağ granitoid and marble and partly decreased from endoskarn to exoskarn zone. Concentrations ranges of REE in the granitoid, endo and exoskarn zones and marble are 14.2 - 190.7 ppm (mean 64.0), 17.9 - 386.2 ppm (mean 171.4), 11.0 - 384.4 ppm (mean 86.2) and 5.7 - 9.0 ppm (mean 14.7), respectively. Andradite-rich parts in proximal zone are characteristic with a convex pattern in LREEs and maximum Pr and positive Eu anomalies. There is a positive correlation between X_{And} content of garnets and the Eu anomaly ($\text{Eu}/\text{Eu}^*=1.0$ – 4.1). In grossular-rich zones REE trends are conformable with those of the Çataldağ granitoid and HREE concentrations are increased due to interaction with marble and Eu displays a negative anomaly. REE patterns in distal zone are similar to those of marbles but are noticeable with decreased arrays (11 – 97 ppm; mean 46 ppm).

Hydrothermal fluid infiltration at Susurluk skarn deposit had a great effect on isotopic composition of calcites. $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values of marbles are in the range of 4.67 – 5.31 ‰ (VPDB) and 29.83 – 27.66 ‰ (VSMOW) and former indicate a marine origin. $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ values of skarn calcites are $\delta^{13}\text{C}$: -11.60 to -0.02 ‰ and $\delta^{18}\text{O}$: $+1.21$ to $+20.62$ ‰. Volatilization and silica-rich fluid infiltration result in a systematic depletion of $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$ ratios of skarn calcites. In such a system that was governed by hydrothermal fluid infiltration, promotion of fluid-rock interaction facilitated iron-silica metasomatism and changed the chemical-isotopic compositions in proximal zone.

Keywords: Hydrothermal fluid infiltration, chemical and isotopic change, Susurluk skarn deposit, Çataldağ granitoid.

GEOLOGY AND MINERALOGY OF SKARN DEPOSIT IN NORTH AND NORTH WEST OF AHAR WITH SPECIAL REFERENCE TO ANJERD SKARN DEPOSIT IN THE NORTH WEST OF IRAN

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Numerous skarn deposits formed at the margins of Oligocene–Miocene plutons in the Ahar region, east Azerbaijan province, Northwest Iran. Subduction and subsequent continental collision during the Paleocene to Oligocene caused extensive I type calc-alkaline to alkaline igneous activity, including intrusion of porphyritic calc-alkaline granodiorite at Ahar and Sungun during these magmatic activities. Skarn type metasomatic alteration and mineralization occurs in the contact between the Upper Cretaceous impure carbonate rocks and the granitoid bodies. Due to these igneous activities the following skarn deposits are found from west to east: (1) Sungun skarn copper porphyry, (2) Anjerd skarn, (3) Zandabad skarn, (4) Javanshaykh skarn, (5) Mazraeh iron-copper skarn, (6) a vein garnet skarn east of Mazraeh and (7) Gowdoul skarn. Most of the skarn deposit in these areas formed at the northern contacts of intrusive rocks with Cretaceous impure carbonate rocks. In some places, such as in the Sungun, Anjerd, Mazraeh and Zandabad areas, the metasomatism is so intense that the original character of the Cretaceous carbonate rocks is unrecognizable. In general, all of these skarns, irrespective of their size, have sharp contacts with both the intrusive body as well as crystalline limestone and have same mineral composition Andraditic garnet skarn, epidote skarn, magnetite-garnet and chalcopyrite-epidote skarns are the most common mineral characteristic of these skarn deposits. Texturally, the skarns may show mineralogical overprinting, brecciation, and porphyroblastic, poikiloblastic and/or cataclastic texture. The skarnification processes, in both of the areas are divided into the pro grade stages and retrograde stages. Anhydride minerals like garnet and pyroxene are the result of pro grade metasomatism. Oxide (magnetite and hematite) and sulfide ores (chalcopyrite, pyrite, bornite), as well as carbonate minerals (siderite, ankerite and malachite) are the products of retrograde stage, the last stage of retrograde metamorphism accompanied with barren quartz vein.

The Anjerd skarn is located at the western limit of Ahar granodiorite, northeast of Anjerd village and 28 km northwest of Ahar town. This skarn extends about 1 km, striking NE-SW with a thickness of 0.5 km and is associated with brecciated limestone and hornfels. Silicate minerals include pyroxene, garnet, andesine, amphibole (hornblende-actinolite and tremolite), vesuvianite, chlorite, talc, specularite, wollastonite, cerussite, gehlenite, glaucophane, and sphene. Ore minerals include sulfide group (pyrite, chalcopyrite, molybdenite, chalcocite, bornite, pyrrhotite) and oxides (magnetite, hematite, and goethite); carbonate minerals are malachite, calcite, dolomite and ankerite. Malachite and magnetite are more prominent in the exoskarn, whereas sulfide ores mainly occur within the endoskarn.

Keywords: Iran,, exoskarn endoskarn, ore skarn. Anjerd skarn

MINERALOGY AND CHEMISTRY OF „CUCUTENI-TRIPOLYE” (COPPER AGE) FINE CERAMICS FROM ROMANIA

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Spread on a large surface which extends from the central parts of today Romania into Moldavia and Ukraine, remnants of a Copper age culture called „Cucuteni-Tripolye” and dated in the V-IVth milenium BC were exhumed. Geologically, the area belongs to the Eastern European Platform and consists of only Sarmatian sediments: clays, marls and sands.

A number of 46 ceramics potshards exhumed 60 km west of Iasi, with the characteristic light red to light orange body color and the surface painted with white-red-brown geometric patterns, were subject of the study. Optical microscopy in polarized light, X-Ray Powder Diffraction, Electron Microprobe, and ICP-MS whole rock chemistry were used for the identification of the mineral phases, the raw materials and technological conditions of firing. The ceramics consists of a red, highly porous ceramic body, with more or less oriented texture. The clayish matrix includes quartz, plagioclase, K-feldspar, muscovite and biotite clasts and calcareous micr ofossils. A high amount of calcareous siltic clays fragments clearly different compared to the matrix, occurs. Other rock fragments consist of quartzites, micaschists, granites, gneisses, silicastones, porphiritic volcanics, volcanic tuffs a.o.

The ceramics shows an intermediate to acidic chemistry. The content of elements such as Rb, Cs, Nb, Th, U and in particular Au is relatively high. The Backscattered Electron images revealed a highly inhomogeneous matrix, consisting of a fine grained groundmass of clay minerals, firing phases and tiny grains of quartz, feldspar, calcite and lamellae of muscovite. The identified feldspars are predominantly K-feldspars ranging from a pure end member to anorthoclase and albite. Ca-bearing plagioclases are extremely rare. Muscovite varies from Al-rich compositions to phengitic micas. The final firing products of clay minerals are either crystalline, amorphous or glassy. Their composition resembles an intermediate compound between K-illite and a hypothetical Ca-illite with a wide range of composition. The non-stoichiometric character of most of the newly-formed phases points to a fast firing, at 850 to 950°C.

Key words: Romania, Copper Age, Ceramics, EMPA, ICPMS

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CLAY CONTENTS AND ENVIRONMENTAL SIGNIFICANCE OF BIGADIÇ BORATE MINERALS, BALIKESİR, TURKEY

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The study area is located in Bigadiç town, 37 km southeast of the Balıkesir city in Turkey. The Bigadiç borate deposits with a reserve of 1030 Mt are the largest boron deposit of the world (DPT, 2001). The Turkish borate deposits were formed in Miocene lacustrine environments which were influenced by volcanic activity from Tertiary to Quaternary time. Colemanite and ulexite are the principal minerals of the Bigadiç deposits (Baysal, 1973; Helvacı and Alaca, 1991; Koç et al., 2009; Koçak, 2009). This paragenesis also includes searlesite and reedmergnerite (Koç et al., 2009; Koçak, 2009) which are non-marine, autogenic boron silicates deposited alkaline lake environments (Hay and Moiola, 1963; Sheppard and Gude 1968; Taylor and Surdam, 1981; Yang and Rosenberg, 1992).

The relation between clay contents and depositional environment of the Bigadiç borate deposits is first discussed in the present study. Although the presence of clay minerals was mentioned in previous works, none of them studied the clay mineralogy in detail. In this respect, clay contents of 13 samples collected from the Tülü, Acep and Simav pits of the deposit were identified with XRD method. It was found that clay minerals are composed of montmorillonite and trace amount of illite indicate a potassium input to the basin and depositional environment had a basic character. The mineral assemblage might yield a temperature below 60°C for the depositional environment (Baysal 1973, Sunder, 1980). Krauskopf (1989) also suggests that clay minerals were precipitated from aluminum silicates at temperatures of a couple of hundred degrees and formation at lower temperatures took place in a long time period. It is concluded that owing to dominant borate (colemanite and ulexite) and clay (montmorillonite) mineral assemblage, the minerals in the basin were formed from basic type solutions at temperatures of a couple of hundred degrees or they precipitated at temperatures below 60°C in a long time period.

Keywords: Bigadiç, borate, clay minerals.

GEOCHEMISTRY AND HEAVY METALS CONTAMINATION OF SOIL CASE STUDY FROM SOIL OF FLOOD PLAIN OF QWEIK RIVER, ALEPPO, SYRIA

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Qweik river originated from Turkey and flow through Aleppo city (the second largest city of Syria) from the north to south, and because of the extraction of the water in the river became dry since 1970s. The sewage wastewater and industrial wastewater of the city flow in the channel of the river, and this water polluted by heavy metals. The wastewater mixed with natural water of Euphrates river by artificial channel extend from Al-Asad lake to Qweik river in Sandarat Campus, North Aleppo, the channel flow capacity is about 3m³/sec. the purpose of this project to enhance the water quality of Qweik river and dilute the concentration of heavy metal pollutants, also, there is a treatment station to the sewage water before the mixing with the natural water.

Some industrial units within the municipal boundaries also discharge untreated wastewater to the sewer system. This industrial wastewater contains specific metals and metalloids and other toxic elements, which hardly undergo treatment at the wastewater treatment plant because of its design limitations to treat domestic wastewater only. The plant has been in operation since 2002 with capacity of (346× 10³ m³ d⁻¹).

The major industries of the area deal with weaving and textile, tannery, cement and construction material, batteries and liquid gas, and chemicals. In practice, Qweik River contains a domestic-industrial, treated-untreated mix wastewater. The farmers prefer using of wastewater for three reasons: (1) wastewater is available around the year or most part of the year (57% of farmers consider this as the most important reason), (2) wastewater is a source of nutrients (26% of the farmers), and (3) pumping cost of wastewater is less than that groundwater pumping (17% of the farmers). (ICARDA 2005, ICARDA-IWMI, 2006, ICARDA-IWMI, 2008).

There is no information available on typical background values for metal and metalloid concentrations. Even after the operation of the wastewater treatment plant in Aleppo, the possibilities of soil and crop contamination in wastewater irrigated areas cannot be eliminated for the reasons: (1) many chemicals pass through the post-treatment effluent because the treatment plant has been designed to treat domestic wastewater, and (2) about half of the wastewater is treated.

PETROGENESIS AND GEODYNAMIC OF MIOCENE VOLCANIC ROCKS IN THE UŞAK-GÜRE BASIN, WESTERN ANATOLIA, TÜRKİYE

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Western Anatolia is characterized by wide-spread Neogene continental volcanic activity that was accompanied by fluvio-lacustrine sedimentation in several continental basins. The Uşak-Güre basin is one of the prominent NE–SW-trending basins developed on the northern part of the Menderes Massif core complex. Three different volcanic units (Beydağı and Payamtepe volcanic units and Karaağaç dikes) were recognised within the Uşak-Güre basin using new mapping and radiometric age data. Our new $^{40}\text{Ar}/^{39}\text{Ar}$ radiometric data show that Cenozoic volcanism in the Uşak-Güre basin started (17.29 Ma) with the Beydağı volcanic unit, which is located in the northern part of the basin where it interfingers with the İnay group. The youngest radiometric age from the Beydağı volcanic unit is from the Beydağı caldera (12.15 ± 0.15 Ma) in the south. Also, the $^{40}\text{Ar}/^{39}\text{Ar}$ dates of the Payamtepe volcanic unit restrict it to a period between 16.01 ± 0.08 and 15.93 ± 0.08 Ma. The volcanic rocks display a broad compositional range from basaltic trachyandesite to rhyolite, and are high-K calc-alkaline to shoshonitic and ultrapotassic. The geochemical features of the volcanic rocks are comparable with those of the other volcanic areas in western Anatolia, indicating that they were derived from subduction-related metasomatically enriched mantle lithosphere. The volcanic rocks from the Uşak-Güre basin reflect a complex petrogenetic evolution. Their genesis includes magma mixing and fractional crystallization processes which were likely accompanied by crustal assimilation. The rocks of the Beydağı volcanic unit have been affected by ~0-60% mixing with the more mafic magmas of the Payamtepe volcanic unit and subsequent plagioclase and pyroxene dominated fractional crystallization processes. Exhumation of the Menderes core complex accompanying the lithospheric-scale extensional fault systems provided natural conduits for the transport of calc-alkaline and potassic magmas in Uşak-Güre basin. The origin of the early-middle Miocene Uşak-Güre lavas in western Anatolia is best explained by delamination of lithospheric mantle slices that were heterogeneously enriched by previous subduction-related processes.

Keywords: western Anatolia; Uşak-Güre basin; extensional volcanism; $^{40}\text{Ar}/^{39}\text{Ar}$ dating; Aegean tectonics.

CHEMICAL AND PHYSICAL PROPERTIES OF NA- AND CA-BENTONITE OF ORDU (N.E. TURKEY)

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Widespread and intense hydrothermal alteration associated with volcanogenic massive sulfide and vein-type sulfide deposits are observed throughout the Eastern Black Sea province. Different types of clay minerals occurred during the alteration. Two types of bentonite are generally distinguished: Ca-montmorillonite and Na-montmorillonite. Both are usually pure, but laterally or vertically contain silica polymorphs, feldspar, biotite and, rarely, pyrite crystals. The Na-bentonite is green to greenish yellow and nearly pure montmorillonite. The Ca-bentonite is white to purple and contains a lower proportion of non-clay minerals. Na₂O, K₂O and CaO contents of Na-bentonite vary from 2.20 to 2.70, 0.60 to 1.40 and 1.10 to 3.50 wt %, respectively, and from 0.40 to 1.40, 0.60 to 2.40 and 1.20 to 2.20 wt % in Ca-bentonite. Tetrahedral charge deficiency of Ca-montmorillonite is lower than Na-montmorillonite indicating that these montmorillonites are mainly hydrothermal in origin and partly derived from volcanoclastic material in-situ and/or in the subaerial environment.

The pH results of the studied Ca-bentonite ranged from 6.46 to 8.33 while for Na-bentonite were from 9.60 to 10.10 at a temperature of 21 °C. The lowest pH was recorded in Ca-bentonite which was classified as neutral or near-neutral bentonite. Na-bentonite samples were basic to slightly-basic. The CEC values for Na-bentonitic clays ranged from 69.80 meq/100g to 92.40 meq/100g and for Ca-bentonite were from 27.20 meq/100 g to 46.20 meq/100 g. Swelling values of Ca-bentonites are between 3 and 8 ml while in Na- bentonites 16 and 23 ml. Viscosity of Na bentonites are ranged from 11 to 21 ps.s at 600 rpm whereas in Ca-bentonite are 4 pa.s. The layer charge of montmorillonites is higher than 0.46. Filtration of Na- and Ca-bentonites varies from 15 to 18cm³ and 70 to 260 cm³.

According to the investigated bentonites' chemical, mineralogical and preliminary technological properties: Na-bentonite can be used in drilling fluids, foundry mixes, the paper industry, landfill, toxic waste dumps, cement and detergents while Ca-bentonite can be used in paper, paint, drilling muds, bonding foundry molding sands and bleaching, iron ore pelletizing, cat litter, dried foodstuffs and foundry.

Keywords: Na-bentonites, Ca-bentonites, Ordu, Physical Properties, Chemistry

PETROLOGIC AND GEOCHEMISTRY OF EOCENE VOLCANIC ROCKS IN KAVIR NATIONAL PARK OF IRAN

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The Eocene volcanic rocks in North Qom Salt Lake (Kavir National Park) are a small part of Urumieh-Dokhtar magmatic belt volcanism. The erupted magmas show a broad range of composition from basaltic to rhyolitic. In this paper, we present mineral chemistry of mafic alkaline volcanic rocks. Porphyritic texture with vitric to microlitic mesostasis is more common in these rocks. The Plagioclase, K-feldspar, Clinopyroxene and Olivine phenocrysts are the most important minerals analyzed. Disequilibrium textures, (such as oscillatory and reverse zoning, compositional differences between phenocrysts and their surrounded mesostasis, sieve texture and resorption along grain boundaries), reveal that the magmatic processes have occurred in a thermodynamically open system. Magma mixing with fractional crystallization has played the most vital role in the evolution of mafic alkaline rocks in North Qom Salt Lake. The primary magma of these Alkaline rocks was formed by low degree melting of upper mantle source, and experienced contamination and magma mixing during ascending through the thick continental crust.

Keywords: Iran, petrology, volcanic, national park, kavir iran

GEOLOGICAL AND GEOCHEMICAL INVESTIGATION OF VAN AREA CHROMITITES

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Turkey is one of the major chromite suppliers in the world market. Although ophiolitic complexes are widespread in Hakkari and Van area, geographically the potential of chromitites is not known very well and this area is excluded from major Turkey's chromitite areas. Van area chromitites are related with ultramafites and situated in east of Van province. This ophiolitic unit is located within East Anatolian Accretionary Complex (EAAC) and extends in east-west direction. The EAAC is a 150-180 km wide, NW-SE trending belt and is interpreted as a remnant of a large accretionary complex which has developed on the Neo-Tethyan oceanic lithosphere that has subducted northward towards the Eurasian continent during the Upper Cretaceous-Oligocene.

In this study, geological and geochemical characteristics of Alabayır, Mehmetalan and Yukarıbalçıklı chromite deposits in EAAC are investigated. Chromite ore is observed as massive, nodular and disseminated-banded type within harzburgite and dunitic rocks. Strong deformation is effective on both wall-rocks and chromitite. Especially, Yukarıbalçıklı chromitite occurs in milonitic shear zone. Chromite ore in Alabayır area contains (n=4) 36.5 wt. % Cr₂O₃, Mehmetalan (n=11) 45.3 wt. % Cr₂O₃, and Yukarıbalçıklı area (n=12) 43.5 wt.% Cr₂O₃, with average contents of 11.9, 7.9 and 7.6 wt. % for SiO₂, 14, 10 and 4.2, wt. % for Al₂O₃, 12.6, 14 and 13 wt. % for Fe₂O₃ and 20.5, 19.6 and 18.2 wt. % for MgO, respectively. The data relevant to chromite ores in dunite are plotted in the TiO₂ versus Al₂O₃ diagram. The composition of the massive and disseminated-banded chromites of Van area falls within the field of the supra-subduction zone (SSZ) peridotite. However, geochemical properties of mafic dykes related to ophiolite units exhibit back arc basin characteristics.

The range for PGE contents of the chromite ore (n=27) is 79-647 ppb with an average ~240 ppb. Os, Ir and Ru show relative enrichment, compared to Pt, Pd and Rh elements. This enrichment is consistent with other chromitite deposits in Turkey. The highest value of PGE is obtained from milonitic shear zone chromitite in Yukarıbalçıklı area. The PGE content of chromitite in this area is as follows: Ru 60-280 ppb, Ir 33-105 ppb and Os 30-170 ppb. The highest Pt value is 60 ppb, Pd contents are less than 20 ppb. Besides, Rh values are between 5-12 ppb. The relatively high Ir-group (IPGE) enrichment in chromitites is related to post-magmatic processes covering an extended period of deformation events and serpentinization processes.

Keywords: Accretionary Complex, Chromitite, Van, PGE, Ophiolites.

SOILS DEVELOPED ON OPHIOLITIC ROCKS UNDER MEDITERRANEAN CLIMATIC CONDITION IN THE CENTRAL TAURIDE: MINERALOGICAL AND GEOCHEMICAL ASSESSMENT

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Ultramafic soils are characterized by high concentrations of heavy metals of natural origin such as chromium, cobalt, manganese, and nickel—as well as a shortage of primary nutrients. This can result in extremely disadvantageous for all living beings. In this study, the region of Central Tauride (Aladağ and Bolkardağları) has been selected as research area. Soil samples were collected at six locations at Central Tauride region. The sampling locations are situated on characteristic ultramafic soils of the Central Tauride, which are characterized by a heterogenic soil structure within a small area. A number of analytical methods including XRD, SEM and ICP have been employed to characterize representative samples collected from the soils developed partially weathered country rocks with respect to their chemical and mineralogical contents.

Soil horizons did not well developed on the limestone and ultramafic parent rocks that include mainly harzburgite-dunite, ophiolite mélange due to rapid weathering and steep topography. However, soil zones well-developed, forming terra-rosa over ophiolite mélange and its debris. Clay species belonging to smectite, kaolinite, and mixed-layer groups have been formed during pedogenesis. Clay contents and abundances vary depending on the morphology. Although the limestone, harzburgite and dunite don't contain quartz, the soils developed on them comprise significant amounts of quartz. Mazmılı area soils did not develop homogeneously, they are rather inhomogeneous. Pedogenesis resulted in the appearance of saponite and its decomposition in the upper horizons, the latter in spite of the alkaline conditions, probably because of the influence of moss and lichens.

In generally, most of the soil profiles, MgO and CaO contents show depletion upward, whereas, the other major element oxides including, as Al₂O₃, Fe₂O₃, SiO₂ and MnO increase. These soils are slightly basic and enriched in K₂O, and Na₂O. Heavy immobile elements such as Zr and Ti show strongly parent rock-controlled distributions. A total of six soil profiles have been investigated in this research. Chemical analysis indicated that the major and trace element chemistry of all samples show good agreement with the world soil standards. Only difference noticed was anomalous chromium and nickel values due to the host rock chemistry and Pb and Zn values in the Alihoca region.

Keywords: Weathering of Mafic Rocks, Ophiolitic Melange, Mediterranean, Central Tauride.

USING OF THE REFLECTANCE SPECTROSCOPY AS A TOOL TO DEFINE THE MINERALS AND THE ROCKS

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The reflectance spectroscopy is one of the methods using to produce information about materials such as mineral, vegetation, rock and soil. Particularly, the reflectance spectra provides the tool quite useful to determine the materials depends on chemical composition.

Reflectance spectroscopy has an advantage according to traditional some method. One of these advantages is easier to prepare the samples for analysis. Furthermore, spectrometer provides the possibility of usage in-situ during field study. The analysis of measured spectra and obtaining of results can be quickly performed. A lot of minerals and rock have the diagnostic spectral features with its characteristic absorption property. The diagnostic absorption and reflectance features belong to the wavelength refer the compositional features of mineral and rocks. Electronic processes produce the spectral features in the Visible and Near Infrared (VNIR) region. Vibrational processes produce the diagnostic spectral features in the Shortwave Infrared (SWIR) region. It can be determined many materials using these spectral features.

In this study, the using of the VNIR and SWIR reflectance spectroscopy of to define particular minerals and rocks observed. The spectra of opal, illite, halloysite, goethite, limonite, gypsum, jarosite, pyroxene, calcite, zeolite, etc. and some rock samples were measured using ASD FieldSpec Pro spectrometer. Then their spectra was evaluated and defined for each sample. The accuracy of results was checked using XRD analysis and investigation of thin section. The result of investigation introduced that reflectance spectroscopy have some advantage according to other some traditional methods.

Keywords: Reflectance, Spectroscopy, Spectrometer, ASD Fieldspec Pro, Mineral, Rock

MINERALOGY, CHEMISTRY AND GENESIS OF THE FERRUGINOUS SANDSTONE IN BATN AL GHUL AREA/SOUTHERN JORDAN

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Ferruginous sandstone (FS) are studied in detailed for the first time in Jordan. They occur as summit capping on residual hills or ridges which run subparallel to the main faults in the Batn Al Ghul area/southern Jordan. They represent the upper parts of a formerly continuous late weathering surface of Cretaceous Kurnub Sandstone (CKS) and Batn Al Ghul (BG) groups. The iron-formation is relatively up to 20 m thick and concordantly interbedded with silicic-sandstone rocks. Most of the units dominated by red colours and up to 15 cm thick ferribands are distributed randomly throughout CKS and BG groups and are not associated with sediments of particular environmental facies types. The ferribands predominantly occur at the contact of different lithologies and the sediments are ferruginized by impregnation of iron oxides and oxihydroxides.

Field, petrological, mineralogical and geochemical data on the FS at Batn Al Ghul/southern part of Jordan are presented, high-lighting the main petrographic, mineralogical, chemical and genesis of a silicate facies of iron-formation in the study area. Petrographic examinations revealed that the FS are composed of quartz grains and iron oxides mineralization. Most of the ferruginous sandstone are quartz arenites. The sandstones are well cemented. Cement is consist of iron oxides of different colours, which makes the colours of CKS\BG rocks varicolored. The colour is vary from red-black, yellow, brownish to violet. Quartz and iron oxides are the main constituents of the ferruginous sandstones identified by XRD. The iron oxides are identified as hematite and limonite. Chemical analyses using XRF of selected bulk samples of ferruginous sandstone indicate that the Fe_2O_4 content ranges from 2.71 to 39.20%, and SiO_2 is from 52.80 to 95.40%, while the Al_2O_3 from 0.30 to 1.53%. SEM-EDS analyses confirm that the FS facies is mostly made of Si, Fe, Al, in addition to O. Fe varies from 2.49 % in the groundmass to 53.65% in the matrix, while in coated sands it varies from 1.39% to 18.79%, and in the groundmass is around 7.25%. It could be argued that the in chemical red beds, as well as, in the FS, the source of ferric iron can be attributed to extensive post-depositional dissolution of detrital grains, e. g. iron bearing heavy minerals like glauconite. The feeribands or iron crusts predominantly occur at the contact of different lithologies, e.g. sand-/claystone contact, while detrital red beds result from resedimentation of older red beds after transport processes.

Keywords: Ferruginous sandstones, facies, ferribands, cement, Jordan.

THE SULFATE REDUCING BACTERIUM EXPERIMENTS IN AMD WATERS OF THE MADEN (ELAZIĞ) COPPER DEPOSIT

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The sulfate reducing bacterium, *Desulfovibrio desulfuricans* can initiate some metals precipitation from solution via direct reduction. Additionally, separation of metals from AMD (Acid Mine Drainage) can occur via indirect sulfide-mediated precipitation. This study was conducted to evaluate the influence of anion (sulfate) and metals (copper, iron, manganese, zinc and nickel) on the reduction by this bacterium. Furthermore, the sulfate reducing bacterium methods were evaluated to selectively precipitated metals and reduction of SO₄ from Maden (Elazığ) Copper Deposits AMD seepage waters. Therefore, the metals and sulfate compositions in AMD water samples were measured before bacterium treatment and after bacterium treatment, respectively to determine the influence of bacterium. Before and after bacterium were measured metal and sulphate compositions of AMD waters in different ratio (0.2; 2; 20 ml) in two different sample locations (M1 and M2). Cu, Fe, Mn, Zn, Ni and SO₄ values were measured to determine the influence of the bacterium effect. According to these measurement, Cu values ranging between 151 µg/l and 5.82 µg/l and between 1447 µg/l and 29.1 µg/l, Fe values ranging between 132.2 µg/l and 2.43 µg/l and between 517 µg/l and 9.92 µg/l; Mn values ranging between 75.7 µg/l and 19.33 µg/l and between 1695 µg/l and 449.46 µg/l, Zn values ranging between 34.4 µg/l and 0.45 µg/l between 3212 µg/l and 40.22, Ni values ranging between 4.3 µg/l and <0.1 and between 70.4 µg/l and 4.49 µg/l and SO₄ values ranging between 1417.8 µg/l and 788.38 µg/l and between 1719.2 and 925.22 (unit) for M1 and M2 locations, respectively.

Consequently, the effectiveness on both metals and SO₄ by the sulfate reduction of bacterium was determined in this study. This study shows that the sulfide may be bound by metals, such as Cu, Fe, Mn, Zn and Ni and precipitated as metal sulfide or adsorbed by *Desulf ofibrio desulfirican*.

Keywords: *Desulf ofibrio* sp., Cu, Fe, Mn, Zn and Ni, Maden (Elazığ), sulphate

PETROGRAPHY AND PETROCHEMISTRY OF BASALTIC PILLOW LAVAS AROUND ELAZIG AND MALATYA AREAS: PRELIMINARY RESULTS ABOUT THEIR PETROLOGY AND TECTONIC ENVIRONMENT

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Basaltic pillow lavas around Elazığ and Malatya areas are mostly interbedded with pelagic limestone, shale, mudstone and radiolarian-bearing cherty, and locally transitional to these pelagic sediments vertically and horizontally. The tectonic environment of deposition or formation containing pillow lavas together with pelagic sediments is still a matter of debate since there are complex geological relations in the field and regional setting of the unit. Pillow lavas generally show a hypocristalline groundmass with hyalomicroclitic, hyalomicroclitic porphyric, glomeraporphyric, microclitic porphyric and amygdaloidal textures. The rocks contain primarily plagioclase+augite+olivine, and show a common spilitisation. Common alterations are carbonatization, chloritization, silicification and oxidization.

Based on the immobile major and trace element chemistry, the rocks classify mainly as basalt and basaltic andesite, and show common tholeiitic and to a minor amount calcalkaline characteristics; having SiO₂ (52.33-41.77%wt), TiO₂ (2,10-0,58 %wt), Al₂O₃ (19,79-11,00%wt), K₂O (0,04-3,03 %wt), Na₂O (6,79- 1,80%wt), LOI (11,5-2,0 %wt) contents, and Mg numbers between 16,33 and 48,87.

In major and trace element variation diagrams; CaO, MgO and Sc indicate negative correlation whereas TiO₂, P₂O₅, Y, Nb and Hf indicate identical positive correlation with Zr. In addition, SiO₂, TiO₂, P₂O₅, Hf, Ga, Nb, Y, Zr and V indicate negative correlation whereas MgO, Co, Sc, Ni positive correlation with Mg numbers. These variations may be explained by fractionational crystallization processes.

N-type MORB normalized trace elements patterns are pronounced with enrichment in large-ion lithophile elements (Sr, K, Rb, Ba, Th) whereas HFSE elements are slightly enriched or close to MORB values, with almost parallel patterns. In addition, most of the samples show slight negative Nb and Ta anomalies indicative of a subduction signature. The chondrite normalized rare earth element (REE) patterns exhibit low to moderately enrichment relative to chondrite values. Furthermore, LREE enrichment relative to HREE are low (La_N/Lu_N =2.11-1.23) with almost flat-lying HREE patterns. In some samples, slight negative Eu anomalies related to plagioclase fractional crystallization are observed in the REE patterns. The tectonic discrimination diagrams reveal that the basaltic lavas may have formed in a back arc basin environment.

Keywords: Pillow Lavas, Elazığ, Malatya, Basaltic Rocks, Back Arc Basin

APPLICATION OF EGYPTSAT-1 AND ETM DATA FUSION IN DISCRIMINATION OF VOLCANIC AND GRANITIC ROCKS AT THE NORTHERN EASTERN DESERT OF EGYPT

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The late Proterozoic Precambrian basement rocks encountered at the extremely northern part of the Eastern Desert of Egypt comprise igneous and metamorphic assemblages unconformably overlain by Neogene sediments and Quaternary deposits. At Gabal Gharib area, the calc-alkaline metamorphosed volcanics and younger Dokhan volcanics are intruded by syn to late and post magmatic intrusions which comprise gabbro-diorite, tonalite-granodiorite, monzogranite-alkali feldspar granites and alkaline riebeckite granite. The data fusion of Landsat ETM and Egyptsat-1 with the spectral signature characterizations was applied to discriminate the different varieties of volcanics and granitic rocks exposed at the study area. Field study was carried out to check and evaluate the obtained remotely sensed data. This study revealed that the Landsat ETM- Egyptsat-1 fused band ratio image (7/4, 3/7, 4/5) can successfully applied to discriminate the exposed basement rocks particularly the volcanic and granitic rocks encountered at the northern part of the Eastern Desert of Egypt as well as their structural features.

Keywords: Eastern Desert, Egypt, basement rocks, Fused image, Landsat ETM+, Egyptsat-1

MICROTHERMOMETRIC PROPERTIES OF SUSURLUK SKARN DEPOSIT, BALIKESIR, NW TURKEY.

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Fluid inclusion studies on skarn minerals provide significant information on temperature and chemical compositions of mineralizing fluids and pressure of the skarn system as well. Besides, fluid inclusions also allow precise the definitions on prograde and retrograde stages which are represented by high and low temperature-salinity conditions, respectively. The Susurluk skarn deposit developed at the contacts between the Çataldağ Granitoid and Mesozoic carbonate rocks is represented by endo and exoskarn (proximal zone, distal zone and vein skarn) zones. The exoskarn has a general skarn zonation consisting of garnet-pyroxene-vesuvianite-wollastonite minerals which are associated with schelite, chalcopyrite and bornite mineralizations. Microthermometric data on exoskarn zone indicate that boiling took place at the first stage of skarnization at temperatures of 587°–592°C. Solutions of the first stage in which scheelite mineralization occurred are characterized by homogenization temperatures of >600 to 587°C and salinity range of 11-16% NaCl equiv. At the second stage of skarnization, higher homogenization temperatures and salinities were recorded; from 371 to >600°C and from 36 to >70% NaCl equiv., respectively. High salinity values from fluids and Fe sulfite mineralization (chalcopyrite and bornite) are attributed to boiling phenomenon. The presence of anhydrous minerals such as garnet and clinopyroxene and high temperature and salinity values of fluids indicates that only prograde stage was developed. The Susurluk skarn deposit which entirely shows shallow skarn system characteristics might have been formed at a pressure of around 1 kbar.

Keywords: Fluid inclusion, boiling, Susurluk skarn deposit, Çataldağ Granitoid.

GEOCHEMICAL PROPERTIES AND HEAVY MINERAL ASSEMBLAGES OF PLIOCENE AGED TERRIGENOUS ROCKS IN HATAY-SAMANDAG SUBBASIN

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The study area is located in the easternmost margin of the Mediterranean region. Pliocene aged unit, having thickness between 50-100 m, is entitled Samandag Formation (Kozlu, 1982). The depositional environment of these mudstones can vary as coastal, shallow marine and submarine channel types. Six mudstone samples have been analysed for major and trace element geochemistry. The chemical index of alteration (CIA)(Nesbitt and Young, 1982) is between % 3-65, this indicate that the conversion of feldspar to clay is moderate. Th chemical index of weathering (ie K-free index) is similar to CIA index giving a range of % 3-70. The index of compositional variability (ICV)(Cox et al., 1995) is between % 3 -57. That values are also indicate that a moderate weathering, and possible source is between average granite and basalt trend (Lee, 2002). On the other hand high Ni and Co values in trace element data suggest that ultramafic and mafic source effect. The heavy minerals of these sandstones are rutile, zoisite, glaucophane, zircon, titanaugite, sphene, augite, chlorite, hornblende, tourmaline, pyroxene, epidote. These mineralogical assamblages indicate that source of ophiolitic and dynamothermal metamorphic rocks (Pettijohn, Potter-Siever, 1973).

Keywords : Heavy Minerals, Geochemistry, Pliocene, Mudstones

GEOCHEMISTRY OF THE ÇATALDAĞ GRANITOID, BALIKESİR, NW TURKEY

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Following the collision of Anatolide-Tauride block with the Sakarya continent in the Oligocene-Miocene widespread volcanism and coeval plutonism were developed at north of the İzmir-Ankara suture zone in western Anatolia. The Çataldağ Granitoid, which is one of the magmatic intrusions that were generated as a result of Neotectonic activity in northwestern Anatolia covers an area of about 450 km² and was intruded into the Fazlıkonağı Formation, Mesozoic crystallized limestone, marbles and Yayla Mélange. The granitoid has a composition in the range of granite-granodiorite and shows peraluminous/metaluminous character and subalkaline and calc-alkaline affinity. It is represented by enrichment in LREEs and negative Eu ($Eu/Eu^*=0.42-0.93$) anomaly. Primitive mantle-normalized patterns indicate a significant enrichment of LIL (Rb, Th, U, K) elements and relatively depletion of HFS (Ta, Nb, Ti) elements. Negative Nb and Ti anomalies of samples are indicative of subduction and continent crust components in magma development. Rb-Sr isochron age of the Çataldağ granitoid is found as 20.9 Ma (lower Miocene). The initial $^{87}Sr/^{86}Sr$ ratio of 0.707127 may yield that the granitoid is derived from magma with both mantle and crustal components.

Keywords: Çataldağ Granitoid, geochemistry, petrology, $^{87}Sr/^{86}Sr$ ratio, NW Anatolia.

GEOCHEMICAL COMPARISON OF THE HEMATITES IN DİVRİĞİ - PINARGÖZÜ (SİVAS), KARAKUZ (MALATYA), ATTEPE (KAYSERİ) AND FEKE (ADANA) IRON DEPOSITS

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In this study, the hematite mineralizations in the Fe ore deposits, which have peculiar geochemical properties, type and genesis, located in the Divriği (Sivas), Hekimhan (Malatya), Attepe (Kayseri) and Feke (Adana) were studied. The Divriği, Pınargözü and Attepe ore deposits located in Central Anatolia, the Karakuz ore deposits located in Eastern Anatolia, whereas Feke ore deposits located in southern Anatolia. The major-, trace and rare earth element analyses were performed on the hematite mineralizations by ICP-MS. The Fe_2O_3 concentrations of the ore deposits are very high except Feke region. In this region the Fe_2O_3 concentrations are economically insufficient for industry.

Zr, Ta, Sr, Sc V and rare element concentrations in the samples of Feke region, As, Na, Ca, Bi in the samples of Karakuz region, Sb, Sr, Fe, W, Mo and Sn elements in the samples of Pınargözü region show highly positive anomalies. The REE patterns of all regions are similar, except Attepe region. The negative Eu and Ce anomalies, in the Karakuz (Malatya) and Attepe (Adana) regions support the hydrothermal origin of the ore mineralizations, whereas the negative Ce and Eu anomalies and positive La and Nd anomalies support the scarn origin of the ore mineralization in the Divriği region. The Au concentration was seen in all deposits, whereas the highest concentration seen in Divriği Section B deposits with 9.6 ppm.

Keywords: Hematite, REE, Rare earth elements, ore deposits, geochemistry.

PALEONTOLOGY &
STRATIGRAPHY

CONSTRAINING UPLIFT OF THE SOUTHERN MARGIN OF THE CENTRAL ANATOLIAN PLATEAU FROM BIOSTRATIGRAPHY AND $^{87}\text{Sr}/^{86}\text{Sr}$ STRATIGRAPHY ON THE HIGHEST MARINE SEDIMENTS OF THE MUT BASIN (SOUTHERN TURKEY)

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At the northern margin of the Mut-Ermenek Basin (Southern Turkey), well exposed, undeformed Miocene marine deposits cap the basement rocks of the southern margin of the Central Anatolian Plateau (CAP). From the Başıyayla section, which ranges from 1781 m a.s.l. at the base to 1839 m a.s.l. at the top, we collected 24 samples, for a total thickness of about 40 m of the Köşelerli Fm.

Micropaleontological analyses were performed on calcareous nannofossil, ostracod, bryozoa, benthonic and planktonic foraminifera, and macroforaminifera assemblages to discern paleoecological characteristics of the marine paleoenvironment in the Başıyayla area and to define the age of the Başıyayla section. Also for this latter purpose, Sr ratios ($^{87}\text{Sr}/^{86}\text{Sr}$) were measured on tests of benthonic and planktonic foraminifera as well as on benthonic planar macroforaminifera (**Heterostegina** gr. **costata** and **H. papyracea**).

The different ostracod assemblages recognized along the Başıyayla section record a littoral marine environment with a depth between the outer infralittoral (40 m) to the inner circalittoral (120 m). Most of the identified ostracod species show a wide Neogene stratigraphical distribution, but the concomitant presence of **Cytherella vulgata** and **Aurila freudenthali** (last record in the Tortonian) and **Semicytherura velata** (late Tortonian-Present) constrains the age of the studied section to within the late Tortonian. Moreover, the occurrence in the upper part of the Başıyayla section of both **Globigerinoides extremus** and **Catapsydrax parvulus** allow us to define the **Globigerinoides extremus-Globorotalia suterae** Interval Subzone (MMi 12a), which ranges from 8.35 to 7.81 Ma (upper Tortonian).

$^{87}\text{Sr}/^{86}\text{Sr}$ measurements were performed on 5 samples of the study section from tests of benthonic planar foraminifera (**Heterostegina** spp.), and benthonic and planktonic foraminifera. A total of 19 sample aliquots were analysed for $^{87}\text{Sr}/^{86}\text{Sr}$ measurements (11 **Heterostegina** spp., 3 planktonic, 5 benthonic) giving a range of values between 0.708821 and 0.708848 for a range of LOWESS IV estimated ages of 12.71 to 11.20 Ma. Three oysters sampled ~30 m above the top of the Başıyayla section yielded $^{87}\text{Sr}/^{86}\text{Sr}$ ratio values between 0.708824 and 0.708833, for a range of LOWESS IV estimated ages of 12.58 to 12.17 Ma. The discrepancy between the $^{87}\text{Sr}/^{86}\text{Sr}$ estimated ages and the biochronology for the Başıyayla section point to a strong departure from the global ocean Sr curve of the Tortonian seawater of the Mut Basin.

The stratigraphical study of the Başıyayla section, which represents the highest marine deposits capping the basement rocks of the Mut-Ermenek basin so far sampled, point to an age younger than the late Tortonian (8.35-7.81 Ma) for the start of uplift of the CAP southern margin.

Keywords: Anatolian Plateau, Mut Basin, Biostratigraphy; $^{87}\text{Sr}/^{86}\text{Sr}$ stratigraphy, late Tortonian

LATE MESSINIAN OSTRACOD BIOZONATION: STRATIGRAPHICAL CONSTRAINTS FOR THE BASE OF THE *LOXOCONCHA MÜLLERI* ZONE DERIVED FROM CENTRAL APENNINE (ITALY) AND ADANA BASIN (SOUTHERN TURKEY) SUCCESSIONS

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Detailed paleontological analyses on ostracods, carried out on several late Messinian successions in the Mediterranean area, supplied reliable data to support the definition of two biozones for the late Messinian post-evaporitic interval: the *Loxoconcha mülleri* Zone and the *Loxocorniculina djafarovi* Zone.

The *Loxoconcha mülleri* Zone is an interval biozone: its lower boundary corresponds to the FO in the Mediterranean area of the Paratethyan species *Loxoconcha mülleri*, while its upper boundary is represented by the FO in the Mediterranean area of the Paratethyan species *Loxocorniculina djafarovi*. In the lower part of the biozone the ostracod assemblages are very scanty and *L. mülleri* is accompanied by scarce *Cyprideis agrigentina*; in the upper part *C. agrigentina*, rare *Amnicythere* indet., *Loxoconcha eichwaldi* and *Tyrrhenocythere pontica* are present.

The *Loxocorniculina djafarovi* Zone is defined as a local “total distribution-range” biozone and is limited by the FO and LO in the Mediterranean area of the homonym taxon. Within this zone, the progressive increase of the Paratethyan contingent occurs, including several Leptocytheridae, *Loxocauda limata*, *Caspiocypris alta* and *Caspiocypris pontica*. The boundaries of the *Loxocorniculina djafarovi* Zone are rather well constrained through astrocyclicty (from ca. 5.42 to 5.33 Ma), whereas only recent data collected in the central Apennines (Italy) and in the Adana Basin have allowed to constrain the basal age of the *Loxoconcha mülleri* Zone. The Colle di Votta section crops out in the Maiella Mt. area (central Apennines, Italy). In this section the Messinian Primary Lower Gypsum unit (PLG) is well exposed, cut at the top by the Messinian Erosional Surface (MES); above the MES, the early post-evaporitic deposits are characterised by lenses of brecciated limestones within marls, followed by marls and calcareous marls rich in plant remains. In the upper part of the succession a volcanoclastic layer is present, correlatable with the well known Maccarone ash layer dated 5.5 Ma. Micropaleontological analyses record the presence of *L. mülleri* and *C. agrigentina* fifty centimetres below the volcanoclastic layer and above it. The Decontra section (Maiella Mt. area) is made of PLG that crops out at the base, followed, after the MES, by a post-evaporitic succession. This section starts with the Resedimented Lower Gypsum unit (RLG) characterised by resedimented gypsum beds intercalated with pelites. Upwards the succession continues with alternated marls and clays with marly limestone intercalations. Micropaleontological analyses have shown the presence of *L. mülleri* and *C. agrigentina* two meters above the last resedimented gypsum bed.

The Adana section crops out to the northwest of Adana (southern Turkey). The sedimentary succession rests upon the MES and is made of resedimented gypsum beds intercalated with marls and clayey marls. Within the marly layers, micropaleontological analyses record the presence of *L. mülleri*, *C. agrigentina*, *Tyrrhenocythere pontica* and Leptocytheridae indet.

According to the CIESM (2008) age model for the Messinian Salinity Crisis, the RLG deposited during the MSC acme (stage 2.1: 5.61-5.55 Ma). Thus, it is during this time interval that the first Paratethyan immigrant (*L. mülleri*) entered the Mediterranean area.

Keywords: Ostracods, Mediterranean biostratigraphy, late Messinian

THE LATE MIOCENE LIGNITE DEPOSITS OF THE DUZYAYLA LOCALITY (HAFİK – SIVAS, TURKEY) AND THEIR VERTEBRATE FOSSIL RECORD

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The Düzyayla locality is situated in the north-east of Turkey, about 10 km north-west of Hafik and 40 km to the north-east of Sivas. The Late Miocene İncesu formation, as exposed in the Hafik-Düzyayla region, consists of mudstones, lignite, sands, conglomerates and lacustrine limestones. The Late Miocene locality of Düzyayla has yielded a huge collection of remains of large and small mammals. In the present study, the rodents and insectivores from a lignitic clay bed are described.

Keywords: Late Miocene, Düzyayla -Hafik, lignite, rodents and insectivores,

TRACE FOSSILS OF UPPER EOCENE-LOWER OLIGICENE, IN THRACE BASIN (NW, TURKEY)

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The Middle-Upper Eocene submarine fan sequence is exposed in the northwest of the Saros Bay and around Gaziköy, Korudağ, Keşan, Yenimuhacir regions. The submarine fan deposit consists of several facies associations such as middle and outer fan, slope and prodelta. Deep sea fan deposits are represented by Gaziköy (Middle-Upper Eocene) Formation and Keşan Group (Upper Eocene), whereas prodelta sediments are represented within the Mezardere Formation which constitutes the lower formation Yenimuhacir Group (Upper Eocene-Lower Oligocene). From the study area, 4 stratigraphical sections comprising Keşan and Yenimuhacir groups were measured and the mid and outer fan facies association deposits were found to be more common than the others. The middle fan association was divided into two sub-associations: distribution channels and interchannel areas.

31 ichn ofossils were recognized within the submarine fan sediments. 11 of these traces composed of ichnogenus (*Cardioichnus* isp, *Bergaueria* isp, *Lockeia* isp, *Planolites* isp, *Ophiomorpha* isp, *Rutichnius* isp, *Zoophycos* isp, *Helminthoidichnites* isp, *Helminthopsis* isp, *Cochlichnus* isp, *Megagraption* isp.) and 20 of them are ichnospecies (*P. beverleyensis*, *O. annulata*, *O. rudis*, *T. suevicus*, *C. intricatus*, *H. annulata*, *P. tubularis*, *L. pustulosa*, *P. incertum*, *S. vertebralis*, *S. strozzii*, *S. prisca*, *N. irregularis*, *C. sinuosa*, *H. japonica*, *H. flexuosa*, *P. majus*, *P. arvense*, *P. hexagonum*) level. In addition, a new ichnospecies, *Osculichnus libialis*, is found within the Mezardere Formation of Late Eocene-Early Oligocene age.

Trace fossils representing submarine fan sediments are wide spread, whereas the type and the amount of the deltaic species are quite different and they are only represented by a few species. Distribution and relative abundance of the trace fossils are compared in order to interpret the depositional environment and trace fossils associations are found to be related to various parts of the deep sea fan model.

Keywords: Trace fossils, Middle-Late Eocene, Early Oliocene, Submarine fan, Thrace Basin, Turkey.

THE TRACE FOSSIL NUMMIPERA EOCENICA FROM THE LITTORAL CALCARENITES OF THE SOĞUCAK FORMATION (MIDDLE-UPPER EOCENE) IN THE GÖKÇEADA ISLAND, TURKEY

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The Soğucak Formation (Middle-Upper Eocene) is composed of about 113 m. thick calcilutites, calcarenites and reefal limestones. The calcarenites in the Gizliman section (about 15 m), W Gökçeada, contain bioclasts, including corals, large bivalves and large foraminifers, especially *Nummulites perfaratus* and *Nummulites millecaput*. Locally, tests of the nummulites are involved in the wall structure of the trace fossil *Nummipera eocenica* Hölder, 1989, which is known from the Eocene nummulitic limestones in Poland, Croatia and Tunisia. The trace fossil is vertically to obliquely oriented, up to 12 cm long, and 4-6 cm wide. The tests are densely packed in the wall that is 1-1.5 m thick. They are perpendicularly to obliquely arranged in respect to the burrow axis. This trace fossil is considered as a burrow of decapod crustaceans or polychaetes. By the analogy to *Diopatra cuprea*, a polychaete reinforcing its burrow by bioclasts (trace fossil *Diopatrachus*), the polychaete origin is more probable. *Nummipera eocenica* seems to be a characteristic component of the Eocene high-energy carbonate ramp sediments in the Mediterranean region, which are rich in large foraminifer tests.

Keywords: *Nummipera eocenica*, trace fossils, large foraminifers, Middle-Upper Eocene, Soğucak Formation, Gökçeada Island

HOW DID THE MESSINIAN SALINITY CRISIS IMPACT THE ADANA BASIN?

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The Messinian salinity crisis (MSC), which happened in the Mediterranean Basin between 5.96 and 5.33 Ma, developed in three main evolutionary stages: 1) **Primary Lower Gypsum** (5.96-5.60 Ma), with deposition of selenite in shallow basins and euxinic shales in deep basins; 2) **Resedimented Lower Gypsum** (5.60-5.53 Ma), with carbonate, clastics and salt in the deepest basins, just above the Messinian erosional surface (MES); and 3) **Upper Evaporites**, with an increase in continental water influxes and the diffusion of Lago-Mare bi ofacies throughout the Mediterranean Basin (5.53-5.33 Ma).

The MSC affected southern Turkey in marginal basins connected with the late Miocene evolution of the Taurus Mountains and the more external Kyrenia Range and Misis Mountains. The Adana Basin, which developed in a tectonically active area as a Miocene thrust-top basin, is one of the best onshore basins of southern Turkey for exposing the effects of the MSC.

According to the published Neogene stratigraphy of the Adana Basin, the Messinian stage is recorded either within the lower part of the Handere Fm or by the Adana group. The base of the Handere Fm, or conversely the base of the Adana group, which according to the literature corresponds to the base of the Messinian stage, rests conformably on the Tortonian Kuzgun Fm. Accordingly, Messinian gypsum beds related to the MSC are signalled either in the Handere Fm (Gökkuyu Mbr) or at the top of the Adana group. Following both the results of field work carried out recently on the Handere Fm and the preliminary results of the micropaleontological analyses, the Handere Fm should be amended at least for its chronostratigraphic significance.

In the western part of the basin (Karayayla and Topçu sections), a cyclical succession of anhydrites and black shales record the main evaporative event of the Mediterranean (**Primary Lower Gypsum**). In the Karayayla section the anhydrites with black shales seem to lie conformably on pre-evaporitic Messinian marls. Most gypsum deposits that crop out in different sections of the Adana Basin (Topçu, Tepeçaylak, Gökkuyu, Adana, etc.) pertain to a unit characterized by **Resedimented Lower Gypsum**. The base of this unit corresponds to a spectacular erosional surface cutting down to either the **Primary Lower Gypsum** (Topçu section) or the pre-evaporitic Tortonian-early Messinian deposits (Gökkuyu and Adana sections). This erosional surface correlates with the MES of the Mediterranean area. The **Resedimented Lower Gypsum** of the Adana section contains **Cyprideis** sp. and **Loxoconcha mülleri**, which pertain to the Messinian early-Lago-Mare bi ofacies (**L. mülleri** Zone). A younger erosional surface (MES₂) affects the Messinian succession of the Adana Basin. Above the MES₂ a continental unit consisting mainly of fluvial coarse-grained deposits rests unconformably on **Primary Lower Gypsum** (Karayayla), **Resedimented Lower Gypsum** (Topçu, Tepeçaylak, Adana), and pre-evaporitic marls (Gökkuyu). Some fine-grained intercalations both at the base and at the top of those mainly channelized fluvial deposits contain ostracods with Paratethyan affinities pertaining to the Messinian late-Lago-Mare bi ofacies (**Loxocorniculina djafarovi** Zone). Although they are considered Pliocene in age, these findings allow us to assign the thick fluvial conglomerates of the Handere Fm to the latest Messinian Lago-Mare event.

Keywords: Messinian salinity crisis, Adana Basin, evaporates

THE LATE PALAEOZOIC TRILOBITES OF TURKEY AND NEIGHBOURING AREAS AND THEIR PALAEOBIOGEOGRAPHICAL SIGNIFICANCE

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Trilobites are emblematic representatives of Palaeozoic ecosystems, but during most of the Carboniferous and the Permian they only represent a minor component of benthic marine faunas. Accordingly, they have attracted little attention. This is despite the fact that they are essential for understanding the late evolutionary history of the group and, more specifically, for documenting the different steps that led to their complete eradication during the Permo-Triassic mass extinction. Carboniferous and Permian outcrops in Turkey (Eastern and Western Taurides, Hazro Region) and in neighbouring areas (Bulgaria, Caucasus, Crimea, Iraq, and Iran) have yielded a variety of trilobite faunules, which suggests that this region may prove to be of particular interest for the study of Late Palaeozoic trilobites if properly investigated. Here we review previous and new discoveries of Permo-Carboniferous trilobites in this region and we examine how they shed light on the late evolutionary history of the group. Affinities between these faunules and between them and contemporary faunas from other regions in the world are discussed to stress their significance for local and global palaeogeographical models during the Permian.

Keywords: Trilobita, Carboniferous, Permian, Turkey, palaeogeography

THE DETERMINATION OF LATE MIOCENE ROCKY PALAEOSHORE BY BIOEROSION TRACE FOSSILS FROM THE BOZCAADA ISLAND, ÇANAKKALE, TURKEY

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Late Miocene rocky-shore in the Bozcaada Island has been identified by bioerosion trace fossils assemblages. The preserved faunal remains and bioerosional structures in/on boulders and shells were collected from the rocky coast area of the Habbeli Bay in the western part of the island.

Bioerosion traces in/on boulders and shells are predominantly represented by drill holes-duraphagus scars (cf. *Oichnus*), phonoroid borings (cf. *Conchotrema*), clinoid sponge borings (*Entobia goniodes*, *E. geometrica*, *E. laquea*, *E. ovula*, *E. solaris*, *Entobia* isp.), bivalve borings (*Gastrochaenolites torpedo*, *G. lapidiscus*, *Gastrochaenolites* isp., *Phryxichnus* isp.), annelid borings (*Meandropolydora sulcans*, *M. decipiens*, *Meandropolydora* isp., *Caulostrepsis teniola*, *Caulostrepsis* isp.), echinoids borings (*Circolites* isp.) and bryozoan borings (cf. *Trypanites*). The barnacles are also common as encrusters.

The assemblage of borings can be ascribed to the *Entobia* ichn ofacies, which is typical of Neogene rocky-shores. It characterizes littoral rocky-shore environments, including wave-cut platforms and marine flooding surfaces (transgressive surfaces) in the stratigraphic record.

Keywords: Bioerosion, rocky-shore, trace fossils, Late Miocene, Bozcaada, Turkey.

RELATIVE SEA-WATER TEMPERATURE CHANGES IN THE MID TO LATE MIOCENE OF THE ADANA BASIN, TURKEY

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Some of the species of nannoplankton are sensitive to water temperatures. While *Coccolithus eopelagicus* and *Reticulofenestra gelida* indicate cooler water condition, Discoasters, Sphenoliths and *Calcidiscus leptoporus* species are warmer water types. It has defined the relative changes in the sea water temperatures with these nannoplankton species' abundance in two well logs in the Adana Basin.

At the first well, total abundance of cooler water species was %45, while that of warmer species was %3 in the Mid Miocene. Total abundance for cooler water species decreased to %34, in contrast total abundance of warmer species increased up to %7 during the Late Miocene. Thus, the sea water temperature cooler during the Mid Miocene at *Sphenolithus heteromorphus*, *Discoaster exilis* and *Discoaster kugleri* zones became warmer in the Late Miocene at *Discoaster quinquaramus* zone.

At the second well, cooler water species' total abundance was %46, but warmer species' total abundance was %11 in the Mid Miocene. Cooler water species' total abundance decreased in %41, but warmer species' total abundance increased in %18 in the Late Miocene. Thus, the sea water temperature cooler in the Mid Miocene represented by the *Discoaster kugleri*, *Catinaster coalitus* and *Discoaster hamatus* zones became warmer in the Late Miocene represented by the *Discoaster hamatus*, *Discoaster calcaris* and *Discoaster quinquaramus* zones. Because of the second well is located at southern, it has got much species.

Data on the nannofossil abundance from the Adana Miocene Basin show that sea water temperature was cooler in the Mid Miocene and the water heat increased in the Late Miocene in the Adana Basin.

Keywords: Adana Basin, Miocene, Nannoplankton, well log, Turkey.

TRACE FOSSILS FROM THE MIDDLE CAMBRIAN SOSINK FORMATION IN THE MARDIN-DERIK REGION, SOUTHEASTERN TURKEY

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The Lower Palaeozoic in the Mardin-Derik area are composed of Telbesmi, Sadan, Koruk, Sosink and Bedinan Formations in an ascending order.

The Sosink Formation is a clastic series consisting of gray shales, siltstones and sandstones. The underlying Koruk Formation is composed of thin bedded limestones and passes into the pink colored shales and nodular limestones of the Sosink formation. The Sosink Formation is overlain by the Bedinan formation which is characterized by alternating shales with sandstones.

The Sosink formation is regarded as Late-Middle Cambrian as previously suggested by various researchers, but it is dated for the first time as Middle Cambrian in this study on the basis of trace fossils. 16 ichn ofossil taxa (*?Lockeia* isp, *?Skolithos* isp, *Planolites* isp, *P. montanus*, *Palaeophycus* isp, *Monomorphichnus* isp, *Helminthopsis* isp, *?Trichophycus* isp, *?Helminthoidichnites* isp, *Archaeonassa* isp, *Didymaulichnus* isp, *Thalassinoides* isp, *?Gyrolithes polonicus*, *?Ptychoplasma* isp, *Protovirgularia* isp, *?Teichichnus* isp,) were identified based on their morphological analyses. The trace fossils were likely produced by trilobites, suspension feeding annelids and deposit feeding ‘worms’, probably polychaetes They are represented by *Skolithos* ichn ofacies, which is typical of high energy environments, intertidal to shallow subtidal zones.

Keywords: Trace fossils, *Skolithos* ichn ofacies, Sosink Formation, Middle Cambrian, Mardin-Derik, Turkey.

PALYNOLOGY OF PALAEOZOIC SEQUENCES IN THE WESTERN DESERT OF EGYPT: PRELIMINARY RESULTS FROM THE DEVONIAN OF THE SIFA-1 BOREHOLE

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Palaeozoic rocks in the Western Desert of Egypt are not exposed and information about these strata are only known from subsurface data derived of hydrocarbon exploration wells. Therefore, only little has been published about the Palaeozoic successions and the (bio-) stratigraphic framework of this area. Most activities on hydrocarbons have been concentrated on Mesozoic (e.g., Cretaceous and Jurassic) reservoirs. Palynological analyses of 51 rock samples, as applied for ongoing studies of the Sifa-1 borehole, represent a useful tool to provide various data which can be compared with those from neighbouring areas, e.g., Libya, and may lead to a better understanding of the depositional history in this part of the Western Desert.

The productive palynological samples of the Sifa-1 borehole yield excellent organic-walled microfossils (OWM) in terms of relative abundance and diversity. The palynological record indicates a succession from the Upper Silurian to Lower Permian. Diagnostic OWM, including the marine acritarchs and chitinozoa and the terrestrial spores allow to establish distinct assemblages characteristic for eight time slices of the Silurian to Devonian: Upper Silurian (?Ludlovian/pre-Pridolian), Lower Devonian (Lochkovian, Pragian/Emsian), Middle Devonian (Eifelian, Givetian), Upper Devonian (Frasnian, Famennian), and the uppermost Devonian (Strunian). Furthermore, the relative abundance and the ratio of marine and terrestrial OWM show variations in the palyn ofacies throughout the studied interval.

Keywords: Organic-walled microfossils, palynostratigraphy, palyn ofacies

FACIES CHARACTERISTICS AND BIOSTRATIGRAPHY OF LATE CRETACEOUS SEQUENCE (KERMUTDERE FORMATION) IN THE GÜMÜŞHANE AREA (NE TURKEY)

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So as to define outcropping, distribution, rock type, sediment texture-tissue-micro fauna characteristics, biostratigraphic data with fossil contents of the Late Cretaceous aged Kermutdere Formation in the Gümüşhane area were implemented stratigraphic, sedimentologic and biostratigraphic studies. For these purposes, outcropping, correlations, macroscopic characteristics of this formation were made field studies and three measured stratigraphic sections which are located in Mescitli, Akçakale and Kale (Karadelikler Hill) were studied.

The Kermutdere Formation widely outcrops in the Mescitli, Akçakale and Kale areas in the Gümüşhane region and its lithology consists of monogenic breccia/conglomerate, calciturbidites, micritic limestones and siliciclastic turbiditic sediments. Late Cretaceous aged these marine sediments pass laterally and vertically to each other study area. The Kermutdere Formation conformably overlies the Late Jurassic-Early Cretaceous aged platform carbonates, named as Berdiga Formation. It starts with monogenic breccia/conglomerate in the Mescitli and Kale areas, with calciturbidites in the Akçakale and Tekke areas. The formation is unconformably overlain by the Eocene Alibaba Formation which consists of conglomerate, nummulitic sandy limestones and andesitic lava flows and pyroclastics. Thickness of the Kermutdere Formation changes between 45-1200 m. in the region, and it is rich in planktonic foraminifera.

Monogenic breccia/conglomerate is lateral transitive with calciturbidite. This Monogenic breccia/conglomerate display thinning and fining-upward character. Two different micr ofacies types were differentiated based on detailed micr ofacies analysis. These are; planktic foraminiferal wackestone and packstone (MF-1), siliciclastic turbiditic sandstones alternated with glauconite-marl-limestone-tuff (MF-2). It is interpreted that the monogenic breccia/conglomerate and calciturbidite lith ofacies were deposited on slope environment, while the planktic foraminiferal wackestone, packstone micr ofacies and siliciclastic turbiditic lith ofacies show-indicate a deep-sea environment. Also, three planktic foraminiferal biozones were recognized in the formation: *Dicarinella asymetrica* Total Range Zone (TRZ), *Globotruncanita elevata* Partial Range Zone (PRZ), *Globotruncana ventricosa* Interval Zone (IZ). Based on the stratigraphic ranges of globotruncanid species the Kermutdere Formation was attributed to the Santonian-Middle Campanian.

Keywords: Santonian-Middle Campanian, Micr ofacies, planktic foraminifera, Biostratigraphy, NE Turkey/Eastern Pontides

TRACE FOSSILS, CALCAREOUS NANNOPLANKTON ASSEMBLAGES AND PALAEOENVIRONMENTAL INTERPRETATION OF THE KEŞAN AND MEZARDERE FORMATIONS IN THE YENİKÖY-KORUDAĞ-MALKARA-İNECİK AREA, SW THRACE BASIN (NW TURKEY)

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Seventeen species of 9 genera of calcareous nannoplankton have been recognized in study of 76 samples from the 4 measured sections which have been obtained from the Keşan and Yenimuhacir formations northeast of the Saros Bay and around Yeniköy, Korudağ, Malkara, and İneçik. A Late Eocene age was derived when studying the distribution of nannoplankton assemblages in the samples from the two formations. Distribution and abundance of temperature-sensitive calcareous nannoplankton species show a variations between the samples of the sections from both of formations. Sea-surface water temperature changed in the study area throughout the Upper Eocene time interval and was probably affected by the interplay between warm and cool currents or climatic changes. In the same samples, 19 ichn ofossils taxa were recognized within submarine fan sediments depending on their morphological characters. According to the ichnological data, submarine fan sediments are characteristic for the Keşan Formation, whereas prodelta sediments are represented in the Mezardere Formation which is found at the bottom of the Yenimuhacir unit. The distribution of the determined trace fossil groups is compared with the interpretation of the respective depositional environment. Trace fossil associations were found to be related to the various elements of a deep sea fan model (such as outer and middle fan, slope, and prodelta). The inner fan facies shows a *Skolithos-Cruziana* ichn ofacies, and the middle fan facies as well as the inner fan facies and the outer fan facies are characterized by mixed ichnoassemblages belonging to the *Skolithos-Cruziana* ichn ofacies and the *Nereites* ichn ofacies, and showed eutrophic-oligotrophic conditions. The outer fan indicates *Nereites* ichn ofacies, both indicating low oxygen or anoxic and completely oligotrophic conditions. The Mezardere Formation also shows a *Skolithos* ichn ofacies which is indicating normal salinity and a seasonal temperature variability.

Keywords: Calcareous nannoplankton, Late Eocene, NW Turkey, submarine fan, trace fossil.

STRATIGRAPHY AND PALEOENVIRONMENTAL DEVELOPMENT OF THE LATE CRETACEOUS DEPOSITS IN THE CENTRAL TAURIDES (S TURKEY)

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The study of the ten outcrop sections from the Late Cretaceous (from Cenomanian to Maastrichtian) deposits in the Central Taurides (S Turkey) allowed to differentiate five biostratigraphic units based upon benthic and planktonic foraminifers, and to understand the successive sedimentary history of the Central Taurides carbonate platform. The middle to upper Cenomanian inner platform (tidal to shallow subtidal) carbonate succession, characterised by the *Pseudorhapydionina dubia* zone, unconformably overlies the *Palorbitolina lenticularis* and its lateral equivalent *Voloshinoides murgensis/Debarina hahounerensis* zones of the lower Aptian. The conformably overlying laminated packstones and mudstones with ostracods and miliolids deposited on tidal flat during probably early Turonian. This regressive phase resulted in emergence of the platform which is documented by the presence of microbial injected desiccation cracks and carbonate breccias. The second transgressive episode on the Late Cretaceous carbonate platform occurred in the Santonian time, represented by the *Pseudocyclammina sphaeroidea* zone and characterised by rudist shell concentrations. The platform carbonate deposition was ceased by the early Campanian (*Globotruncanita elevata* zone) flooding, resulting in deposition of the hemi-pelagic and pelagic carbonates with calcispheres and planktonic foraminifers on open shelf and slope. The following calciclastic and siliciclastic turbidites, which were derived from platform carbonate, pelagic carbonate and ophiolitic source materials during the late Campanian (*Globotruncanita calcarata* zone), reflect foreslope to basinal conditions.

Keywords: Biostratigraphy, Lithostratigraphy, Late Cretaceous, Central Taurides, Turkey

DIATOM COMMUNITIES OF EARLY PLIOCENE LACUSTRINE DEPOSITS IN THE KARACASU CROSS GRABEN, WESTERN ANATOLIA, TURKEY

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The present study comprises paleontological analyses of diatom-bearing lacustrine deposits to substantiate the palaeoenvironmental history of the Early Pliocene Karacaören Formation within the Karacasu Cross Graben in the Aegean Extension Province between Denizli and Aydın, Turkey. Twenty-five diatom species were identified, belonging to 16 genera, from 24 samples out of one measured stratigraphic section of the respective formation. The fossil diatom assemblages are mainly comprised of brackish, mesotrophic, mesosaprophic, alkaline taxa. The flora is dominated by benthic and littoral species, while the number of planktonic species is limited, indicating that the lacustrine facies of the Karacaören Formation was deposited in a shallow, alkaline, mesotrophic and mesosaprophic brackish water lake environment.

Keywords: Aegean Extension Province, Diatom, Early Pliocene, Karacaören Formation, Lacustrine Deposits.

OSTRACODS FROM TERTIARY SEQUENCES OF THE GÜNEY-BULDAN-BABADAĞ-KALE AREA (DENİZLİ, SW ANATOLIA)

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In this study, Tertiary ostracoda from an area around Güney-Buldan-Babadağ-Kale (Denizli, SW Anatolia), have been investigated. The study area comprises Paleogene and Neogene units covering a basement made up of schists, quartzite schists and reddish meta conglomerates. It is unconformably overlain by Oligocene sediments comprising siltstone-sandstone and claystone partly including thick coal layers. This unit is characterized by the following ostracod genera and species: *Cytheromorpha zinndorfi* (Lienenklaus), *Nucleolina multicostata* (Deltel), *Cladarocythere apostolescui* (Margerie), *C. hantonensis* Keen, *Hemicyprideis montosa* (Jones and Sherborn), *H. elongata* Keen, *H. helvetica* (Lienenklaus), *Neocyprideis apostolescui* (Keij), *Leptocythere* sp., *Callistocythere vittata* Sönmez-Gökçen, *Cyamocytheridea punctatella* (Bosquet), *Candona* (*Pseudocandona*) *fertilis* Triebel, *Xestoleberis subglobosa* (Bosquet). This fauna indicates that the unit has been deposited in lagoonal and littoral environments.

Early Miocene (Burdigalian) units unconformably cover the Oligocene sediments in the southeast of the study area and include the following shallow marine ostracod species: *Bairdia subdeltoidea* (Muenster), *Neonesidea corpulenta* (Mueller), *Neomonoceratina helvetica* Oertli, *Krithe papillosa* (Bosquet), *Ruggieria dorukae* (Bassiouni), *R. tetraptera* (Sequenza), *Tenedocythere prava* (Baird), *T. salebroso* Uliczny, *Pokorniyella deformis minor* (Moyes), *Hermanites haidingeri minor* Ruggieri, *Loxoconcha cristatissima* Ruggieri, *Loxocorniculum quadricornis* (Ruggieri), *Paracypris polita* Sars. Units of Late Miocene age unconformably overly the early Miocene sediments and represent lacustrine-lagoonal conditions. Some associations of ostracods containing elements such as *Cyprideis torosa* (Jones), *C. mehesi* Sissingh, *Loxoconcha agilis* Ruggieri, *Darwinula stevensoni* (Brady and Robertson), *Ilyocypris gibba* (Ramdohr), *Candona* (*Caspiolla*) *lobata* (Zalanyi), *C. (Caspiolla) fastigata* Freels, *Candona namanganica* (Snejder), *C. decimai* Freels, *C. candida* (Müller), *C. elongata* (Svejer), *C. devexa* Kaufmann, *C. xanthica* Freels, *C. parallela pannonica* Zalanyi, *Candona* (*Lineocypris*) sp., *Heterocypris* sp., *Eucypris* sp. have been found in the weathered, pale cream coloured and loosely cemented marls and claystones of the respective formation. The effects of the tectonic regime are clearly reflected in the fauna which was found in the Oligocene sediments. The ostracods found in this study have been correlated with previously described faunas of Oligocene sequences from NW Europe and the Paris Basin and with other late Tertiary limnic ostracod associations of Europe and Turkey.

Keywords: Güney-Buldan (Denizli), Ostracoda, Tertiary

THE UPPER MIOCENE BOZKIR FORMATION (ÇANKIRI BASIN, CENTRAL ANATOLIA PLATEAU): MULTIDISCIPLINARY ANALYSES OF A CONTINENTAL SABKHA PALAEOENVIRONMENT

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The Central Anatolia Çankırı basin is located to the E of the İzmir-Ankara-Erzincan suture zone and S of the North Anatolian Fault System. The sedimentary succession is more than 4 km thick and was deposited during 5 different sedimentary cycles time spanning from the Upper Cretaceous to Quaternary. Within the Upper Miocene cycle, three different formations have been distinguished: the Tuğlu Formation (lower to upper Tortonian), the Süleymanlı Formation (MN13-Messinian p.p.) and the Bozkır Formation (Messinian p.p.). In the northern part of the Çankırı basin, the Bozkır Formation presents a total thickness of about 200 m. It unconformably overlies the Süleymanlı Formation and it is constituted by a cyclic succession of clays, sandy clays and of gypsum layers with different thicknesses and characteristics.

The results of multidisciplinary analyses on the Bozkır Formation are presented here. Two composite sections have been sampled in two localities, Bozkır and Süleymanlı, for a total thickness of 21.43 m. Eleven gypsum banks were selected for preliminary geochemical, mineralogical and petrographical analyses. The measured $^{87}\text{Sr}/^{86}\text{Sr}$ values (ranging between 0.707469 and 0.707674) are lower than the standard values for the Messinian gypsum of the Mediterranean Basin and the coherence of all values excludes a re-opening of the isotopic system. Most likely, such isotopic values are related to dissolution processes of Sr from Oligocene evaporitic deposits showing same $^{87}\text{Sr}/^{86}\text{Sr}$ values. In all samples, minerals were identified by XRD analyses. The gypsum micr ofacies analyses on thin sections suggested that the nodular gypsum and laminated gypsum levels deposited diagenetically in unconsolidated pelitic sediments. Such laminated secondary gypsum facies is typical of a continental sabkha environment. There, the gypsum can precipitate from CaSO_4 rich interstitial brines through capillarity motion from groundwater during high aridity moments. On the pelitic samples, micro palaeontological and magnetic susceptibility analyses have been performed. Most samples were barren, but a 4 m thick pelitic interval has provided ostracods and gyrogonites. The magnetic susceptibility reaches its maximum peaks within this interval. The ostracod assemblage is oligotypic, dominated alternately by *Cyprideis* sp. and *Ilyocypris* sp.. When *Ilyocypris* dominates, also abundant gyrogonites of the genus *Chara* occurs, testifying the low salinity (<5‰) of the water body. Such pelitic intervals represent humid phases, with intense precipitation and run off as confirmed by the magnetic susceptibility.

The characteristic cyclicity and the stratigraphic position of the Bozkır Formation allow a comparison with the successions deposited during the Messinian Salinity Crisis (MSC), in the Mediterranean Basin. The Bozkır Formation could be related to the precessional cyclicity of the Lower Evaporites recorded in the Mediterranean area during the onset of the MSC (5.96-5.61 Ma). If such a hypothesis would be confirmed by further analyses, the Bozkır Formation could represent the continental counterpart of the palaeoceanographical and palaeoclimatic variations occurred during the MSC.

Keywords: Messinian; Continental sabkha; Ostracods; Sr isotopes

EVIDENCE OF MIDDLE JURASSIC AGE IN SELISHTA AND DRAJA SECTIONS (EASTERN SECTOR OF ALBANIDES): PRELIMINARY DATA

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The Eastern sector of Albanides comprises the Kollovozi and Muhur tectonic units, belonging to the Korabi zone, which corresponds to the Pelagonian zone in Greece.

This study examines the radiolarian assemblages from cherts intercalated in two pelagic carbonate sections exposed in Selishta and Draja areas (Eastern Albania).

Draja section is situated about 300 meters in the east of Draje-Reç village (Dibra region). The section consists of from bottom to top: a) cherty limestones of Middle Triassic–Early Jurassic age (thickness about 100 meters); b) Red radiolarian cherts (thickness about 12 meters)

The samples 028 and 029 come respectively 2 m and 9,5 m above the limestone. The samples have been etched with hydr ofluoric acid at different concentration, utilizing the method proposed by Dumitrica (1970), Pessagno and Newport (1972), Baumgartner et al. (1981) and De Wever (1982). The complete faunal assemblages from the examined samples are as follows:

Sample 028: *Tricolocapsa plicarum* ssp. A (Baumgartner et al., 1995); *Williriedellum* sp. A. sensu Matsuoka; *Eucyrtidiellum unumaense* s. l. (Yao); *Parvicingula dhimenaensis dhimenaensis* Baumgartner; *Tricolocapsa* sp.; *Stichocapsa robusta* Matsuoka. Age: Latest Bajocian – Early Bathonian due to the presence of *Stichocapsa robusta* and *Tricolocapsa plicarum* ssp. A.

Sample 029: *Acanthocircus* sp. cf. *A. suboblongus suboblongus* (Yao); *Unuma* sp. cf. *U.* sp. A (Baumgartner et al., 1995); *Eucyrtidiellum unumaense* s. l. (Yao); *Unuma echinatus* Ichikawa & Yao; *Protunuma turbo* Matsuoka; *Triactoma* sp. Age: Late Bajocian-Early Bathonian to Middle Bathonian due to the coexistence of *Protunuma turbo* and *Unuma echinatus*.

The section of Selishta is located about 2 km in the East of Selishta village. From bottom to top, the section comprises: a) cherty limestones and turbitic limestones with *Protopeneroplis striata*; b) a siliceous portion, (about 18 m thick), represented by the intercalation of red radiolarian cherts, red siliceous shales and green siliceous cherts. In this level are also present oolitic limestone intercalations; c) Melange “blocks in matrix”

The sample 338 comes about 3 m above the limestone. Radiolarian assemblages: *Eucyrtidiellum* (?) *circumperforatum* Chiari & Marcucci & Prela; *Eucyrtidiellum* sp.; *Parvicingula* (?) *spinata* Vinassa; *Tricolocapsa plicarum plicarum* Yao; *Tricolocapsa* sp. cf. *T.* sp. S. (Baumgartner et al., 1995); *Unuma* sp. A. (Baumgartner et al., 1995); *Zhamoidellum ventricosum* Dumitrica; *Tricolocapsa* sp. M. (Baumgartner et al., 1995). In this paper we adopted the radiolarian zonation based on Unitary Association Zones (UAZ) proposed by Baumgartner et al. (1995).

Age: Latest Bajocian-Early Bathonian due to the coexistence of *Tricolocapsa plicarum plicarum* and *Eucyrtidiellum* (?) *circumperforatum* Chiari & Marcucci & Prela.

The dating of radiolarian chert deposition in Albania contributes to complete the picture of siliceous deposition in this area. It also has bearing on the paleogeographic interpretations.

Keywords: Jurassic sections, radiolarian chert, Radiolaria, turbitic limestone.

BIOSTRATIGRAPHY OF RADIOLARIAN CHERTS OF THE SPAÇI REGION (MIRDITA ZONE, ALBANIA)

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Previous studies distinguished two ophiolitic belts in Albania, on the basis of their tectonic position and geochemical and petrological characteristics, a western and an eastern ophiolite belt, respectively. In both, the western and the eastern belt, the ophiolites are covered by radiolarian cherts (Kalur Cherts Formation).

The radiolarian cherts described here are derived from the Kalur Cherts in the Spaçi region (Northern Albania). The section of radiolarian chert is situated north of the GurthSpaçi village. It includes, from bottom to top: 1- dacitic and andesitic extrusives; 2- red radiolarian cherts (about 2,5 m thick); 3- melange “blocks in matrix”.

Samples G 4/1, G 4/2, G 4/3 e G 4/4 have been taken from 0,5 m; 0,9 m; 2 m and 2,3 m above the extrusive. The complete faunal assemblages from the studied samples are listed below:

Sample G 4/1: *Eucyrtidiellum unumaense pustulatum* Baumgartner; *Tricolocapsa plicarum* s. l. Yao; *Tricolocapsa* sp. S. (Baumgartner et al., 1995); *Stichocapsa robusta* Matsuoka; *Protunuma turbo* Matsuoka; *Archeodictyomitra* sp..

Sample G 4/2: *Transhsuum brevicostatum* gr. Baumgartner; *Protunuma turbo* Matsuoka; *Transhsuum maxwelli* gr. (Pessagno); *Tricolocapsa* sp. cf. T. sp. S. (Baumgartner et al., 1995); *Sethocapsa funatoensis* Aita; *Archeodictyomitra* sp.; *Tricolocapsa* sp.; *Saitoum levium* De Wever; *Stichocapsa convexa* Yao; *Eucyrtidiellum unumaense* s. l.(Yao)

Sample G 4/3: *Tricolocapsa* sp. S (Baumgartner et al., 1995); *Tricolocapsa plicarum* s.l.Yao; *Protunuma turbo* Matsuoka; *Tricolocapsa* sp.; *Eucyrtidiellum semifactum* Nagai & Mizutani; *Archeodictyomitra* sp.; *Transhsuum maxwelli* gr.(Pessagno); *Saitoum levium* De Wever; *Sethocapsa funatoensis* Aita; *Unuma latusicostatus* (Aita).

Sample G 4/4: *Tricolocapsa plicarum* s.l. Yao; *Tricolocapsa tetragona* Matsuoka; *Tricolocapsa* sp. S. (Baumgartner et al., 1995); *Unuma latusicostatus* (Aita); *Protunuma turbo* Matsuoka; *Stichocapsa japonica* Yao; *Quarticella ovalis*; *Protunuma* sp. cf. *P. ochiensis*; *Eucyrtidiellum semifactum* Nagai & Mizutani; *Williriedellum* sp. A. sensu Matsuoka; *Tricolocapsa* sp. cf. T. sp. S (Baumgartner et al., 1995).

The age of sample G 4/1 is Early Bathonian to Late Bathonian-Early Callovian due to the presence of *Stichocapsa robusta* and *Eucyrtidiellum unumaense pustulatum*. The age of sample G4/2 is Late Bajocian to Late Bathonian-Early Callovian because of the presence of *Protunuma turbo*. The age of sample G4/3 is Late Bajocian-Early Bathonian due to the coexistence of *Eucyrtidiellum semifactum* and *Unuma latusicostatus*. The age of sample G4/4 is latest Bajocian-early Bathonian due to the presence of *Tricolocapsa tetragona*, *Unuma latusicostatus* and *Eucyrtidiellum semifactum*.

In conclusion, the red radiolarian cherts of the Spaçi section have been deposited during time interval ranging from the latest Bajocian to the early Bathonian.

Keywords: age, radiolarian chert, Jurassic

PRESENCE OF MIDDLE JURASSIC BASALT-RADIOLARITE BLOCKS IN “BLOCKS IN MATRIX” MELANGE AT THE PERIPHERY OF OPHIOLITIC MASSIF OF GOMSIQ (NORTHERN ALBANIA)

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The Albanian Ophiolites represent one of the best examples of oceanic lithospheric fragments within the circum-Mediterranean orogenic belts. Ophiolites display well developed and preserved sequences consisting of two subparallel belts, extending over a length of more than 250 km, with distinct petrological, structural and metallogenic features. The ophiolites lie on a heterogeneous complex, known as Rubiku Complex, which is regarded as: a- a melange including very large blocks (olistoliths) or, b- a pile of thrust sheets. The Rubiku complex rests above epicontinental units: the Krasta-Cukali and Kruja Units to the west and the Korabi Unit to the East.

The melange “blocks in matrix” shows a thickness of about 200 – 300 m and occurs throughout the whole Mirdita areas for over 150 square kilometers. In a study area, the melange “blocks in matrix” crops out about 1,5 km in the East of hydro-central of Vau i Dejes. This melange shows a fabric that includes blocks ranging from several centimeters to several hundreds meters in size set in a well foliated shaly matrix. Generally, the matrix is made up of gray, green to red shales with randomly distributed, cm-size clasts, showing angular to surrounded shape. Blocks occurs as slabs with thickness ranging from several tens of meters up to kilometers. Lithologies in the blocks includes both continental and oceanic derived rocks. The ocean derived rocks are represented by the whole ophiolite sequence: in order of abundance, mantle ultramafics, basalts, gabbros and cherts occur. The continental derived lithologies are volumetrically dominant. They include, in order of abundance, sandstones, Triassic volcanics, cherts, carbonates and minor metamorphic rocks. Previous papers have evidenced the presence of basalt- radiolarite blocks of Middle and Late Triassic age. In this study, we confirm also the presence of basalt- radiolarite blocks of Middle Jurassic age.

The radiolarian assemblages described here come from a level of radiolarian cherts (about 0,8 m thick) into the basalt block. The sample Al 1205 is taken 0,3 m above the bottom.

The radiolarian assemblage for sample Al 1205:

Sample Al 1205: *Parvicingula dhimenaensis* s. l. Baumgartner ; *Transhsuum brevicostatum* gr. (Ozoldova); *Acanthocircus suboblongus minor* n. ssp Baumgartner.; *Protunuma turbo* Matsuoka; *Stichocapsa convexa* Yao; *Theocapsomma cordis* Kocher; *Striatojaponicapsa plicarum* s. l.; Yao *Unuma* sp. A.; *Williriedellum* sp. A. sensu Matsuoka; *Unuma echinatus* Ichikawa & Yao; *Sethocapsa funatoensis* Aita.

Age: Latest Bajocian-early Bathonian to Middle Bathonian for the presence of *Theocapsomma cordis* Kocher and *Unuma echinatus* Ichikawa & Yao.

Keywords: radiolaria, ophiolite, cherts

THE GRADUAL TRANSITION FROM TRIASSIC-JURASSIC CARBONATES TO MIDDLE JURASSIC RADIOLARIAN CHERTS IN LUNIKU SECTION (MIRDITA ZONE, ALBANIA)

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The Luniku section is exposed nearby the Luniku village, about 1 km northeast of Librazhdi city (Eastern Albania). In this area crops out the mostly complete and well preserved Triassic-Jurassic pelagic sequence. The Luniku section also represents one of the rare sections in Albanides where the relationship between Middle Triassic- Lower Jurassic limestones and Middle Jurassic radiolarian cherts which lie above them are very well exposed. The lithostratigraphic column of the Luniku section consists, from bottom to top, of:

- Metamorphosed terrigenous formation of Silurian-Devonian age;
- Terrigenous detritic sequence (Verrucano type) of probably P-?T₁ age (thickness about 15 meters);
- Yellow sandstone alternating with shale levels (thickness about 3-4 m);
- Grey, thick- bedded oolitic limestone;
- Lower Triassic reddish nodular limestone with *Meandrospira pusilla*, *Glomospira* sp., *Ammodiscus parapriscus* etc. In Kçira area, a similar section contains also ammonites.
- Grey to yellow, thick-bedded dolomitic limestones (about 30-40m thick);
- Reddish nodular limestone of Anisian age, with *Meandrospira dinarica*, (thickness about 3-4 meters). In some rare areas this limestone is accompanied by rift related volcanics;
- Reddish radiolarian cherts belonging to Anisian /Ladinian boundary (thickness 3-4 m);
- Pelagic nodular limestone intercalated with radiolarian cherts (Hallstat Limestone facies of about 150m thickness). These deposits are in Middle Triassic- Lower Jurassic age. Turbiditic limestone intercalations are also present within the succession. In the upper part of this level, the intercalations of radiolarian cherts become more abundant towards the contact with radiolarian cherts. The transition from pelagic nodular limestone to radiolarian cherts occur in a few meters.
- This succession is topped by the radiolarian cherts (about 60 metres thick) and overlain by block-in-matrix type mélange. The radiolarian assemblages examined from this level (*Unuma latusicostatus* (Aita); *Stichocapsa robusta* Matsuoka; *Eucyrtidiellum unumaense* s. l. Yao; *Williriedellum* sp. A. sensu Matsuoka; *Saitoum levium* De Wever; *Acanthocircus suboblongus minor* Baumgartner indicate an age ranging from Lateast Bajocian – Early Bathonian to late Bathonian – Early Callovian due to the coexistence of *Unuma latusicostatus*, *Stichocapsa robusta*, *Saitoum levium* and *Williriedellum* sp. A. sensu Matsuoka.

Keywords: Triassic, Jurassic, limestone, radiolarian chert

INTEGRATED BIOSTRATIGRAPHY (*INOCERAMUS* AND PLANKTONIC FORAMINIFERA) AND CORRELATION OF THE UPPER CRETACEOUS IN THE GAGRA-JAVA ZONE AND DZIRULA MASSIF

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In the basis of biofacial analysis of the Upper Cretaceous there are taken researches, which were carried out on the joint of the Gagra-Java folded zone and Dzirula massif. There twelve *Inoceramus* and fourteen planktonic foraminifera zones are recognized-differentiated.

I complex of *Inoceramus tenuis* layers contains *Inoceramus scalprum* Böhm, *In. crippsi* Mantell. *Rotalipora appenninica* zone is distinguished by planktonic foraminifera (PF). The age of mentioned complexes is early Cenomanian. II complex of layers is with *Inoceramus pictus*. It also contains *Inoceramus scalprum* Böhm, *In. orbicularis* Noetling, *In. bohemicus* Leonhard. There are segregated layers with small *Hedbergella* (by PF). *Hedbergella planispira* (Tappan), *Globigerinelloides ultramicra* (Sub) also were found. Present complex is dated as middle-late Cenomanian. III complex zone is *Inoceramus labiatus*. *Inoceramus hercynicus* Petrascheck, *In. opalensis* Böse, *In. striatoconcentricus* Gümbel are appearing here. Two zones are segregated by PF: *Whiteinella archaeocretacea* and *Dicarinella hagni* (III and IV). Complex's age is established as terminal part of Cenomanian- Early Turonian. IV complex of *Inoceramus lamarcki* zone is characterized by appearance of type-index with *Inoceramus striatoconcentricus* Gümbel, *In. stillei* Heinz, which was firstly recorded by *In. dzirulensis* Tlashadze. Complex V (PF) with *Marginotruncana schneegansi* and *Marginotruncana pseudolinneiana* corresponds to present complex. Besides, there appears *Marginotruncana angusticarinata* (Gand.). The age of the complex is Late Turonian. V complex of *Inoceramus wandereri* zone. *Inoceramus* cf. *websteri* Mantell, *In.* cf. *obeliscus* Petrascheck are also presented there. Mentioned complex corresponds to complex VI by foraminifera - *Marginotruncana coronata*. Zone age is Early Coniacian. In VI complex of *Inoceramus involutus* there present: *Inoceramus* cf. *koegleri* Andert, *In. crassus* Petrascheck. To this complex corresponds complex VII (PF) with *Marginotruncana sigali* and *Marginotruncana renzi* and also *Marginotruncana sinuosa* (Porthault), *M. tarfayaensis* (Lehmann). Zone age is Late Coniacian. VII complex of layers with *Inoceramus lesiginensis*. *Inoceramus crassus* Petrascheck, *In. inconstans* Woods are met. It is dated by Early Santonian. The *Dicarinella concavata* zone is characterized by the presence of *Inoceramus böhmi* and assigned to the Upper Santonian. It corresponds to-is identical to-the *Rosita*-emended as *Contusotruncana fornicate* zone. IX complex of layers with *Inoceramus salisburgensis*. This complex is correlated with complex X PF - *Globotruncana arca*, which is dated by Early Campanian. Complex X of *Inoceramus barabini* zone is characterized by presence of *Inoceramus simonovitchi* Tsagareli, *In.* cf. *regularis* d'Orbigny. Complex XI is identical with *Globotruncana ventricosa* zone and complex XII - *Globotruncana morozovae* (PF). Given complexes are dated by Late Campanian. XI complex of layers with *Inoceramus* cf. *clchicus* contains *Inoceramus simonovitchi* Tsagareli, *In.* cf. *regularis* d'Orbigny. *Globotruncana stuarti* (complex XIII) is distinguished here by planktonic foraminifera, in singular cases there presents *Gansserina gansseri* (Bolli). Stratigraphic spreading interval of this complex is corresponding to Early Maastrichtian. XII complex of layers with *Inoceramus planus* contains *Inoceramus* cf. *regularis* d'Orbigny. That complex is identical to *Abathomphalus mayaroensis* zone according to PF, and there also occurs *Abathomphalus intermedius* (Bolli). The interval corresponds to Late Maastrichtian.

Keywords: Cretaceous, Biostratigraphy, Planktonic Foraminifera, *Inoceramus*, Dzirula,.

AN UNUSUAL OCCURRENCE OF *COMPTONIA* IN MIOCENE DIATOMITES FROM THE ETİLİ LOCALITY (ÇANAKKALE–ÇAN AREA)

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A great number of leaves has been collected from the Miocene (late Burdigalian–Langhian) of Etili locality in the Canakkale–Çan area. Along with *Ulmus* sp, *Quercus* sp., *Myrica* sp., Betulaceae, Juglandaceae, *Liquidambar* sp., *Acer subcampestre*, *Zelkova* sp., *Celtis* sp., Cupressaceae; *Tetraclines*, *Pinus* sp. and Lauraceae, an unusual number of segmented leaves clearly belonging to *Comptonia* (Myricaceae) has been discovered. They are preserved as impressions in a light brown fine grained rock which turned out to be mainly composed of diatom shells. There is no organic material of the leaves preserved, but some details of cuticles may be recovered by SEM from the fine-grained matrix. Leaves of *Comptonia* are rare elements or even missing in many of the Miocene plant taphocoenoses not only of that area, but also over much of Europe. Today, *Comptonia* is a monotypic genus mostly restricted to poor and acidic substrates in the eastern half of North America, but it was widely distributed across major parts of the Northern Hemisphere throughout most of the Tertiary. Since there is only a single extant species, it is only of limited use as living relative for comparative palaeoecologic and palaeoclimatic analyses.

With respect to the frequency of *Comptonia*–leaves in the Miocene of Çanakkale–Çan area, it is interesting to note that the respective basin shows some volcanic influence and the host rock is a diatomite. There may have been areas blanketed by volcanic material, and sun-loving *Comptonia* may have been a member of the open pioneering vegetation with its deciduous leaves easily transported into existing lakes. Since silica was washed into these lakes due to leaching of loose volcanic material by percolating water, blooms of diatoms occurred and their shells have been preserved.

Keywords: *Comptonia* leave, Miocene, Çan, Diatomite, NW Turkey

SEISMIC STRATIGRAPHICAL INVESTIGATION OF İZMIT BAY WITH SHALLOW SEISMIC SECTIONS

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By using Uniboom system, 45 lines of shallow seismic records were obtained in the Gulf of İzmit. Total length of the lines is approximately 300 km. Apart from the seismic and bathymetric data, field geology knowledge was formed a basis for interpretations in this study. Each of the seismic section in itself be associated with each other have been interpreted stratigraphic and structural sense. As a result, formations and faults have been determined in the seismic sections.

By interpreting the seismic data obtained from investigated area using seismic stratigraphical methods, the following units have been defined from top to the bottom; recent sediments, truncation surface belongs to last glacial periods and the older sediments formed earlier to this period seen on acoustic basement. From old to young a total of 4 different type sedimentary series such as 1, 2, 3, and 4 have been identified on the acoustic basement. Sequence thickness varies between 10 milliseconds and 45 milliseconds. Unconformity surface, which is determined in the seismic sections, shows high reflection amplitude, undulating structures in all sections and the younger sediments are seen terminating by leaning on this surface. These unconformities are thought to occur as a result of the tectonic events.

Keywords: Shallow Seismic, İzmit Bay, Seismic Reflection, Sea Level Change

HYDROGEOLOGY

EFFECTS OF THE ANTHROPOGENIC ACTIVITIES ON THE GROUNDWATER HYDROLOGY AND CHEMISTRY IN DELİÇAY-TARSUS COASTAL AQUIFER (MERSİN)

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Deliçay-Tarsus coastal plain (DTCP) is located along the Mediterranean Sea coast of the Mersin province and covers an area of 234 km² between Deliçay and Tarsus (Berdan) Rivers. Due to ongoing intense anthropogenic activities in the area, the land use is very complex, where a significant portion (84%) of the area is utilized by various forms of agricultural activities. The most of the remaining area can be classified as forest, industrial, and residential. The ecological importance of the DTCP area, on the other hand, can be attributed to existence of important coastal ecosystems. For instance, the 4.5 km beach at Kazanlı is the second most important nesting site in the Mediterranean for the “critically endangered” marine turtle species. Nevertheless, the DTCP ecosystem has been irreparably altered by land use/cover (LULC) changes that took place mostly through human intervention, which in turn, resulted in modification of the basin hydrology, drainage patterns, groundwater storage and chemistry.

This study is aimed at investigating the impact of natural processes and ongoing anthropogenic activities on the groundwater chemistry and hydrology in the DTCP area. For this purpose, in August 2008, a total of 193 well and 10 surface water samples were collected for the characterization of their physicochemical properties and to gain a better understanding on interactions occurring between groundwater and surface waters in the study area. Additionally, in-situ hydraulic conductivity and water-level measurements were carried out in selected locations to determine the hydrogeologic properties of the DTCP coastal aquifer. The results obtained from this study were analyzed using various statistical and geostatistical techniques and compiled in a database using a Geographic Information System (GIS) to create, display and visualize various thematic maps showing the impact of human activities on groundwater hydrology and chemistry in the area. By far the most important pollution source in the area is seawater intrusion, which is caused by heavy groundwater pumping for agricultural, industrial, and domestic purposes. Especially, the vicinity of Kazanlı and Kulak coastal settlements were greatly affected by salinization of groundwater resources. Intense anthropogenic activities and land use changes occurred in the past 30 years have greatly affected the groundwater levels (compared to pre 1978 data), where in places 2 to 5 m declines observed in groundwater levels. This situation, in turn, has resulted in the modification of the groundwater flow directions and deterioration of groundwater quality and quantity in the DTCP area.

Keywords: Land Use, Multivariate Data Analysis, GIS, Groundwater Level, Water Chemistry

INVESTIGATION OF HYDROGEOCHEMICAL FEATURES OF WATERS IN INSUYU FORMATION (CIHANBEYLI-KONYA)

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The purpose of this study is to investigate hydrogeochemical properties of cold spring water and groundwater receiving from Insuyu formation which have approximately 500 km² area that located in the west of Cihanbeyli town, about 90 km north-eastern of Konya. Middle Miocene-Lower Pliocene aged Insuyu formation is composed of limestone, marl, sandstone, claystone and claystone with gypsum. Medium-thick bedded, abundant calcite-filled limestones have karstic structures.

In the Insuyu formation there are four cold water springs. All of the springs come out to surface by the influence of Cihanbeyli normal fault, extending from NW-SE to W-E directions and this springs constitute the Insuyu Creek. The springs have temperature range between 14,5-17,5 °C, discharge between 11-80 l/s and electrical conductivity value range from 608 to 745 µS/cm. Depth of 30 drilling wells in the Insuyu formation range from 30 to 120 meters. Groundwaters have discharge between 20-40 l/s and electrical conductivity value range from 562 to 1876 µS/cm.

Dominant cations in investigated springs and groundwaters are Ca and Mg, anion is HCO₃ and hydrochemical facies of water are Mg-HCO₃ and Ca-HCO₃. Lithological effects on the formation are fairly excessive. According to International Association of Hydrogeologists (IAH), Bogrudelik and Akpınar springs are Mg-Ca-HCO₃-Cl bearing waters, Pınarbaşı and Insuyu springs are Mg-Ca-Na-HCO₃-Cl bearing waters. Limestones belonging to Insuyu formations form the aquifer unit of the springs and groundwaters, clay and clay with gypsum levels constituted impermeable units.

δ¹⁸O values of investigated springs and groundwater vary from -8,12 to -10,58, δ²H values vary from 63,26 to 73,37, which reveal meteoric origin. The tritium values of springs and groundwater vary from 0,23-0,70 TU. This indicate long residence times and slow infiltration of precipitation. According to tritium values, waters also reflect deep circulation and are more old waters than 50 years.

Keywords: Insuyu Formation, Spring, Grundwater, Döterium, Tritium.

THREE-DIMENSIONAL SUBSURFACE CONTAMINANT TRANSPORT OF HEAVY METALS IN THE HYDROGEOLOGICAL SYSTEM BETWEEN LAKE MOGAN AND LAKE EYMR (GÖLBAŞI-ANKARA)

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Groundwater contamination in the hydrogeological system because of leakage from Lake Mogan (Gölbaşı, Ankara) was investigated by modeling the groundwater flow regime and monitoring groundwater quality. In this study, MODFLOW-2000 and MT3D-MS were used to estimate of groundwater flow and heavy metal transport in the hydrogeological system composed predominantly of alluvial deposits between Lake Mogan and Lake Eymir. Field observations and laboratory data indicates that groundwater flow Lake Mogan toward Lake Eymir is primarily occurs through sandy and silty-clayey horizons with respective hydraulic gradient and hydraulic conductivity values of $i \leq 0.0012$ and $10^{-8} \leq K \leq 10^{-10}$ m/s. The model grid covers an area 5.2 km southwest to northeast and 1.51 km northwest to southeast, covering a flow domain of 7.86 km². The transient state model was calibrated to historical surface water and groundwater level data between September 1999 and March 2006. The simulated water balance shows that about 0.00084 m³/s of recharge from Lake Mogan to hydrogeological system and 0.00046 m³/s of discharge from hydrogeological system to Lake Eymir. Laboratory batch sorption and column transport experiments were performed to determine transport parameters. The batch sorption experiment was conducted in two separate systems, i.e. single and multi components. Single batch experiment was performed to determine equilibrium condition between the heavy metal ions and soil adsorption sites. The sorption isotherms data from multi batch experiments were used to calculate the sorption parameters. Single batch experiment indicated that equilibrium was attained within 9 days from the start of the sorption test. As a result of multi components batch experiments, carried out under the local chemical equilibrium assumption, for Zn and Mn, the sorption process was well described by the Freundlich or Langmuir isotherm model whereas sorption of Cu was better described by the linear isotherm model. Dispersivity coefficient was estimated from breakthrough curves of NaCl measured under steady-state flow conditions. Solute transport models have been run first for the case without sorption then, run for the case where sorption is effective. In the first case, contaminants were found to spread spatial-temporally in the flow domain based on the prevailing advective and dispersive processes. In the second case, on the basis of K_d values, a sorption order of Cu > Zn > Mn were found to be effective under natural flow conditions for the contaminants entering the hydrogeological system from Lake Mogan. Based on a scenario that, the constant concentration of 100 gr/m³ attributed to Mogan Lake for 30 years, following a period of 30 years of zero concentration, and the spatial and temporal distribution of the concentration in the hydrogeological system is estimated for 60 years. Mass transport model infers that the amount of Cu to be sorbed in aquifer during the next 60 years will amount to 2x10⁸ gr, while the amount of Cu arriving at Lake Eymir would be 0.062 gr. The amounts of Zn and Mn to be arrived at Lake Eymir at the end of 60 years simulation period are found to be 4200 gr.

Keywords: Lake Mogan, groundwater flow, MT3D-MS, solute transport model, heavy metals

IN-SITU THERMAL RESPONSE TEST FOR BOREHOLE THERMAL ENERGY STORAGE APPLICATIONS IN TURKEY

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Underground thermal energy storage (UTES) is a reliable, sustainable and energy-saving Technology for cooling and heating of the buildings and industrial processes all over the world. BTES (Borehole Thermal Energy Storage) is a type of UTES systems which use the borehole heat exchangers (BHE) for energy storage medium. For successful BTES applications, thermal conductivity of the ground and the thermal resistance of BHE are the two most important design parameters. These two parameters can be determined by in-situ measurements which give reliable design data. The measurement method has been developed in the past decade, and is now usually referred to as the Thermal Response Test (TRT). In recent years, BTES applications started to increase in Turkey. For proper design and operation of BTES systems in Turkey, it is essential to carry out an in-situ TRT prior to construction of each system. This paper attempts to give the current situation of TRT test in Turkey.

The equipment used in TRT was constructed at Lulea University of Technology in 1995-1996 and donated to Cukurova University Center for Environmental Research as part of the collaborative activities within International Energy Agency Implementing Agreement on Energy Conservation through Energy Storage. The TRT equipment is on a covered trailer and consists of a built-in resistance electric heater, data acquisition system, an expansion tank of 0.05 m³. 1.75 kW pump circulates the heat carrier fluid through the borehole. The heater has a step-wise adjustable power rates of 3-12 kW. The inlet and outlet fluid temperatures, ambient air temperature, air temperature inside the trailer, power rate are measured and recorded by the data acquisition system at desired time interval on site. Borehole thermal resistances, R_b and effective ground thermal conductivities, λ_{eff} are determined using the line-source method to evaluate the test results.

Since 2000, more than 20 thermal response tests have been realized by Çukurova University in Turkey. Each test differs in geological, climatic conditions and BHE characteristics. In this paper some test results will be given.

In-Situ TRT is a routine tool that is used for investigating the ground thermal properties for the design of BHE in many countries around the world. Using the line-source based evaluation technique borehole thermal resistances and effective ground thermal conductivities are determined for different sites in Turkey. These values obtained are necessary for the optimized design of the BTES system.

Keywords: Ground sources heat pump, Borehole thermal energy storage, thermal resistance, thermal conductivity, energy efficiency

THE DETENTION OF KARST DEVELOPMENT IN THE ALADAGLAR RANGE (KAYSERİ, NİĞDE, ADANA) DURING THE QUATERNARY GLACIATIONS

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The Aladaglar Range, extending in an area of 1000 km² between the elevations of 400 m and 3750 m, hosts one of the important karst aquifers in Turkey with an average annual discharge of 1 billion m³. The development of karst in the massif started in Late Paleocene by hypogenic processes and continued until Late Miocene by epigenic processes under tropical, sub-tropical and temperate climate conditions. Both the elevation reached by the late Miocene and the cooling trend in global climate resulted in the dominance of the freezing/thawing and glacial processes between the Pliocene and Middle Holocene. During the Pliocene, the freezing and thawing processes became effective particularly at the higher elevations and limited the recharge by precipitation due to partial destruction of epikarst zone. The remaining epikarst zone has been scoured completely by the extensive glaciations during the Pleistocene. During this period, many of the previously active karst shafts have been clogged with the debris produced by glacial scouring. The recharge of karst system by precipitation decreased largely due to scouring of epikarst zone, clogging of vertical karst shafts and locking of precipitation recharge in ice phase during the Pleistocene glaciations. Despite the substantial decrease in the discharges of karst springs, the surface flow fed by the snowmelt and precipitation at lower elevations enabled a continuing incision in the major streams surrounding the massif during the Pleistocene. This situation limited the karst base level incision toward valley bottoms and resulted in the formation of springs, which are hanged on the valley walls today. The dominance of temperate climate since late Pleistocene caused complete melt down of the ice cap and valley glaciers and initiated the recharge of karst system by annual precipitation that resulted in the reactivation of major karst springs. The travertine bridges located over the Zamanti River at the downstream of major deep-flow karst springs are thought to have formed since Early Holocene reactivation of these discharges. The mild and wet climate conditions that have been affecting parts of the massif looking at the Mediterranean Sea since Early Holocene resulted in development of the polygonal karst landforms abound with karrens and dolines up to an elevation of 1800 m. The current dominance of freezing and thawing processes at upper elevations prevents development of epikarst.

Keywords: glaciation, karst, hydrogeological system, Aladaglar, Quaternary

“ENGINEERED SINKHOLES” TO INCREASE WATER RESOURCES ARTIFICIALLY

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Climate change, population growth and improper use of water cause freshwater resource shortages around the world. Artificial recharge, defined as “augmenting the surface water into underground formations”, intends to increase the long term stability of a clean water supply to both people and the environment. The main advantages of storing water in aquifers are to reduce of evapotranspiration and keep water clean.

Flood control structures, store the excess water with little benefit, reduce recharge, and increase evapotranspiration, are common in arid and sub-arid environments. There are thousands of them in the United States alone. The alternative methods for artificial recharge have been evaluated for upstream flood control dam #37 in southern Oklahoma in order to prevent some storm water from becoming run off and to use it more wisely. This study shows that an “engineered sinkhole” will be best solution for artificial recharge in terms of environment, safety and economy.

Keywords: artificial recharge, engineered sinkhole, flood control structure, Arbuckle-Simpson aquifer.

GEOCHEMISTRY OF GROUNDWATER OF RROGOZHINA AQUIFER (WESTERN ALBANIA)

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The aquifer of Rrogozhina spread out over the Albanian pre-Adriatic depression and extends from Shkodra in the north to Vlora in the south, over a surface of 2100 km². It is a multilayered aquifer consisting of intercalations between water-bearing Pliocene sandstone and conglomerate with impermeable clay layers. This aquifer occurs under typically artesian conditions because of its impermeable clay basement and semi-impermeable Quaternary cover. The main recharge source of the aquifer is represented by precipitations thanks to its vast (around 500 km²) outcrop on the hilly terrains. Other recharge sources of the aquifer are the Quaternary alluvial aquifers on it, the rivers that intersect the aquifer transversally and the boundary aquifers. The groundwater shows variable geochemical composition due to different mineralogical composition of its medium, vast extension of the aquifer, variable geological and hydrogeological features, relationships with boundary aquifers and seawater, relations of the tested groundwater with respect to recharge and discharge zone and possibly the depth of wells. However, the mainly magmatic – carbonatic mineralogical composition of the water – bearing sandstones and conglomerates has determined a geochemical composition of groundwater consisting mostly of HCO₃-Mg-Ca hydrochemical groundwater type. Such a geochemical composition characterizes the groundwater of Rrogozhina aquifer as chemically immature groundwater, which mainly plots near the center of the Piper plot. Dissolution of minerals seems to be the major geochemical processes in the formation of the groundwater composition. Other hydrochemical types are less important and are mainly related with the Na enrichment in water through cation exchange processes between groundwater and clay formations that are more abundant over the plain extension of the aquifer. The above mainly magmatic composition of sandstones and conglomerates is also responsible for the high content of iron in the groundwater of this aquifer. Iron content is higher in sandstone related groundwater where the silt fraction is mainly composed by iron-bearing minerals such as magnetite, epidote, granate, sphene, amphibole and pyroxene. In general, the wells are drilled down to 250m. The general mineralization and general hardness of groundwater pumped from the above drilled section range from 500 to 800 mg/l and from 11 to 25°dH, respectively. At the pHs commonly encountered in groundwater (pH=7.0-8.5), HCO₃⁻ is the dominant carbonate species present. In general, up to the above drilled depth, all the hydrochemical parameters of the groundwater fit the Albanian and EU limits for the potable water. In some cases, NH₄⁺, SO₂, Cl⁻, etc, are found in concentrations higher than the limits of drinking water. In the diagram (not shown) of Total Mineralization (TM) versus well depth (H) was found that groundwater can maintain TM values less than 1.0 mg/l up to a depth that ranges from 400 to 500m according to the well position with respect to recharge and discharge zone.

Keywords: aquifer, groundwater, geochemical composition, mineralogical composition.

AQUIFER THERMAL ENERGY STORAGE FOR GREENHOUSE CLIMATIZATION

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The goal of this paper is to determine the heating and cooling potential of greenhouses in the Mediterranean climatic zone, with aquifer thermal energy storage (ATES) known as one of the underground thermal energy storage application systems (UTES). In 21st century Turkey has become the 5th largest under-cover crops producer in the world. For high yield and quality in greenhouse crops during the winter months, inside temperature should be maintained at the critical value that can change depending on the species grown in greenhouse. For instance, for tomatoes the critical inside temperature should be maintained not below 12-13 °C and not above 30 °C in the greenhouse. Based on this criterion and last 20 year's climate data in Mediterranean Region, a greenhouse needs approximately 150 kW to meet the heating load during 90 days of a year for 8 hours in a day (Abak et al.1995). To provide this heating load, 6 L/m² No 6 Fuel-Oil or 9 kg/m² coal must be consumed. The fossil fuel consumption leads to an economic burden in the operating cost, besides ashes and undesirable gas emissions from coal combustion are the biggest barriers of the greenhouses in the Mediterranean zone. Additionally, the cooling requirement of the greenhouses for early autumn and spring months in the Mediterranean Climate and the advantages provided after cooling applications have been calculated in this project.

In this application, two separate greenhouses, each having an area of 360 m², in the research area of the Horticulture Department - Faculty of Agriculture have been selected. One of them was heated and cooled by ATES technique. In the second one conventional heating system was used and there was no cooling system. Tomato and eggplant were cultivated in both greenhouses. Outside and inside temperatures of greenhouses, as well as ground water and exchanger water temperatures were recorded during whole experimental period. Plant growth and fruit yields were also measured.

The results from tomato and eggplant cultivated greenhouses heated and cooled by ATES and conventional heating system will be presented in this paper. Consequently, these two different systems/greenhouses were compared in terms of economical, environmental and agricultural aspects. ATES greenhouse used nearly 78% less energy than the control greenhouse. Also regarding "0" fossil fuel usage in ATES greenhouse, positive environmental impact resulting from reduction in emissions are observed. Additionally the amount of crop production was about 20% more for the ATES greenhouse.

Keywords: Aquifer Thermal Energy Storage, Aquifer, Energy Conservation, Environment

EFFECT OF ILLEGAL WELL ON GROUNDWATER IN THE CUMRA PLAIN (KONYA):A CASE STUDY ON THE ALIBEYHUYUGU

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The study area is located in the south-eastern part of Konya city. Çumra plain has important water potential. Decreases of groundwater level are increasing because of global warming, climatic change, scarcity of rains, unconscious usage, changing of plant pattern in recent years. In study area, in 2009, monthly average temperature is 11,42 °C, annual average rainfall is 295,38 mm. Evaporation is 281 mm which makes up 95 % of the annual rainfall.

Lower Jurassic- Lower Cretaceous aged Lorasdağı formation form the basement in the study area. This basement is overlined angular unconformably by Upper Miocene- Lower Pliocene aged Ulumuhsine formation which is overlined angular unconformably by Pliocene aged Divanlar formation, Cumra formation and Yagmurlar formation and Qaternary aged alluvium overlies all these units by unconformity.

In the study area, Ulumuhsine, Cumra ve Yagmurlar formastions and alluvium include water flowing in a direction is from southwest to northeast.

In Konya Closed Basin, there are 22000 legal drilling wells, 67000 illegal drilling wells and vast majority of them are Çumra plain.

Depths of illegal drilling wells in the Alibeyhüyüğü town varies between 100-200m., discharge is between 11-80 l/s, static level range from 25 to 28 meters. The amount of water drawn from the illegal wells is approximately 4 times higher than the legal wells. Increasing number of wells from day to day and uncontrolled excessive water pumping cause decreasing of groundwater levels in the study area which has a semi-arid-arid characteristics.

Keywords: Alibeyhüyüğü, Illegal well, groundwater level, static level

GROUNDWATER AND SALINITY EXPLORATION BY USING VERTICAL ELECTRICAL SOUNDING METHODS. A CASE STUDY, HATAY AREA

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In this study, Vertical Electrical Soundings (VES) were made in order to determine the potential of groundwater transportation and hydrogeology around the areas of Yayladağ district in Hatay Province. Potential of electric current transmission of a geological unit depends on the porosity of the material, the degree of pore-pore connections, the volume of water in pores and conductivity. According to Schlumberger electrode arrays, at the total of 30 points in the range of $AB/2=350$ m, by using DES (Vertical Electrical Sounding) measurements, apparent resistivity values were calculated in the study area.

Obtained apparent resistivity values have been evaluated by using the IPI2WIN computer program, thus, the real resistivity values of the layers on each point and layer thicknesses have been determined. Following this, according to the obtained data, geoelectrical sections have been prepared and two drilling locations that probably contain groundwater have been identified.

The study area is close to the sea and irrigation cooperatives and individuals in the region, the pumping of water from wells or taken into account, the sea water in regions affected by the detection of possible interference was investigated. In this program, using Surfer 8, $AB / 2 = 20$ m, 50 m, 100 m, 150 m, 200 m and 250 m of contour map was prepared for the apparent resistivity. With the result that the resistivity values obtained in the study area due to the high level of salt water with no intervention were identified.

Keywords: Groundwater, Resistivity, VES, Aquifer, Salinity

EVALUATION OF EFFICIENCY OF SAMARRA DAM RESERVOIR ON TIGRIS RIVER, MIDST OF IRAQ

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The study aims at evaluation of the changes that occurred at Samarra dam reservoir, in terms of dependency on water quality, flow properties of Tigris River, the chemical composition and grain size analysis of the sediments, trap efficiency of the reservoir and estimation of the quantity of the sediments accumulated in the reservoir along the previous fifty years.

The data of discharge, velocity of current and slope of water surface were analyzed to estimate the condition of sediment transport and sedimentation in the reservoir.

Hydrochemically, the pH, EC, TDS, TSS, TH, SAR, cations K⁺, Na⁺, Mg⁺⁺, Ca⁺⁺, anions Cl⁻, SO₄⁼, HCO₃⁻, and trace elements Fe, Cu, Ni, Pb, Cr were determined to evaluate the water quality. The hydrochemical facies and water type were derived from these data. The water classified as fresh and it is usable for different purposes.

The grain size analysis was done to determine the nature, origin, transport of the sediments and to design the method of draining of these sediment out of the reservoir. The wet sieving method used to determine the percentage of sand, while hydrometer analysis was used to separate the clay and silt percentages. The percentages are 0-6%, 51.3- 73.34%, 24.83- 35.89% for sand, silt and clay respectively, which reflect the dominating size as silt, and reveals that the clay percent compose of the fine particles that are drained out of the reservoir as suspended load.

The geochemical analysis of reservoir sediments showed that the average values of organic material, pH, EC, CaCO₃ are 4%, 8.1, 0.46 ds/m, 21.8% respectively, according to these properties the sediments of reservoir can be used as agricultural soil in the nearby areas.

The estimated trap efficiency of the reservoir was 0.09, which reflects low efficiency of reservoir to trap the sediment that extends the economic life of the reservoir. The annual suspended load that enter the reservoir was calculated as 3820000 tons, and the annually trapped sediments is 343800 tons, so, the trapped sediments along the last 50 years is 17190000 tons. These data can be used by the dam operators to design the program of draining of sediments out of the reservoir.

Keywords: Samarra, dam, reservoir, Hydrochemistry, trap efficiency

PRELIMINARY WORKS OF A GROUNDWATER FLOW MODEL; VALCO SAN PAOLO (ROME-ITALY)

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The preliminary procedures of a groundwater flow modeling includes these following steps; Define study objectives, develop a conceptual model and select a computer code.

The Valco San Paolo district is located in the south of Rome urban area along the Tiber River, and the development of a groundwater model has made necessary to study the groundwater circulation because of the new construction of important buildings. The geological reconstruction of the studying area based on data collected from 267 boreholes variable from shallow to deep. Seven cross sections are constructed through the alluvial body. The reconstructed units consist of: about 1.5 m of man-made fill; about 7.5 m of “historical” alluvia, clay silt evolving into sandy silt and into weakly silty sand with diffuse organic matter; roughly 10 m of yellowish to black sand with a gravelly basal layer having millimeter-scale elements in a sandy matrix; approximately 30 m of silty clay with diffuse organic matter and scarce sandy intercalations; gray sand gradually passing to gravel downwards; about 12.5 m of prevalently calcareous-marly gravel with heterometric centimeter-scale elements. Starting from about 63m from ground level, this alluvial succession of Holocene age (14,000 a to present) rests, with erosional contact, on consistent clay of Pliocene age (Marne Vaticane - UMV); these marls represent the geological bedrock of the area. According to this study, sediments divided into 6 main units. Top elevations of every units formed in ArcMap 9.2 by interpolation and the best fit computer contouring method has been chosen for each surface.

Development of the conceptual model requires the collection and analyses of hydrogeologic and hydrologic data pertinent to the aquifer system under investigation. By means of monitoring, the amount of water exchange between river-aquifer can be well understood. Level and temperature variations of Tiber river, electrical conductivity, temperature, pH variations of confined basal gravel and sand aquifer are monitored during 3 months (Sept.-Dec.2009). The hydrogeological analysis was based on an interpretation of water-level data obtained from both Casagrande piezometers and open tube piezometers are measured in the study area together with permeability data for the different lithotypes and background literature information. Hydraulic boundary conditions which are the interface between the model area and the surrounding environment have been selected. The model area is 6.5 km² and was discretized with a finite-difference grid that was composed of 26 rows and 25 columns with uniform cell dimensions of 100 m by 100 m.

Groundwater flow model construction is the process of transforming the conceptual model into a mathematical form. Fundamental components of the groundwater flow model include: dimensionality, discretization, boundary conditions and hydraulic properties form the basis of preliminary works of groundwater modelling.

Keywords: Groundwater Modelling, Conceptual Model, Boundary Conditions, Aquifer, Tiber Alluvium

DETERMINATION OF THE CATCHMENT BASIN AREA OF KARSTIC SPRINGS IN THE NORTH- EAST OF KHOUZESTAN, IRAN

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The karstic springs of Bibi-Talkhon and Dare-Anaari are among the biggest karstic springs of north-east of Khuzestan (SW Iran), which have been in the Zagros folded zone, and they will be appeared a long with Thrusts of Pabdeh and Chale-Monnar respectively. Calcareous reservoir rock of these karstic springs, are placed in the south limb of anticlines-Pabdeh and Chale-Monnar respectively. These rocks are called Asmari limestone, and they are highly faulted and crushed. By studying the physico-chemical parameters, and hydrogeological and structural reviews, possible catchment basin of these springs was determined. In this study, in order to calculate area of the catchment basin of these springs, the dynamic storage calculation method of the karstic limestone was used, and based on the area of the catchment basin of these springs; counting 50 percent penetration rate was determined.

Keywords: Karstic spring, Anticline, Catchment basin, Karstic limestone, Thrust

DELINEATION OF BASIN BOUNDARIES OF SAIMBEYLI (ADANA) OBRUK WATERFALL HYDROLOGICAL SYSTEM BY USING GIS

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A basin is an area which is surrounded by natural borders that controls the hydrological system. Once the basin is defined the system can be understood better and also the response to different effects of the system can be analyzed. For this purpose, Saimbeyli Obruk Waterfall karstic system's catchment area was selected as the study area and the morphological properties of the basin and the drainage pattern to be used in the hydrological analysis by using GIS.

The study area is located in western part of Eastern Taurus between Tufanbeyli and Saimbeyli towns about 160 km to the north of Adana. It takes place partly in the topographical maps Elbistan L36 d3, L36 d4, Gaziantep M36 a1 and Adana M35 b2. Within this context, the basin boundary of Obruk Waterfall spring was delineated. The spring is discharged from Jurassic-Cretaceous Köroğlutepesi karstic limestone which extends in the NE-SW direction over a surface area of 59,95 km². Delineation of the basin boundaries was achieved by Archydro application of ArcGIS 9.2 software. This application has been performed for both the whole basin including all the study area and the sub basin of the karstic spring. The polygons obtained through this application were then saved as separate GIS layers. In this study, the base map used for the application is the topographic map of 1:25 000 scale. The following steps were followed in order to accomplish the delineation of the watershed; preparation of TIN files, preparation of digital surface modeling and determining the basin boundary of Obruk karstic spring by applying Archydro application of ArcGIS 9.2 software.

Total 35,91 km² area has been calculated for the basin of Obruk Waterfall. As the ArcGIS program defines the watersheds according to only the drainage patterns a sub basin has been delineated for the study area. Saimbeyli Obruk Waterfall is a karstic spring which discharges through a strike slip fault. So the fault boundary has been taken into account when the catchment area was delineated for the study area.

Keywords: Geographic Information System, Archydro, Basin, Obruk Waterfall, Köroğlutepesi Karstic Limestone

MINEROLOGY &
PETROGRAPHY

MAGMATIC EPIDOTE IN THE DEFORMED GRANITOIDS OF THE NORTH OF SHAHREKORD, SANANDAJ–SIRJAN ZONE, IRAN

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Numerous large and small plutons of syn-tectonic granitoids were intruded in a ductile shear zone in the north of Shahrekord, Sanandaj–Sirjan Zone, Iran. Field observations and petrographical studies indicated that these syn-tectonic rocks were intruded in metamorphic rocks. Granitoids, which show foliation and lineation due to mylonitization, are seen as elongated bodies stretching parallel to the main trend of the shear zone. The trend of foliation and lineation in granitoids is also seen fully parallel to the country rocks. Mylonitic foliation is defined by biotite, allanite and amphibole. Stretched quartzes are also seen parallel to foliation and show undulose extinction and partially in the form of subgrains. The mineralogical compositions of these granitoid rocks comprise quartz, k-feldspar, plagioclase, biotite, amphibole, allanite, apatite, magnetite, zircon, epidote, clinozoisite and sphene. White mica hasn't been observed as an original mineral, but in some of extremely deformed granitoids, it formed at the expense of feldspars during fluid- influenced deformation. Epidotes exhibit magmatic origin texturally and compositionally and indicate that the granitoids must have formed at high pressures. Epidote is a common late-stage magmatic mineral in calc-alkaline plutonic complexes. Its occurrence is a function of partly magma composition and partly the depth of emplacement. Very low TiO_2 (<0.1 wt %) and pistacite contents ($\text{Ps} = [(\text{Fe}^{3+} / (\text{Fe}^{3+} + \text{Al}))]$) of Ps_{27} to Ps_{30} are diagnostic of magmatic epidote. Since magmatic epidote is stable at >6 kbar in granitoid magmas, the granitoids of the north of Shahrekord must be formed in high limiting pressure during deformation.

Keywords: Magmatic epidote, deformed granitoids, shear zone, Sanandaj – Sirjan Zone

A QUANTITATIVE MINERALOGICAL STUDY OF CHROMITE ORES FROM POZANTI-KARSANTI OPHIOLITE AND ITS EFFECT ON CHROMITE SAND BENEFICIATION

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The Pozanti-Karsanti Ophiolite (PKO), located in the western part of the eastern Tauride belt, Southern Turkey is a late cretaceous oceanic lithosphere remnant (Parlak, 2000). The mantle portion of the PKO hosts chromite ores within dunite pockets inside harzburgites with different degree of serpentinization. The present study concerns several small chromitite bodies located about 40 km NE of Aladag. They show quite different features in terms of texture, degree and type of alteration and mineralogy.

Small amounts of high Cr_2O_3 chromite ore have been mined from several places within one exploitation license, either from open pit or gallery works. In order to assess the possibility to install a chromite sand beneficiation plant, the parameters of chromite ore that affect enrichment have been determined. The most critical of such parameters is quantitative mineralogy as the small size of the deposits requires to develop a cost efficient technique and hence high cost techniques like the use of Mineral Liberation Analyzer (MLA) or QUEMSCAN are not affordable. The best technique to be used depends on ore mineralogy and geochemistry. For low altered chromitite where the assumption of homogeneity of chromite Cr_2O_3 content and absence of Cr_2O_3 in the silicate matrix is valid quantitative mineralogy can be assessed by image analysis on representative thin sections. For more altered ores, where ferritchromite is present and Cr_2O_3 is to some extent redistributed within silicate phases quantitative mineralogy can better be determined with a combination of image analysis on BSE images and Quantitative Phase Analysis (QPA) based on powder X-ray diffraction analyses.

Quantitative mineralogy was used together with average mineral chemistry of all the main phases to assess the possibility to enrich the studied chromite ores. Results show that some of the chromitite bodies can be enriched by gravity separation at a low to intermediate efficiency of the beneficiation plant.

Parlak, O. (2000). Geochemistry and significance of mafic dike swarms in the Pozanti-Karsanti ophiolite (Southern Turkey). Turkish Journal of Earth Sciences (Turkish J. Earth Sci.), vol. 9, pp. 29-38.

GEOLOGY AND NI-CO MINERALIZATION OF LATERITES OF THE OMAN MOUNTAINS

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After the emplacement of the Oman ophiolite, a slab of oceanic crust and upper mantle, onto the East Arabian margin during the late Cretaceous lateritic profiles developed as a result of long-lasting weathering of the ophiolitic rocks under tropical to subtropical conditions.

Field observations and mineralogical analyses of nine lateritic profiles from four separate localities (Ibra, East Ibra, Tiwi and Al-Russayl) along a NW-SE transect across the Oman Mountains indicate that the laterites consist of four distinct zones showing local variations within each profile. These zones include in ascending order the following facies: a) protolith (saprock), b) saprolite (locally containing boulders), c) oxide-rich laterite (locally pisolitic and with multiple silcrete layers), and d) clayey laterite. These lateritic profiles are capped unconformably either by clastics of the Late Cretaceous Qahlah Formation or by Palaeogene carbonates of the Jafnayn or Abat Formations.

The bulk geochemistry of the different rock types in the sections shows a typical Ni-laterite pattern, in which magnesium (Mg) and silica (Si) become depleted towards the top of the profile, whereas iron (Fe) and aluminum (Al) increase. In the Ibra sections, a significant enrichment of Ni (1.75%-1.91%) occurs in the altered gabbro just above the protolith, while the Ni content decreases significantly in the saprolite zone down to below the detection limit. The behavior of cobalt (Co) is similar to that of Ni, with an observed increase from 0.01% in the protolith up to 0.04% and 0.07% in the oxide and clay laterites, respectively. Generally, Ni, Co and manganese (Mn) are enriched in the oxide-rich horizon particularly near the interface between the limonite and saprolite zones. In the East Ibra profiles, Ni increases from 0.16% to 0.26% in the protolith and saprolite, respectively, to about 0.56% in the lower part of the oxide zone, and to about 0.97% in the uppermost clay-rich zone. Cobalt follows a trend similar to that of Ni, increasing from 0.01% in the protolith to 0.06% in the upper parts of the oxide laterites. In the Al-Russayl profiles, Ni and Co grade up to 1.3% Ni and 0.07% Co compared to the less developed saprolite (0.17% Ni and 0.01% Co) with local high concentrations of up to 1.64% Ni and 0.33% Co. In the Tiwi profiles, Ni shows a slight enrichment in the oxide zone (0.37%) compared to the saprolite (0.22%) and protolith (0.20%). The highest Ni concentrations (0.66%) is found in the lower part of the oxide zone near the contact with the lower saprolite zone. Cobalt shows some enrichment in the oxide zone where it reaches up to 0.02% compared to 0.01% in the saprolite zone.

The geological and geochemical characteristics of the investigated laterites reflect that they formed under paleoclimatic and paleotopographic conditions suitable for the formation of well developed laterite profiles across the Oman Mountains. The identification of the main Ni-bearing minerals and the estimation of the laterite grade and tonnage are currently being under investigation for economic considerations.

Keywords: Laterite, Nickel, Ophiolites, Oman Mountains

MINERAL-CHEMISTRY OF COGNATE INCLUSIONS IN ALKALINE ULTRAPOTASSIC LAVAS FROM DENİZLİ REGION, WESTERN ANATOLIA: PETROGENETIC IMPLICATIONS FOR SHALLOW LEVEL MANTLE PROCESSES

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Bulk-rock and mineral-compositions of cognate inclusions found in alkaline ultrapotassic magmas from Kocapınar district (Denizli - western Anatolia) have been investigated. Mineral assemblages consist of phlogopitic mica, diopsidic clinopyroxene, K-feldspar, apatite and calcite-dolomite minerals. Whole-rock geochemistry of inclusions show a near-primitive nature with high MgO (up to 15.1 wt.%), Cr (195-2270 ppm), Ni (213-335 ppm) and a potassic character, K₂O 1.97-2.81 wt.% (greater than Na₂O, 0.42-2.17 wt.%). These data imply that the inclusions crystallized from magmas formed by melting of a metasomatised, enriched peridotitic mantle source. The analyzed phase compositions of inclusions in ultrapotassic rocks in Kocapınar district also provide geobarometric constraints on magmatic crystallization conditions. The Putirka et al (2003) geobarometer were used to estimate pressure of crystallization based on clinopyroxene compositions; the results indicate relatively low to moderate pressures of (ranging between 0.14 – 2.49 GPa, corresponding to 4.5-76 km depth) crystallization. Titanium, Cr and Ba contents of phlogopite in the inclusions are significantly higher than in phlogopites reported from garnet-peridotites, reflecting crystallization of an enriched magma that was not saturated with spinel in the upper mantle. In other words, the unusually high Cr contents of phlogopite as well as clinopyroxene and the bulk rocks reflect an unusual ultrapotassic and mafic magma which was not saturated with spinel but was saturated with olivine based on Ni contents less than 400 ppm. The absence of olivine in the inclusions and the relatively low Ni contents indicate that early-formed olivine probably reacted with liquid to form phlogopite. Groundmass sanidine is a late stage phases. Presence of calcite and dolomite in the inclusions may indicate an important role for CO₂-rich fluid/melts in the petrogenesis of these magmas. The relatively low to moderate pressures inferred for crystallization of these inclusions are consistent with a shallow level mantle petrogenesis rather than a deep-seated origin related to mantle convection.

Keywords: Cognate inclusions, Mineral-chemistry, Ultrapotassic lavas, Denizli, Western Anatolia

PLATINUM GROUP ELEMENT & MINERAL GEOCHEMISTRY OF THE CHROMITITES IN KIZILDAG (HATAY) OPHOILITE, S TURKEY

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Kızıldağ ophiolitic complex, being an allocthonous mass, is the last member of Amanos mountain in southern Turkey. The Kızıldağ ophiolite is one of the best preserved Neothetian oceanic lithospheric remnants of Turkey. It is represented, from bottom to top, by mantle tectonites, ultramafic to mafic cumulates, isotropic gabbros, sheeted dike complex, plagiogranites and extrusives (low-K tholeiites and boninites). The ultramafic to mafic cumulate rocks are composed of dunite, wherlite, olivine gabbro, olivine gabbro-norite and gabbro. The sheeted dikes are composed of diabase and microdiorite. There are tectonitic rocks such as harzburgite and dunite which are stratigraphically visible at the bottom level of Kızıldağ ophiolite.

The chromitite deposits, studied for PGE geochemistry in Kızıldağ ophiolite, are hosted by cumulate dunites (banded and disseminated type) and tectonite dunites at Hatay-Kisecik-Sarıgöl area. Total PGE content of chromitite samples are between 94-334 ppb, the Pd/Ir ratios are between 0.16-1.50, and Pt/Ir ratios are between 0.25-1.85. It has been determined that all the samples are enriched for Ir-group PGEs (average Os: 33.5, Ir: 31.3, Ru: 76.6, Rh: 11.3, Pt: 23.3, Pd: 15.8 ppb).

PGMs in Kızıldağ chromitites are laurite, erlichmanite, iridium, osmium, native palladium, PGE alloys [(Pt,Fe) and (Pt, Cu)] and irarsite. Au-Ag alloys are also detected. The Ni sulphides are heazlewoodite, millerite, awaruite, pentlandite, as well as native Cu and other sulphides. Notable amounts of uvarovite, which replaces chromite at the margin and between its grains, as well as chlorite which replaces olivine can explain the source of the unusual Au mineralization as the result of the contact metamorphism and interaction of a mafic ore body with ultramafic matrix rocks.

According to previous studies the ophiolitic suite may be interpreted to include two different parental magma source with tholeiitic and boninitic composition and Kızıldağ chromitites have a supra-subduction zone (SSZ) origin. High-Al chromite composition of Kızıldağ chromitites and their IPGE enrichment indicate that they are much more fertile for hosting PGM concentrations in the chromitites.

Keywords: Hatay, Kızıldağ, Chromitite, Platinum Group Elements, Platinum Group Minerals

TECTONO-MAGMATIC EVOLUTION OF THE CENTRAL IRANIAN BASEMENT DEDUCED FROM THE METAMORPHIC ROCKS EXPOSURES

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The central Iranian realm is a combination of different fold-thrust belts with basement exposures covered by thick sedimentary strata. Limited stratigraphy and geochronology studies combined with geochemistry of orthogneissic rocks led to identification of several crustal blocks with basement rocks, exposed as tectonic windows, in central Iran.

Available geological and geochronological data indicate that there were strong extensional phases during late Cretaceous time in Iran. These phases may be related to subduction initiation in Zagros and/or back-arc opening in Central Iranian block. Such extensional phases are accompanied by core complexes/exhumation of high-grade metamorphic rocks in central Iran. To date just four core complexes have been reported in Iran. One of these core complexes (Biarjomand core complex) is located in NE Iran, south-southwest of the Sabzevar upper Cretaceous ophiolite. The other tectonic window including high-degree metamorphic rocks is located SW of the Biarjomand core complex, and known as Chah-Jam metamorphic rocks. The main question here is what is the relationship between Sabzevar basin and core complex formation/exhumation of the metamorphic rocks? What are the age of core complex protolith and the age of exhumation?

The Biarjomand metamorphic core complex is a ~60 km long, a NE-trending structure which lies in NE central Iran near the boundary with the eastern Alborz Mountains. The complex consists of three structural units separated by two major low-angle normal faults. (1) A core consisting of amphibolite-grade gneisses, amphibolites, mica schists, dolomitic marbles, quartzites and gneissic granites. (2) A low-grade metamorphic carapace of Jurassic mylonitic volcanoclastic rocks and 3) An unmetamorphosed cover section consisting of Jurassic-Cretaceous carbonates.

The Chah-Jam metamorphic rocks are mostly composed of orthogneiss, amphibolite with well-developed garnet-bearing leucosome veins and/or felsic dikes, indicating high-temperature crystallization. Metasedimentary rocks with marl protolith accompany the gneissic rocks.

Like as other studies, focused on the central Iranian basement, geochronological data indicate that the protolith of the metamorphic successions formed during Late Neoproterozoic continental arc magmatism and exhumed later during late Cretaceous extensional phases.

Keywords: Metamorphic basement, Core complex, Orthogneiss, geochronology, Central Iran.

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