**כ"ג - כ"ה אדר התשע"ז, 21-23.3.2017**

# כנס החברה הגיאולוגית הישראלית

## מצפה רמון 2017

## חוברת תקצירים


**החברה הגיאולוגית הישראלית מודה למוסדות ולגופים הבאים**

**על תמיכתם ותרומתם לכנס השנתי במצפה רמון 2017:**

המכון הגיאולוגי

כימיקלים לישראל

גיאופרוספקט

רציו חיפושי נפט

המכון הגיאופיזי

נשר מפעלי מלט ישראלים בע"מ

גיאוכום הנדסה אזרחית וגיאולוגיה

נובל אנרגי'

חקר ימים ואגמים לישראל

מחצבות מלט הר-טוב

גיאוטופ – מ. לוין

דלק קידוחים

המרכז הישראלי לחקר הים התיכון

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ד"ר עמיר אידלמן - גיאולוג

אבנר חיפושי נפט

ביה"ס ללימודי הים ע"ש צ'רני אוניברסיטת חיפה

-BioAnalytics פתרונות אנליטיים

גיאו-לוג שירותים גיאוטכניים

אפק – אנרגיה ישראלית

אוניברסיטת בן-גוריון בנגב

האוניברסיטה העברית בירושלים

אוניברסיטת תל אביב

ציון נפט וגז

מרכז מדע ים המלח והערבה

משרד התשתיות הלאומיות, האנרגיה והמים

## חברי ועד החברה הגיאולוגית הישראלית 2016-2017

נשיא – חנן גינת

סגן נשיא – דורון בראון

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מרכז תכנים – נמרוד וילר, בר אלישע

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אחראי אתר אינטרנט – אדם לוי

ועדת ביקורת – און כרובי, קרן קולודנר ואורנה בוך-לויתן.

## The onset of modern-like Atlantic meridional overturning circulation (AMOC) at the Eocene-Oligocene transition - the evidence, causes, and possible implications for global cooling

**Abelson, M. (1), Erez, J. (2)**

1. Geological Survey of Israel
2. Hebrew University

A compilation of benthic $\delta^{18}O$ from the whole Atlantic and the Southern Ocean (Atlantic sector), shows two major jumps in the interbasinal gradient of $\delta^{18}O$ ($\delta^{18}O$) during the Eocene and the Oligocene: One at ~40 Ma and the second concomitant with the isotopic event of the Eocene-Oligocene transition (EOT), ~33.7 Ma ago. From previously published circulation models and proxies, we show that the first δ18O jump reflects the thermal isolation associated with the proto-Antarctic circumpolar current (ACC), and the second marks the onset of interhemispheric northern-sourced circulation cell, similar to the modern Atlantic meridional overturning circulation (AMOC). The onset of AMOC-like circulation slightly preceded (100-300 ky) the EOT, as we show by the high resolution profiles of $\delta^{18}O$ and $\delta^{13}C$ previously published from DSDP/ODP sites in the Southern Ocean and South Atlantic. In addition an onset of anti-estuarine circulation between the Nordic seas and the North Atlantic, started around the EOT. We suggest that while the shallow proto-ACC supplied the energy for deep ocean convection in the Southern Hemisphere, the onset of the interhemispheric northern circulation cell was due to the significant EOT intensification of deepwater formation in the North Atlantic driven by the Nordic anti-estuarine circulation. This onset of the biologically productive circulation cell could have prompted the EOT global cooling.

## Arc-perpendicular and along-arc intrusions: morphologic and seismic expressions, Kamchatka

**Agnon, A. (1), Gusev, A. (2)**

1. Institute of Earth Sciences, The Hebrew University, Jerusalem 91904, Israel
2. Institute of Volcanology and Seismology, Petropavlovsk-Kamchatsky, 683006, RUSSIA

Arc-parallel sheet intrusions are evident in recent to ongoing volcanism in Kamchatka, as dramatically expressed in the Tolbachick eruptions over the last three centuries. We speculate that arc-perpendicular and arc-parallel deep sheet intrusions can explain some odd seismic behavior offshore, and a striking pattern of orthogonal fjords.

On the shelf, between the arc and the trench, epicenters collected over five decades are paired: members in each pair are separated by 15-60 km and up to 0.5 days. The orientation distribution of line segments connecting these pairs varies along the 700 km arc according to the local strike of the 700 km arc. For each ~250 km zone, the distribution is bimodal with orthogonal trends. While the arc-parallel trend is readily explained by subduction related stresses, the perpendicular trend has been puzzling. We surmize that these pairs of events express slow propagation of magma at depth. Similar seismo-magmatic phenomena was discovered four decades ago at Krafla (Iceland). Two decades ago such intrusion related seismic emissions were detected at Juan de Fuca mid ocean ridge, and recently at the Afar. In these three cases the rates of propagation inferred were around 1 km per hour. The typical thickness of these shallow dikes estimated from surface surveys, and in agreement with theoretical arguments, is around 1 m.

Several fjords at the southern sector of the arc form roughly orthogonal sets, seemingly paralleling the two modes of trends marked by epicenter pairs. The fjords are up to 10 km long and 2 km wide, with on-land extensions reaching two additional km. One of the prominent fiords - the Vilyuchinskaya Bay - is heading right to the Vilyuchik volcanic cone. The summit of this stratovolcano towers at 2173 m elevation, 10 km from the fjord's edge at the fjord's north-western heading (300°). The northern escarpment shows indications of recent downhill displacement, possibly rejuvenation of a boundary fault.

We draw a working hypothesis for future research: the epicenter pairs mark the ends of magma sheets, intruding at lower crustal levels. The trends of the intrusions follow the principal stresses. The arc-perpendicular trend parallels the maximum compression, where magmatic over pressures enable the opening mode. The along-arc trend can dilate at crustal levels due to flexure of the overriding lithospheric plate.

Incidentally, the heading 120°-300° connects a nearby chain of volcanoes: Kozelsky-Avacha-Koryak-Aag-Arik. This arc-perpendicular alignment is unique in Kamchatka, and might reflect tectonic heritage. These larger scale features might be related to the magmatic intrusions inferred in this preliminary study.

## Authigenic magnetite in deep sediments

**Amiel, N.(1), Vigderovich, H.(1), Sivan, O.(1)**

1. Department of Geological and Environmental Sciences, Ben Gurion University of the Negev

Magnetite is a semi-conductive iron-oxide mineral that contains both ferrous and ferric iron and has the ability to record the earth magnetic field components. Magnetite crystals can be produced chemically in volcanic and metamorphic rocks, or biologically as intra-cellular crystals by magnetotactic bacteria or as an extra-cellular by-product of dissimilatory iron reduction (so called authigenic magnetite). Due to its mixed-valent structure, magnetite can serve also as an electron acceptor in the dissimilatory anaerobic respiration process. Recently we observed unexpected iron reduction in the deep methanogenetic zone (below the traditional dissimilatory iron reduction zone) both in Lake Kinneret and in the Mediterranean continental shelf sediments. In this study we explore the association between this dissimilatory iron reduction and the production or consumption of authigenic magnetite. Preliminary profiles from Lake Kinneret sediment show "peak" of maximum value in the magnetite concentrations where the increase of ferrous iron was observed . This suggests that part of the magnetite particles was precipitated during the iron reduction. In addition, there is a good correlation between magnetite concentrations and Natural Remanence Magnetization (NRM) intensity, which suggests that the authigenic magnetite has the ability to obtain the magnetic field and to enhance the NRM intensity. Preliminary results from Mediterranean continental shelf sediment profiles show a decrease in magnetite concentrations at the methanogenesis depth, which suggests that magnetite in this case is being probably used as an electron acceptor.

## Salt tectonics and thin-skin contractional deformation in the Deep Levant Basin

**Anagnostoudi, Th. (1), Schattner, U. (1), Lazar, M. (1)**

1. Dr. Moses Strauss Department of Marine Geosciences, University of Haifa, Mt. Carmel, Haifa 31905, Israel

Salt tectonics is known to be the predominant cause for thin-skin deformation of the deep Levant basin, eastern Mediterranean Sea. It is seen by salt induced progressive transition from upslope extension to downslope contraction and through shortening structures in both the Messinian mobile unit and its overlaying Plio-Pleistocene succession. However, the amount of shortening, its differential distribution and development of typical structures have never been mapped or quantified. The current study analyzes two pre-stack depth migrated seismic reflection volumes from the deep Levant basin in order to shed light on these issues. Data show zonation of folds, thrusts, reverse and strike-slip faults, pop-up and pull apart structures. Initial results present the characterization of 408 strike-slip faults from the contractional domain, their interaction and hierarchical stages of their activation. The propagation of compression creates domains of different amounts of shortening, differentiating the area into zones of distinct levels of deformation (longer-moderate-shorter wavelength of deformation). In the Plio-Pleistocene sequence and the uppermost Messinian Unit, the axes of the folds curve around a NW-SE trend, while a different trend appears in the intra Messinian Units. Initial results indicate that the direction and the magnitude of the stress regime has changed from the initiation of Messinian Salinity Crisis till present at least three times. The interaction between structural features produced under different stress regimes serve as the key for understanding initial deformation stages of salt giants.

## Rainfall and meteorology patterns of flashflood-producing storms in the Levant drylands and their hydrogeomorphic implications

**Armon, M. (1), Dente, E. (1,2), Morin, E. (1), Enzel, Y. (1)**

1. Institute of Earth Sciences, The Hebrew University, Jerusalem 91904, Israel
2. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem 95501, Israel

Intense rainstorms leading to flashfloods, which are hydrogeomorphic agents for channel incision, sediment transport, and filling lowlands by sediment and water, occur in the southern Levant drylands. This study characterizes the hydrometeorological conditions of large flashfloods in these drylands: (a) the large-scale meteorology leading to intense rainstorms, (b) the space-time patterns of these rainstorms, (c) the hydrology of the resulted flashfloods, and (d) the geomorphic work of these floods. We present analysis of three flasflood-producing synoptic types: Mediterranean Cyclone (MC), Active Red Sea Trough (ARST) and Tropical Plume (TP). For each of these synoptic types, we analyzed two major sorms with calibrated radar rainfall, meteorological reanalysis, satellite imagery, and measured flashflood hydrographs. Additional events were analyzed for the hydrogeomorphic characterization. Our analysis indicates that the three systems differ in the meteorological conditions leading to intense storms and flashfloods generation. During TPs, atmospheric moisture is advected to the Levant from western equatorial Africa and precipitates due to subtropical-jet's large-scale forcing over the southern Levant. For ARST events, moisture is present in the region, precipitating by mesoscale forcing concurring with diurnal heating. MC events combine advected moisture from the Mediterranean and meso- and synoptic-scale forcing. These meteorological conditions lead to different rainfall and flooding patterns: (a) TPs generate the highest total rainfall depths, simultaneously over a broad region. Thus, it can produce intense flashfloods in a wide range of catchment areas over a relatively broad region; (b) Intense convective ARST storms generate convective-spotty, isolated rain cores that produce scattered, high-discharge, low-volume flashfloods; (c) MCs can generate high-volume, low-peak flashfloods at the northern parts of the region. According to our analysis, the simultaneous generation of flashfloods in multiple smaller catchments is causing TPs to be the primary synoptic system leading to flashfloods in $10^3$-$10^4$ $km^2$ catchment areas. This synoptic scale pattern is rare and was absent from earlier hydrometeorological analyses. Floods, integrated from numerous low-order catchments produce the large floods in higher-order channels, contributing to significant geomorphic work. This is manifested in the Arava channel, where channel incision and avulsion were documented during TPs. It is hypothesized that an increase in frequency of TPs could have led to major hydrogeomorphic changes through the late Pleistocene and Holocene. Similar change in ARST frequency could have contributed to geomorphic work mostly in smaller catchments.

## A comparison of radon signals in natural environments and in enhanced confined systems

**Asperil, T. (1,2), Steinitz, G. (2), Israelevich, P. (1), Bezaly, O.R. (1,2), Malik, U. (2), Piatibratova, O. (2), Marco, S. (1)**

1. Department of Geophysics, Tel Aviv University, Tel Aviv, Israel
2. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501

Radon (222Rn) is a radioactive inert gas formed by disintegration from 226Ra as part of the 238U decay series. The combination of its noble gas character and its radioactive decay make it a unique ultra-trace component for tracking temporally varying natural processes. In the geological environments it occurs at varying concentrations and shows large and complex spatio-temporal variation patterns which exhibit periodic and non-periodic signals of annual to daily scale.

In order to investigate those patterns, experiments were placed at several locations in southern Israel under diverse environmental conditions. Several experiments measure the variation of radon in the natural system (air, seawater). Other experiments are based on Enhanced Confined Mode (ECM) systems in which nuclear radiation is measured from an artificial radon source inside a confined air volume. The ECM systems, were placed at two locations: in the underground tunnel of the Bloch Geophysical Observatory (BGO) at Har Amram, and at the Gulf of Eilat [Inter University Institute (IUI)] at on and off-shore locations.

One goal is to understand the radon behavior under different environmental conditions. The BGO experiments are in a 180-meter-deep tunnel excavated in the Har Amram granite; the IUI experiments are located at a) approximately 3 meters above sea-level (PM-11 gamma detector), b) on the seabed (ECM Barasol alpha detector) and c) dynamic vertical location underwater (PM-11 gamma detector).

Both sites exhibit systematic variations composed of periodic and non-periodic signals. At the BGO tunnel we observe a clear daily signal (1 cycle per day); the underwater experiments reveal different tidal signal (~1.9 cycles per day repetition) which indicate a connection between the radon flux and the local marine tide. Furthermore, two identical ECM systems (Barasol alpha detector with NH geological source) under different environmental conditions at the BGO and on seabed underwater exhibit different radiation patterns.

## Site specific earthquake hazard assessments using ambient noise measurements in Eilat region

**Ataev, G.(1), Giller, D. (1)**

1. The Geophysical Institute of Israel, 6 Habaal Shem Tov st. Lod, Israel, 7128906

The goal of this work is estimating the local site effect for the town of Eilat and its surrounding settlements, using the method of H/V spectral ratio from ambient noise measurements. The ambient noise has been recorded at 325 points in different lithological units during January to June 2016. In addition, the results of 80 old measurements (Zaslavsky et al, 2001, 2002, 2003, 2005) were analyzed and used in this research. Considering the geological data (Beyth, et al, 2011) the magmatic and metamorphic rocks, we suggest as the main reflector that generates the first resonance frequency on the most part of the study area. The intermediate hard layer is presented by these eroded magmatic rocks and responsible for the second frequency. East of the DSF, the conglomerates of Holocene are suggested as the main reflector. Two maps: resonance frequency and its associated H/V amplitude, and three geological cross-sections are presented. Using data of H/V spectral ratios across the investigated area, we developed the subsurface multilayer models at all measurements allowing us to assess the seismic hazard in terms of Site Specific Uniform Hazard Acceleration Spectrum (Shapira and van Eck, 1993). We divided the study area into 13 zones and characterized each of them by a generalized soil column model. This research detects the faults previously traced by geological data and reveals some new faults.

## Diurnal variations in sulfur transformations at the chemocline of stratified freshwater lake

**Avetisyan, K. (1), Eckert, W. (2), Findlay, A. (1), Kamyshny, A. (1)**

1. Department of Geological and Environmental Sciences, Faculty of Natural Sciences, Ben-Gurion University of the Negev, P.O. Box 653, 84105 Beer Sheva, Israel
2. Israel Oceanographic & Limnological Research Ltd., Yigal Allon Kinneret Limnological Laboratory, P.O. Box 447, Migdal, 14950 Israel

Freshwater Lake Kinneret is thermally stratified during the warm period of the year, which results in the depletion of oxygen and formation of hydrogen sulfide in its hypolimnion. During the summer months, the water column is forced daily by strong westerly winds that trigger basin-scale internal waves. As a consequence of these seiches the chemocline oscillates at amplitudes up to 12 m. The main goal of this study was to understand the impact of chemocline displacement on biogeochemical sulfur cycling. In July 2016, after determining the optimum target depth (17.1 m), we conducted hourly measurements of critical physical and chemical parameters in the water column over a 24 hour period. At the beginning of sampling (10:00) the sampling depth was about 1 m below the chemocline. At this depth, anoxic conditions persisted until 24:00. During the night, at 01:00 - 05:00, the water mass at 17.1 m depth turned oxic. Throughout the measuring period, the chemocline corresponded to a temperature of 23.2-24.0°C. Physical and basic chemical parameters (pH, conductivity, ORP, turbidity) depended linearly on temperature both below and above chemocline, although with different respective slopes. Dissolved oxygen concentration decreased linearly with depth above the chemocline, and concentrations of hydrogen sulfide increased linearly with depth below the chemocline. Concentrations of sulfur oxoanions (thiosulfate and sulfite) showed more complicated behavior in the vicinity of the chemocline. The highest concentrations of these species (190 nM for $S2O_3^{2-}$ and 440 nM for $SO_3^{2-}$) were detected in the water layer with 20-22°C temperatures (1-3 m below the chemocline), with very low concentrations above the chemocline (<15 nM) and intermediate concentrations deep in the hypolimnion. In contrast, concentrations of elemental sulfur were dependent not only on the water temperature but also on the time of day. During both the day and night, the concentration of elemental sulfur increases linearly with depth below the chemocline. However, during the sunny hours, concentrations of elemental sulfur are approximately 7 times higher than in the dark. These observations may be explained by a combination of light-independent processes (microbial sulfate reduction and oxidation of hydrogen sulfide to sulfur oxoanions) and the light-dependent oxidation of hydrogen sulfide to elemental sulfur (phototrophic sulfide oxidation). This indicates that the reoxidative sulfur cycle is driven not only by diffusion, but as well by mixing of oxic and anoxic waters due to seiches and by the light intensity reaching the chemocline.

## The effect of alternative seismotectonic models on PSHA results – a sensitivity study for the case of Israel

**Avital, M. (1) and Kamai, R. (1)**

1. Department of Geological and Environmental Science, Ben Gurion University of the Negev, Beer Sheva 84105, Israel

Israel lies on an active plate boundary – with the Dead-Sea Transform (DST) separating the African plate on the west from the Arabian plate on the east. According to the historical, biblical, and archaeological records, devastating earthquakes with recurrence intervals of ~ 100 years are responsible for the repeated destruction of cultural centers in this region. However, the instrumental catalog is very poor due to the combination of its young age, sparse spatial coverage, and moderate seismicity. Therefore, some significant knowledge gaps exist, leading to large epistemic uncertainty when conducting seismic hazard analysis. One of the main sources for epistemic uncertainty is the definition of the underlying seismotectonic model. While the geological community has put a major effort into locating and parameterizing active faults, the only published seismotectonic model for SHA purposes is that of Shamir (2001), which treats all seismic sources in the region as seismogenic areal sources.

In this study a full logic tree, which represents the epistemic uncertainty relates with the seismological parameters, is used for conducting a full PSHA analysis for two sites in Israel. The logic tree contain both areal and linear source model characterization as well as different models of spatial distribution, slip rates, locking depth, and segmentation. A sensitivity study is conducted on the PSHA results, following the propagation of uncertainty from input to output. Finally, the input parameters which control the epistemic uncertainty are identified, so that future research can be focused on reducing uncertainty, and therefore, hazard.

## Probable maximal flood estimation in the Dead-Sea watersheds

**Avni, B. (1), Morin, E.(1)**

1. Institute of Earth Sciences, The Hebrew University, Jerusalem 91904, Israel

High magnitude flash flood events have a great effect on the environment, human life and infrastructures. Probable Maximum Flood (PMF) is the largest flood that may occur from the most severe combination of meteorological and hydrological conditions that are possible over a watershed. Estimation of PMF can help to understand the watershed potential of flooding and can be interpreted to water management field.

Flood envelope curve can count as initial and basic assessment of PMF, where it can be derived from an upper threshold curve over a scatter plot of maximal observed peak discharge as a function of watershed size. Although the method is in wide use, it has a number of intrinsic weaknesses: the maximal peak discharges are strongly dependent on the length of hydrological records. The high magnitude events are usually scarce thus, the watershed's full flow potential is uncertain. Envelope curves are also lacking of detailed comparison of the watershed characteristics except the watershed area.

A better estimation of the PMF can be done with the use of hydrological model. In this research we suggest the "integrative approach" which evaluates the contribution of both meteorological conditions in terms of rain storm characteristics (e.g. intensity, duration, position and speed) and watershed properties such as size, slope and land cover to the flood magnitude. Both observed and transformed (or "synthetic") rain storm data are used. A 23-year high resolution (5-min, 1 $km^2$) corrected and gauge adjusted data base produced from the Shacham-Mekorot meteorological radar system is the main source of data. Different storms from the climate regime representing the Dead Sea are transformed, including alternations of storm location, direction and speed, basing on statistical analysis of those variables over the study area. This process is used in order to expand the storm-watershed configurations examined and to maximize the flood magnitude. Digital Elevation Model and other GIS application such as land cover map are applied to represent the watershed properties. The meteorological and watershed data are used as an input to a robust hydrological model developed for the region. This method is tested on several watersheds in the western tributaries of the Dead Sea to evaluate the factors that control the watershed flooding potential.

Initial results from a case study analysis of the 2.5.2001 rainfall event for the Rahaf watershed show that while the observed peak discharge for this event was 67 $m^3$/sec, changes in storm location, direction and speed lead to substantially higher simulated peak discharge, that is close to the regional envelope curve.

## Patterns and rates of 103-105 yr denudation in carbonate terrains under sub-humid to sub-alpine climatic gradient, Mount Hermon, Israel

**Avni, S. (1), Haviv, I. (1), Matmon, A. (2), Benedetti, L. (3), ASTER Team (4)**

1. Department of Geological and Environmental Sciences, Ben-Gurion University of the Negev, Beer-Sheva 84105, Israel
2. The Fredy and Nadine Herrmann Institute of Earth Sciences, Admond J. Safra Campus, Givat Ram, Jerusalem, 91904, Israel
3. Aix-Marseille Université, Centre National de la Recherche Scientifi que (CNRS)–Institut de recherche pour le développement (IRD)–Collège de France, UM 34 Centre de Recherche et d'Enseignement de Géosciences de l'Environnement (CEREGE), Technopôle de l'Arbois, BP80, 13545 Aix-en-Provence, France.
4. ASTER Team: Maurice Arnorld, Georges Aumaître, Didier Bourlès, and Karim Keddadouche, Centre de Recherche et d'Enseignement de Géosciences de l'Environnement (CEREGE), Technopôle de l'Arbois, BP80, 13545 Aix-en-Provence, France.

Despite the worldwide ubiquity of carbonate terrains, quantification and understanding of rates and patterns of carbonate erosion is still lacking. Carbonate landscapes are prone to chemical weathering (dissolution) and should therefore be strongly influenced by climatic variables such as precipitation. However, isolating the impact of these variables is difficult, as denudation rates are also strongly influenced by tectonic processes, topography, and lithology. This study focuses on deciphering 103-105yr erosion patterns across Mt Hermon – exploiting its climatic gradient (1500-600 mm $yr^{-1}$) and homogenous lithology (Jurassic limestone).

The concentration of in situ cosmogenic $^{36}Cl$ in bedrock and sediment samples is utilized to characterize the spatial distribution of erosion and examine its potential drivers. Our results indicate differential erosion along Mt. Hermon hilltops. The subalpine region (1700-2200 m, ~1300-1500 mm $yr^{-1}$, mean annual temperature of 7°C) yielded an average hilltop erosion rate of 19±8 mm $ka^{-1}$ (n=6), while hilltops at intermediate altitudes (1000-1600 m, ~900-1200 mm $yr^{-1}$) seem to erode faster at 31±7 mm $ka^{-1}$ (n=7). In addition, soil cover seems to enhance erosion rates relative to bare bedrock. This highlights a major difference between carbonates and silicates where numerous datasets suggest an exponential decrease in soil production as the soil thickness increases. OSL ages of sediments in Arar valley, a small intra-mountain basin, are all (n=9) within the last 3000 years and rise gradually with depth. Estimated mechanical erosion rates based on these sediments are 7-21 mm $ka^{-1}$. In contrast estimated chemical weathering rates based on dissolved loads in springs are 40-145 mm $ka^{-1}$. This difference highlights the relative dominance of chemical weathering. The current $^{36}Cl$ results, in conjunction with average hilltops lowering rates measured within the sub-humid Mediterranean climate across the Judean mountain range (500-600 mm $yr^{-1}$, 19±7 mm $ka^{-1}$), suggest that optimum conditions for carbonate erosion and chemical weathering occur beneath the tree line, where soil is abundant, $pCO_2$ is higher than atmospheric values, and snow cover is scarce. This observation has intriguing implications in terms of long-term landscape evolution.

## The role of the Early Pleistocene morphotectonic event on the landscape evolution of Negev Highlands – an example from the Neqarot drainage basin

**Avni, Y. (1)**

1. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501

The Neqarot basin is draining the south-eastern sector of the Negev Highlands toward the Arava valley and the Dead Sea. This basin developed during the Middle- late Miocene in accordance to the regional uplift of the western margin of the evolving Dead Sea Transform. One of the Neqarot tributaries that drain the central part of the Arif-Badad monocline toward the Neqarot syncline is the 35 km2 Anaka basin which joins the main Neqarot basin south of Makhtesh Ramon. The Anaka basin is composed of the Tamar, Ora and Gerofit formations of Cenomanian and Turonian age. At present the course of the main channel of the Anaka stream is almost linear, 12 km long, oriented to the north-east. However, it past course was much longer and largely curved, forming 3 large meanders, 900-600 m long and 700-250 m wide. The total length of the Anaka channel in the meandering sector is 7650 m while the present course is crossing this meandering sector in a short and incised channel, only 3500 m long, shortening the stream course by 54%. Remnants of conglomerate units found along the meandering course of the Anaka stream indicates that during the Pliocene and Early Pleistocene times, conglomerates of the Arava Formation were deposited along the meandering course. The incision of the present stream started after the deposition of the Arava Formation and gradually disconnected the meanders as a result of a migration of the incision wave upstream. The most eastern and downstream meander (meander no. 1) was incised short after the deposition of the Arava Formation, probably during the Early Pleistocene. However, based on the deposition of younger alluvial units within meanders no. 2 and 3 it is concluded that meander no. 2, located 2.6 km upstream of meander no 1,was incised after the deposition of the Middle Pleistocene Q2 unit within the meander, approximately during the interglacial phase of MIS 5, some 140-80 ka BP. Meander no 3, located 3.5 km upstream of meander no. 1, was incised after the deposition of the Late Pleistocene Q3 unit within the meander, most probably during the Holocene. The incision rate along the Anaka stream during the Holocene is ranging 10-7 mm/y. This ongoing incision is marked at present by the 40 m' dry waterfall located at the middle of the disconnected meander no. 3.

This process is a manifestation of the eastward regional tectonic tilting and faulting phase observed along the western margin of the Dead Sea Transform in the Negev and within the Dead Sea basin, evolved circa 1 Ma BP. This event has an on-going influence on the Negev Highland landscape evolution as demonstrated in the Anaka-Neqarot basins.

## High-resolution InSAR Constraints on subsidence mechanisms and geotechnical parameters of sediments along the Dead Sea shores

**Baer, G.(1), Shviro, M. (1,2), Nof, R. (3), Magen, Y. (1), Ziv, A. (4), Haviv, I. (2)**

1. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501
2. Department of Geological and Environmental Science, Ben Gurion University of the Negev, Beer Sheva 84105, Israel
3.Geophysical Institute of Israel, P.O.Box 182, Lod 71100, Israel
4. The Department of Geosciences, Tel-Aviv University, Tel-Aviv 69978, Israel

Sinkholes and sinkhole-related land subsidence constitute a severe geo-hazard along the Dead Sea in Israel and Jordan, affecting both human activities and infrastructure. To discriminate between potential subsidence mechanisms (dissolution, viscoelastic creep, consolidation) and to constrain some of the mechanical properties of the subsurface granular sediments, we examine a 5-year long subsidence record using high-resolution InSAR measurements from the COSMO SkyMed satellites. In particular we study: (a) sinkhole precursory subsidence, which show gradual acceleration before sinkhole collapse; (b) Land subsidence in response to surface loading, which is characterized by a quasi-exponential decay; and (c) Subsidence following flash-flood events, which is characterized by an abrupt increase immediately after the flood and a quasi-exponential decay thereafter. Precursory subsidence duration correlates with the sediment type and can thus constrain sediment properties. Quasi-exponential subsidence decay after flash-floods can be explained by: (a) A decay in salt dissolution rates due to an exponential drop of the groundwater hydraulic head after a flash flood; (b) Viscoelastic creep; (c) A combination of these two mechanisms. The Kelvin-Voigt creep model can explain the entire observed subsidence decay pattern, constraining the viscosity and elastic modulus of the consolidated gravel to 1e+15 - 1e+16 Pa s and ~175 MPa, respectively. However, constraining the elastic moduli to values reported in previous studies (600-4700 MPa), only 10-30% of the subsidence can be explained by viscoelastic creep. This implies that more than 70% of the post-flood subsidence decay should be attributed to decreasing dissolution rates due to the observed exponential drop of groundwater head. The viscosity values obtained by our calculations agree well with numerical simulations of sinkhole formation along the Dead Sea, whereas the elastic moduli are generally on the lower end of previous estimates.

## Challenging science through innocent curiosity

**Baharier, B.(1), and Jenkin, G. (1)**

1.Department of Geology, University of Leicester, UK

Geology is all around us and its application is practically what makes us human. Geology is the basis of everything we do, everything we fight for, what we build with and what we consume; so why do we know so little about it? As children we are extremely curious; we look around and ask many questions and then question the answers. As adults, we tend to accept conventional scientific facts and we raise our children to do so as well. By the time we get to university, we need to re-learn how to critically analyse scientific information. How can we maintain that initial childlike curiosity and scepticism in order to improve our science?

This is where outreach work and its positive benefits come in. In public universities in the UK, promoting outreach programmes is required in order to receive governmental funding. Additionally, grant money is given to universities according to the degree research impacts the public outside of academia. Therefore, outreach programmes can both attract more students of diverse backgrounds as well as increase the impact of academic research.

At The University of Leicester in the UK, there is an emphasis on the importance of preserving and further enthusing the next generation of scientists. Lecturers in the department take their research out of the lab and into schools. For example, pupils have been exposed to research done on vertebrate evaluation and its interpretation from the fossil record. This experiment is done on rotting fish and compares their anatomy to Cambrian fossils that are the subject of an on-going worldwide debate of their place on the tree of life. Pupils are exposed to real-life issues in science in an effort to stimulate their interest in geology.

Furthermore, the University encourages university students of all levels to come up with innovative outreach ideas by offering a bursary for the best ideas and by doing so, not only promotes geological education but also supports young geologists in their early careers.

My proposal is to write an innovative children's book focusing on geology. There are many geology books available but here I aspire to provoke young pupils' curiosity through understanding basic functions such as energy, heat, colour, time, wind, water and fossils to uncover the secrets that rocks can reveal. By doing this, I hope the future generation of scientists will be excited about challenging scientific conventions.

## Geological history of the Or-Akiva Fault – A tectonic boundary between the uplifted Carmel Mt. and the subsided Coastal Plain

**Bar, O. (1), Zilberman, E. (1)**

1. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501

Or-Aqiva fault separates between the Carmel Mt. in the north and the coastal plain of Israel in the south. It is 30 km long, extending in E-W direction from the Samaria Mts. in the east to the Mediterranean in the west. The vertical displacement along the fault near Caesarea is about 400m and it decreases eastwards and increases westward toward the deep sea. Since the Neogene, the tectonic activity along the or-Akiva fault is intimately connected with the uplift of the Carmel block in the north and the subsidence of the coastal plain in the south. We combined several morphological, geological and geophysical methods in order to reconstruct its tectonic history and to evaluate if there is any seismic risk imposed by this fault.

We used several geological and morphological markers, which cross the fault trace: 1. Selected formations of the Judea Group. 2. The Early Pliocene "Lower Shefela" wave-cut surface extending over the entire Ramot Menashe and the western part of the Carmel. In the northern Coastal Plain, south of the Or-Akiva Fault, it is buried under the Pliocene Yafo Formation. 3. An erosion surface, at the base of the Pleistocene Kurkar Group, which extends along the Coastal Plain. 4. Paleosols horizons within the sequence of the Kurkar Group.

We recognized the following activity phases along the Or-Akiva Fault:

1. About 50m displacement before the formation of the Lower Shefela surface.
2. About 300m prolonged displacement after the formation of the Lower Shefela surface, during the deposition of the Pliocene Yafo formation. It was associated with the uplift of the Carmel block in the north and subsidence of the coastal plain in the south. The fault cut and down-faulted the southern part of the Carmel block, which became since this time a part of the coastal plain tectonic province. This part of the Carmel is termed - the "Caesarea structure". During this tectonic phase, a small syncline developed south of the Or-Akiva-fault, forming a depression on the sea bottom between the Caesarea structure and the fault. A thick syn-tectonic sequence of the Early Pliocene Yafo Formation was deposited in this subsiding syncline.
3. About 70 m displacement during the Early Pleistocene, after the formation of the erosion surface at the base of the Kurkar Group. This phase is associated with subsidence of the coastal plain south of the fault and deposition of ~70m thick sequence there.

The entire Middle to late Pleistocene sequence of the Carmel coastal plain is extending southward across the Or-Akiva Fault trace without any sign of deformation. The upper part of this sequence was accumulated since ~160ka and we conclude that the tectonic activity along this fault ended sometime prior to this time.

## Leviathan Gas Field: Main aspects of ultra-deepwater development with a long tie-back

**Bariudin, V.(1)**

1.Ministry of Infrastructure Energy and Water Resource, 14, Hartum St. POB 36148, Jerusalem 9136002, Israel

Leviathan Gas Field (LGF) placing in distance of 90 km from Israel coastal line (affront of Haifa). Water depth in this place is about 1600-1700 m. Two these parameters, deep water and long tie back make development of this field very difficult. Initial decision to develop field was by subsea wells and FPSO above of the field for gas treatment. But it was canceled by political and defense reasons and FPSO has been replaced by fixed platform. Strong restriction to exclude any gas treatment installations on the shore led to design a very big platform. Maybe biggest over the world. So field development plan (FDP) of LGF is very interesting from engineering and economic positions.

## Is the Timna Igneous Complex an additional Neoproterozoic terrane in the northernmost tip of the Arabian Nubian Shield?

**Be'eri-Shlevin, Y. (1), Beyth, M. (2)**

1. Kinneret Limnological Laboratory, Israel Oceanographic & Limnological Research Ltd., P.O.Box 447, 14950, Israel
2. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501

The Neoproterozoic Timna Igneous Complex (TIC) is located at the northernmost Arabian-Nubian Shield (ANS) and is the northernmost exposure of ANS rocks in Israel. Beeri-Shlevin et al., (2009) in a thorough study of the zircon oxygen isotope ratios δ18O(Zrn) in northern ANS basement rocks suggested that the TIC may represent an additional basement terrane possibly separated from Sinai-Elat terranes via a NE-SW discontinuity. The low $\delta^{18}O$(Zrn) values in the TIC rocks indicate very small degree, if any of crustal assimilation. This stands in contrast to rocks of similar age from adjacent terranes e.g., the Amram Rhyolite of Mt. Neshef $\delta^{18}O$(Zrn) 6-7‰ and the AL suite of the Elat area with $\delta^{18}O$(Zrn) values of 6.84 to 6.23‰ (Be'eri et al., 2009). Such differences may stem from a difference in crustal thickness between these terranes.

The TIC is composed of olivine norite which was formed as a cumulate and alkali granite which was formed by fractional crystallization both from a mantle derived monzodioritic magma in a quasi-stratified magmatic cell (Beyth et al. 1994). These rocks are part of the AL suite and are characterized by low $\delta^{18}O$(Zrn) values of 5.50-5.79‰ (Beeri-Shlevin et al., 2009). The magmatic cell was formed 610 Ma ago in the 625 Ma old calc-alkaline granite porphyry crust (CA2 suite by Beeri-Shlevin et al., 2009) during the first stage of the post-collision extensional phase in the ANS (Beyth et al., 1994).

This porphyry collision I type granite was formed by melting of slightly older crust as a granitic batholith (Beyth et al. 1994), with $\delta^{18}O$(Zrn) of 6.17‰ (Beeri-Shlevin et al. 2009). This I type granite is also correlative to the Urf granitic suite in Feinan, south-west Jordan (McCourt, 1990) which bears black schist xenoliths ( Beyth, 2015) from the Island arc complex (IAC by Beeri-Shlevin et al, 2009). The TIC rocks are intruded by swarms of north-south and east-west rhyolite, andesite and composite dykes of the AL suite. The positive εNd(T) in the AL suite and granite porphyry, C2 suite, 3.4 – 4.5 and 5.6 – 5.9, respectively (Beyth et al., 1994), are consistent with both crustal and mantle-derived origin. This is because of the juvenile character of the underlying ANS crust and the relatively short time elapsed since its formation.

Taking into account the restricted size of the TIC magmatic cell (AL) on the one hand and the large area of the exposed granite porphyry (CA2) on the other, the TIC monzodiorite could be mantle derived magma which ascended through a conduit, such as a deep seated fracture, with almost no crustal assimilation. In such a case the low zircon oxygen isotope ratios must not express the thickness of the crust.

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## Paleomagnetism of Golan-Heights Plio-Pleistocene basalts: geomagnetic and tectonic implications

**Behar, N. (1), Shaar, R.(1), Asefaw, H.(2), Tauxe, L.(2), Koppers, A.(3)**

1. Institute of Earth Sciences, The Hebrew University, Jerusalem 91904, Israel
2. Scripps Institution of Oceanography, La Jolla, CA 92093-0220, USA
3. College of Oceanic & Atmosphere Sciences, Oregon State University 104 COAS Admin Bldg Corvallis, OR 97331-5503 USA

The complex structure of Earth's magnetic field can be described, on average, as originating from a dipole aligned with Earth's rotational axis (Geocentric Axial Dipole, GAD). The GAD first order approximation is fundamental in paleomagnetism, especially as a basic work assumption for tectonic reconstructions. However, some worldwide paleomagnetic datasets reveal a persistent deviation of several degrees from GAD structure, and others show inconsistent secular variation patterns. These challenge the simple GAD model, and raise some key methodological questions, such as: "Does the GAD approximation introduces error to paleomagnetic tectonic reconstructions?" and "How many sites (distinct lava flows) in a given location and period are required in order to calculate a reliable paleomagnetic pole"? Here we present a joint paleomagnetic and Ar-Ar geochronology study of the Golan-Heights Plio-Pleistocene lava flows, aiming at addressing the above questions.

We sampled 44 Pleistocene lava flows from Ortal and Golan Formations from center to northern Golan-Heights, and 7 Pliocene flows from the Cover Basalt Formation in the southern Golan. The Pleistocene paleomagnetic pole, calculated from 32 sites (86°N,125°E, A95=4), includes the geographic pole within the circle of error. This implies agreement with GAD model. Also, we found that at least 25 sites are sufficient for averaging secular variations. The Pliocene paleomagnetic pole, calculated from 22 sites, including legacy unpublished data of Late Prof. Hagai Ron and the newly sampled sites (83°N ,248°E, A95= 6.8°) is slightly different than the Pleistocene and GAD poles. Yet, more sites are required for a robust pole calculation.

This implies on the likelihood of detecting and measuring post Pliocene tectonic activity or internal deformation, not yet recognized, in the Golan-Heights.

## Rapid and delayed seismic responses induced by fluctuations of historical water bodies in the Dead Sea Rift

**Belferman, M. (1), Katsman, R. (1), Agnon, A. (2), Ben-Avraham, Z. (1,3)**

1. The Dr. Moses Strauss Department of Marine Geosciences, Leon H.Charney School of marine sciences. Haifa University, Mt. Carmel, Haifa 31905, Israel.
2. Institute of Earth Sciences, The Hebrew University, Jerusalem 91904, Israel.
3. The Department of Geosciences, Tel-Aviv University, Tel-Aviv 69978, Israel.

Despite the global, social and scientific impact of earthquakes, their triggering mechanisms remain often poorly defined. We suggest that dynamic changes in the levels of the historic water bodies occupying tectonic depressions at the Dead Sea Rift cause significant variations in the shallow crustal stress field and affect local fault systems in a way that may promote or suppress earthquakes. This mechanism and its spatial and temporal scales differ from those in tectonically-driven deformations. We use analytical and numerical poroelastic models to simulate immediate and delayed seismic responses resulting from observed historic water level changes. The role of variability in the poroelastic and the elastic properties of the rocks composing the upper crust in inducing or retarding deformations under a strike-slip faulting regime is studied. The solution allows estimating a possible reduction in a seismic recurrence interval. Considering the historic water level fluctuation, our preliminary simulations show a promising agreement with paleo-seismic rates identified in the field.

## High-resolution hydrological record of the last glacial Dead Sea recovered from the ICDP Cores

**Ben Dor, Y.(1), Ahlborn, M.(2), Brauer, A.(2), Tjallingii, R.(2), Armon, M. (1), Morin, E.(1) , Schwab, M. J.(2), Torfstein, A.(3), Erel, Y.(1), Enzel, Y.(1)**

1. Institute of Earth Sciences, The Hebrew University, Jerusalem 91904, Israel
2. Section 5.2: Climate Dynamics and Landscape Evolution, GFZ German Research Centre for Geosciences, Germany
3. Interuniversity Institute for Marine Sciences, Eilat 88103, Israel

The sedimentary record of Lake Lisan can yield the high-resolution hydrometeorology of the Dead Sea basin and the southern Levant during the last glacial, when the lake experienced a significant level rise, ca. 30 ka, to ca. 165 mbsl [m below mean sea level], followed by an abrupt drop (ca. 20 ka). These sediments provide information on the effects of short-term climatic oscillations and the frequency of extreme hydrometeorological events during episodes of significant level rises and falls associated with global climate changes. We examine the sedimentary record of the last glacial maximum from cores extracted by the ICDP from the deepest part of the basin. In this study, we incorporate petrography, geochemistry, image-processing, and statistical methods to describe the record of the last glacial maximum and discuss its hydrological implications in climatological context. Here we present a reconstruction of the high-resolution sedimentology of annually layered sediments from the deep basin, information that is lacking from the exposures at the margins of the lake. We expand on the way fine clastic sediments reached the center of the lake at event and seasonal scales, and contribute to the interpretation of annual laminae and to the sedimentological analysis of extreme hydrometeorological events and their frequency.

## The combined effect of buoyancy and excess pore pressure in facilitating soil liquefaction

**Ben Zeev, S. (1), Goren, L.(2), Parez, S.(3), Toussaint, R.(4), Clement, C.(4), Aharonov, E.(1)**

1. Institute of Earth Science, Hebrew University of Jerusalem, Israel
2. Geological & Environmental Science, Ben-Gurion University of the Negev, Israel
3. University of Chemistry and Technology Prague, The Czech Republic
4. Université de Strasbourg, CNRS, Institut de Physique du Globe de Strasbourg, UMR7516, F-67000 Strasbourg, France

Soil liquefaction is a devastating earthquake hazard, commonly causing tilting, sinking and floating of infrastructure. The classical mechanism for liquefaction requires undrained and loosely packed soil, that upon shear experiences elevated, lithostatic, pore pressure and consequently zero effective stress. However, some field and experimental observations cannot be explained by this mechanism. These include liquefaction of pre-compacted soils, liquefaction under drained conditions, repeated liquefaction events, and liquefaction triggered by small seismic energy density. A recent study suggests a new mechanism for liquefaction that arises only from buoyancy effects of fluids plus grain accelerations. We extend that study and seek a unifying mechanism for liquefaction that accounts both for the buoyancy effect and for elevated pore pressure, though not necessarily with lithostatic values. To achieve this goal, we use a coupled fluid flow and granular dynamics numerical model to study the effect of pore pressure on the sinking of a large object ("intruder") into a drained granular system undergoing cyclic shearing. Results show that despite the drained conditions pore pressure rises during shaking. Although pore pressure remains well below lithostatic values, soil liquefaction occurs and is identified by intruder sinking to its isostatic position. Even simulations with buoyancy effects alone show liquefaction and intruder sinking under certain conditions, yet inclusion of pore-pressure effects add to the buoyancy effect, and is seen to enhance liquefaction and promote intruder sinking.

## Controls over the relation between slope and sediment flux in soil mantled hillslopes: Insights from granular dynamics simulations

**BenDror, E. (1), Goren, L. (1)**

1. Department of Geological and Environmental Science, Ben Gurion University of the Negev, Beer Sheva 84105, Israel

Hillslopes occupy most of the Earth's surface area, and are the main source of sediments to the fluvial routing system. Since the slope of soil mantled hillslopes normally lies below the angle of repose, it has been suggested that sediment mobilization across and from hillslopes is facilitated by climatic, biologic, and tectonic environmental disturbances. Previous empirical studies have shown that sediment flux out of hillslopes depends non-linearly on the slope. However, the functional dependency between the slope and the flux that aspires to span a range of processes from slow creep to rapid landsliding generally lacks a mechanistic explanation. The absence of a physical understanding of the slope-flux relation hinders our ability to assess hillslope evolution in different settings and evaluate the effect of changing environmental conditions on the flux.

Due to the particulate nature of the material composing the upper layer of soil mantled hillslopes, sediment transport on and from hillslopes has discrete granular characteristics. Entrainment of grains, grain travel distance, velocity and acceleration, all depend on the dynamics of the sediment particles and their interactions. It is therefore likely that the spatial and temporal evolution of the sediment flux in response to a given slope and disturbance characteristics should inherently depend on the inter-particle dynamics. For this reason, the current work investigates the relations between flux, slope, and disturbance characteristics at the granular scale. This has the advantage of using first order mechanical principles without the need to assume a priori empirical relations.

We construct a two-dimensional model representing a long hillslope, and we model granular interactions using a soft disc granular dynamics algorithm. Environmental disturbances are simulated by applying temporally and spatially variable 'external' forces to individual grains following a random scheme that is characterized by a maximum magnitude and pseudo-wavelength. We perform many simulations that vary in the layer thickness, the slope, and the disturbances magnitude and wavelength.

Our simulation results reveal a rich meso-scale dynamic behavior with a relatively abrupt transition between two end members. Creep motion that rapidly decays with depth occurs at low and intermediate slope angles, while landsliding with kinematics that follows Bagnold's rheology dominates higher angles, albeit, still below the angle of repose. Disturbances thus effectively reduce the angle of repose as they allow for landslides to develop below the angle of repose of disturbance-free slopes. Our results further demonstrate a positive correlation between disturbance magnitude and pseudo-wavelength to sediment flux, in agreement with previous theoretical predictions. Non-linearity between the slope and the flux is shown to emerge both from the creep dynamics and from the transition between creep motion to landsliding. The simulations further allow a unique view into the micro-mechanics of granular motion down hillslopes.

## Geomorphic response of a continental margin to syntectonic eustatic variations – an example from the Levant margin during the Messinian Salinity Crisis

**Ben-Moshe, L.(1), Ben-Avraham, Z.(2), Enzel, Y.(3), Schattner, U.(1)**

1. The Dr. Moses Strauss Department of Marine Geosciences, Leon H.Charney School of marine sciences, University of Haifa, Mt. Carmel, Haifa 31905, Israel
2. The Department of Geosciences, Tel-Aviv University, Tel-Aviv 69978, Israel
3. Institute of Earth Sciences, The Hebrew University, Jerusalem 91904, Israel.

During the Messinian Salinity Crisis (MSC, 5.97±0.01–5.33 Ma) the Levant margin was subjected to major eustatic and sedimentary cycles as well as tectonic motion along the nearby Dead Sea fault plate boundary. New structures formed along the margin while active morphology responded to the changes. Our study focuses on these morphological developments across the margin. It is based on interpretation of three 3D seismic reflection volumes located offshore Israel. Multi-attribute analysis aided the extraction of key reflectors. Morphological analysis of the data was used for quantifying the unique interaction between eustasy, sedimentation and tectonics. Our analysis divides the Late Messinian morphology of the research area into 5 domains: (a) continental shelf; (b) 'Delta' anticline, diagonal to the strike of the margin; (c) southward dipping 'Hadera' valley, separating between (a) and (b); (d) 'Delta Gap' - a water gap crossing perpendicular to the anticline axis, exhibiting a sinuous thalweg; (e) continental slope. Drainage across the margin developed in several stages. Remains of turbidite flows crossing the margin down-slope were spotted across the area of the Delta anticline. They accumulated along with the MSC evaporate sequence, and before the anticline folded. Rising of the anticline from the then bathymetry either blocked or diverted the turbidites. The rising also defined the Hadera valley. In-situ evaporates cover the valley floor, covered by a fan-delta at the distal end of the valley. The fan-delta complex contains eroded evaporites and Lago-Mare fauna. Its top is truncated by a network of dendritic fluvial channels that drained to the Delta Gap. The Delta gap was carved through the Delta ridge in a morphological and structural transition zone.

We propose that during the first stages of the MSC (5.97±0.01–5.59 ma) destabilization of the continental slope due to oscillating sea level produced gravity currents that flowed through the area of the pre-existing Delta ridge. Subsequent folding of the Delta anticline led to divergent of several flows towards the Delta Gap area during the peak MSC desiccation phase (5.59-5.5 ma). This resulted in sub-aerial incision of a canyon across the gap that outpaced the tectonic uplift of the anticline. During the Lago-Mare regression (5.5-5.33 ma) a fluvio-marine sequence was deposited in the already formed Hadera Valley. Another transgression before the Zanclean flood (5.33 ma) eroded the top of this sequence and rejuvenated the Delta Gap canyon.

## Laboratory simulation of Radon signals: Examination of daily peaks

**Bezaly, O.R. (1,2), Steinitz, G. (2), Israelevich, P. (1), Kotlarsky, P. (2), Piatibratova, O. (2), Malik, U. (2) Asperil, T. (1), Marco, S. (1).**

1. The Department of Geosciences, Tel-Aviv University, Tel-Aviv 69978, Israel
2. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem 95501, Israel

Radon is an abundant, chemically inert radioactive gas. Its most stable isotope, 222Rn, has a half-life of 3.823 days and is the only gaseous atom in the 238U decay series. In earth sciences, radon might be considered as a potential tracer for natural processes, such as tectonic movement and volcanic activity. However, the physical mechanisms that govern radon emanation from rock and transport are not clear. Our team strives to observe and analyse radon signals in monitored environments.

Experiments termed "Enhanced Confined Mode" (ECM) are conducted in a radon enclosed chamber that contains air at atmospheric pressure. The ECM system simulates radon signals and allows us to investigate their characteristics both in the laboratory and in the field.

A Laboratory ECM experiment will be described; its structure comprises of two 222Rn sources of activity ~$10^5$Bq each. The two sources are connected in parallel via tube to a horizontal stainless steel cylinder (~570cm^3). Direct count rate measurements were conducted using a gamma-ray scintillation (NaI) detector placed at the end of the cylinder, at one minute resolution, for over 60 days.

Radon is supplied into the ECM chamber by diffusion where it also undergoes radioactive decay. A priori, steady state of the diffusion and the radioactive decay rates is expected. Surprisingly, our results show deviations from this expected steady state, namely variations that are significant relative to the uncertainty in count measurements. The measurements are characterised by a prominent daily peak. Signal processing measures and analysis of these daily peaks will be elaborately presented.

## Formation and demise of a reef belt at the edge and of the Israeli continental shelf, effects of sea level and sediment supply since the last glacial maxima

**Bialik, O.M.(1), Makovsky, Y. (1,2), Arnon, M. (1), Taha, N.(1), Waldmann N.D.(1)**

1. The Dr. Moses Strauss Department of Marine Geosciences, Charney School of Marine Sciences, University of Haifa, Mount Carmel, 31905 Haifa, Israel
2. The Hatter Department of Marine Technologies, Charney School of Marine Sciences, University of Haifa, Mount Carmel, 31905 Haifa, Israel

Low sea level characterizing the last glacial maxima (LGM) allowed the establishment of shallow-water reefs at positions currently deeper than 100 m. Some of these reefs, like those of the Gulf of Eilat (Aqaba) and Hawaii, initiated during photic conditions and demised as sea level rose. Others, like in southern Australia, were initiated by changes in the nutrient regime but demised when conditions became unhospitable. Here we present new findings for the establishment of reefs and bioherms prior to the Holocene sea level rise in the Eastern Mediterranean, with implications on post glacial nutrients and turbidity changes in the region.

A detailed Sparker seismic survey off Israel reveals the presence of high amplitude mounded features characterize by a chaotic internal seismic facies, located at depths of 172 to 190 msec (~130-140 mbsl) below mean sea level. The unit is subsequently buried by a 38 msec (~29 m) thick finely-layered sedimentary sequence that can be identified along most of the Israeli shelf edge as a discontinuous lineup of elements that range 7 to 50 msec (~5-40 m) in elevation and widens <1.4 km. Interestingly, the mounded features are situated below a sudden change in the bathymetry in which seafloor angle varies from <0.5° in the east to ~1.5° towards the west. The base of the mounded features resides on an unconformity surface of an unknown age, yet stratigraphical correlation with previous studies suggest a last glacial maxima age (~20 Ka).

Cores that penetrate this unit reveal a sequence of mud overlying highly calcareous sediments, with the upper portion composed primarily of tightly packed heterozoan assemblages, most notably serpulids and bryozoans. A sequence of radiocarbon ages recovered along the core reveal that the bioherm and reef biological assemblage were developed ~8 Ka cal. Based on our chronology, we suggest that the reef prevailed during the post glacial maxima transgression and terminated in conjunction to the development of sapropel S1 in the deep basin. Considering the water depth at the demise of the reef (>80 m) and that the biological assemblage is not solely of phototrophic conditions, we postulate that drowning does not appear to be the most likely cause of the termination of the reef. The transition from a calcareous domain to a silisicalstic one suggests the forcing of an external change in the sediment influx regime to the East Mediterranean through the Nile River.

## Reverse and forward 3D kinematic modeling of the Northern Negev

**Boianju, I.(1), Agnon, A.(1)**

1.Institute of Earth Science, The Hebrew University, Jerusalem 91904, Israel

The northern Negev records major deformational events that shaped the terrain since the early Mesozoic and can be regarded as an evolution model for much of the Levant. The terrain is characterized by a succession of various tectonic phases, and the deformation during each phase modified the structures that formed during earlier times. Exploring the relations between superimposed deformational events is essential for finding structural traps, evaluating the oil window and getting a better understanding of the structure. A basin inversion theory has been proposed to explain the deformation on a regional scale. However it is not certain whether all structures in the Northern Negev can be explained by the basin inversion theory alone. This study uses 2D seismic interpretations to build a composite 3D geological structure of the northern Negev. Forward modeling enables a better kinematic understanding of the shape and geometry of the subsurface. Reverse modeling of the structure, or '3D seismic restoration' using the Flexural slip algorithm, allows efficient testing of various deformation scenarios. Reverse and forward modeling of deformational evolution of the northern Negev may distinguish 'inverted' structures from structures that have remained intact, and can be used as a validation technique in other areas around the Levant. Moreover, 3D analysis allows accommodation of lateral shear, expected to play a significant role in the vicitnity of the right-lateral faults of the Negev-Sinai shear zone.

## Reassessment of laminated sequences deposition nature and their potential as flashflood records in the Dead Sea Basin

**Bookman, R. (1), Lopez-Merino, L. (2), Belmaker, R. (1), Eshel, A. (3), Epshtein, V. (3), Leroy, S. (1)**

1. Dr Strauss Department of Marine Geosciences, Charney School of Marine Sciences, University of Haifa, Mount Carmel, Haifa 31905, Israel
2. Institute of Environment, Health and Societies, Brunel University London, UB8 3PH Uxbridge, UK
3. The Ted Arisson Airborne Allergens Monitoring Laboratory, Tel Aviv University, Tel Aviv 69978, Israel

Lacustrine laminated sediments are often varves representing annual rhythmic deposition. The Dead Sea high-stand laminated sections consist of mm-scale alternating detrital and authigenic aragonite laminae. Previous studies assumed these laminae were varves; detritus deposition during the winter and aragonite in the summer. These sequences were used for varve counting and chronology, however this assumption has never been robustly validated. Here, we report an examination of the seasonal deposition of detrital and aragonite couplets from two well-known Late Holocene laminated sections at the Ze'elim fan-delta using palynology and grain-size distribution analyses. These analyses are complemented by the study of contemporary flash-flood samples and multivariate statistical analysis. Because transport affects the pollen preservation state, well-preserved (mostly) air-borne transported pollen was analysed separately from badly-preserved pollen and fungal spores, which are more indicative of water transport and reworking from soils. Our results indicate that (i) both detrital and aragonite laminae were deposited during the rainy season; (ii) aragonite laminae have significantly lower reworked pollen and fungal spore concentrations than detrital and flash-flood samples; and (iii) detrital laminae are composed of recycling of local and distal sources. The conclusions suggest that detrital and aragonite couplets in the Dead Sea laminated sediments are most likely not varves and that the laminae deposition is related to the occurrence of flash-flood events. Consequently, at least for the Holocene sequences, laminated sediments cannot be considered as varves and Quaternary laminated sequences should be re-evaluated. The Dead Sea Basin laminated sequences (as the ICDP Dead Sea Deep Drilling Project record) should be used for the reconstruction of palaeo-flash flood records that will have a significant impact on understanding the palaeo-hydrology of the Dead Sea Basin and its implication to high-resolution climatic interpretation.

## Oxygen profiling in the sediments of the Gulf of Aqaba

**Boyko, V. (1), Kamyshny, A. (1)**

1. Ben-Gurion University of the Negev, P.O.B. 653, Beer-Sheva, 84105 (correspondence: valeri.boyko@gmail.com)

The Gulf of Aqaba is an oligotrophic basin located in hyperarid region with low rainfall, rare seasonal flashfloods and intense aeolian dry deposition from local and distal dust sources. Sediments of the Gulf of Aqaba are moderately depleted in organic carbon content (≤0.6% at sites which are not affected by anthropogenic impact), whereas water column is known to be fully oxygenated throughout the year. Oxygen distribution in water column is controlled by salinity gradients, deep vertical mixing during winter, seasonal primary production and consumption. Oxygen penetration depth in the sediments is closely related to diffusive oxygen transport from bottom water, which in turn depends on availability and concentrations of organic matter and inorganic redox species that can serve as electron donors (dissolved manganese, iron, hydrogen sulfide). This study was aimed to investigate oxygen penetration depth in sediments and to estimate sedimentary oxygen consumption rates and diffusive oxygen fluxes across the sediment-water interface at various water depths of the Gulf of Aqaba.

Sediment was retrieved from nine water depths (17-700 m) along a north-south and a west-east transects as well as in the vicinity of coral reef. Dissolved oxygen concentrations were measured ex-situ in the sediment cores using two profiling techniques – optode microsensor (tip diameter of 50-100 μm) and amperometric "Clark-type" microelectrode (tip diameter of 50-100 μm). The measurements of oxygen profiles were performed in four experimental series: 1) optode system, undisturbed sediment cores, 1-10 hours after collection; 2) optode system, air-exposed sediment cores after transportation to the laboratory, 40-48 hours after field sampling; 3) Clark-type electrode, undisturbed sediment cores, 1-10 hours after collection; 4) Clark-type electrode, air-exposed sediment cores after transportation to the laboratory, 40-48 hours after field sampling. Simulations of oxygen consumption rates and fluxes were calculated according to the existing diffusion-consumption models (1,2). Oxygen penetration depth in sediment measured by both methods was higher at deep water sites than in nearshore sediments, whereas diffusive oxygen fluxes and sedimentary consumption rates in sediments from shallow sites exhibited higher values than in sediments from deep waters. Oxygen penetration depths that were measured by optode sensor were lower than those measured by amperometric microelectrode. Overall slight decrease in oxygen penetration depth and increase in diffusive oxygen fluxes were observed in 40-48 hours after sampling for all the samples.

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## New Bouguer gravity map of the Golan Heights

**Bronshtein, N. (1), Bartov, Y. (2), Aizenshtat, E. (2), Levy, E. (1)**

1. The Geophysical Institute of Israel.
2. Afek Oil and Gas Ltd.

The published National Bouguer Anomaly gravity map of the Golan Heights applied a density value of 2.67 g/cm$^3$ for the rock column interval from the mean sea level to the surface. This value is inconsistent with the measured densities of the Pleistocene-Miocene section as was found in the recent oil exploration drilling campaign in the region. The current study merges the old gravity dataset with about 150 new stations that were measured in the Golan by Afek Ltd. and the Geophysical Institute of Israel, producing an improved dataset that has been uniformly processed. The study uses newly acquired seismic lines and density measurements from boreholes to interpret the Golan subsurface and to delineate the stratigraphic changes of the overburden. Using this information, differential densities were applied to each gravity station. Following this processing phase we compiled a differential Bouguer Anomaly map which compensates for the lithological effect above MSL and better expresses the deep structure and basin shape.
The results provide a gravity analysis that is sensitive to the subsurface structures and is helpful in mapping the boundaries of significant faults such as the Sheik Ali Fault. The map also highlights structures that can be targeted for oil exploration.

## Megiddo-Jezreel License Area: New seismic interpretation of the Bet Shean Valley along the marginal fault of the Dead Sea Transform; Positive flower structure

**Buch-Leviatan, O. (1), Roter-Shindler, L. (1), Politi, M. (1)**

1. Zion Oil & Gas, Inc.

Recent comprehensive interpretation of the Bet Shean Valley area, done by Zion Oil & Gas, Inc. based on both vintage and newly acquired seismic data, both with new processing, revealed an intricate faulting system. As part of this system, the western marginal fault of the Dead Sea Transform (DST) was remapped, consistently downthrowing the eastern block, down to the entire depth of the section. Along part of the eastern side of this marginal fault we discovered that a positive flower structure has emerged, reversely displacing the upper section, also above the Pliocene Cover Basalt. About 70 km to the north of our study area a similar positive flower structure was identified, east of Qiryat Shemona fault, a northern branch of the DST. This structure was previously defined as evidence for a convergent strike-slip faulting during the Pleistocene, which followed the earlier pure strike-slip phase. The newly mapped western marginal fault trace also aligns well with the trace of the southern continuation of Qiryat Shemona fault.
Our conclusions are that the newly mapped marginal fault and flower structure are indeed part of the DST system, and were formed within the same shear zone that acted on the DST and its branches, possibly the later Pleistocene one.

## The photochemical decomposition of dimethylpolysulfanes in aqueous systems under exposure to natural sunlight: kinetics, products and mechanisms

**Buchshtav, T.(1), Kamyshny, A. (1)**

1.Department of Geological and Environmental Sciences, The Faculty of Natural Sciences, Ben-Gurion University of the Negev, P.O. Box 653, Beer Sheva 84105, Israel

Dimethylpolysulfanes (MeSnMe, DMPSs) are formed during the decomposition of algae in both marine and freshwater environments, as well as during the oxidation of sulfur-containing organic matter. The primary pathway for the formation of DMPSs is the biological methylation of inorganic polysulfides, although other pathways, such as condensation of methanethiol, also exist. These compounds have a noticeable repulsive odor at concentrations of micrograms per liter, and thus have an adverse effect on the quality of drinking water.

We measured the kinetics and determined the products of the decomposition of dimethyldisulfane, dimethyltrisulfane, dimethyltetrasulfane and dimethylpentasulfane in aqueous systems under solar irradiation. The decomposition rates were measured as a function of pH and dimethylpolysulfane concentration in order to calculate the quantum yields for this decomposition process, and suggest a mechanism for these processes.

We have previously reported on the decomposition of DMPSs in aqueous systems in the absence of light, and have found the process to be of the second order with regards to DMPS concentration and 0.5 order with regards to hydroxide ion concentration. It was found that under solar irradiation there is no dependence of the reaction rates on hydroxide concentrations, and that the quantum yield of the processes is independent of the DMPS concentrations. In addition, under exposure to solar irradiation, DMPSs decompose directly into methanethiol and inorganic polysulfides, unlike the complex chain reactions we reported on for the reaction in the absence of sunlight.

We estimated the residence time of dimethylpolysulfanes in natural aquatic systems. We have previously reported that in the absence of sunlight, the half-lives of DMPSs in Lake Kinneret vary from months for Me2S5 to millions of years for Me2S3. In the presence of sunlight the half-lives of DMPSs vary from less than a minute for Me2S5 to approximately 20 minutes for Me2S2, which explains the seasonal nature of odor complaints from water consumers, as well as the absence of any odor complaints from consumers served from the National Water Carrier.

## Erosion of the 30-km-long Sharon sea-cliff between 2015-2016 as quantified with high-resolution airborne LiDAR

**Bustan, I. (1), Mushkin, A. (1), Katz, O. (1), Crouvi, O. (1)**

1. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem 95501, Israel

Approximately 50 km of Israel's Mediterranean coast is characterized by periodical cliff collapses that drive inland. This process causes damage and poses risks to buildings and infrastructure along the cliff top as well as to recreational beachgoers. Historically, studies of this process relied heavily on mapping changes of cliff-top location using aerial photographs. Recent studies demonstrated a complementary approach that utilizes airborne LiDAR to understand contemporary cliff-retreat processes in 3D.
This study focuses on the dynamics of the Sharon sea cliff between Herzlia and Olga during 2/2015-2/2016 as documented with two respective airborne LiDAR campaigns each acquired at a resolution of 4 points per square meter. Focusing on volumetric changes along the cliff and the talus piles at its base, we mapped 201 collapse events that range in size between 0.1-387.1 $m^3$ and measured a total sediment erosion of ~20,000 $m^3$ from the Sharon sea cliff during the examined time period. Our results provide and additional step in an ongoing multi-year effort to better understand the processes and rates driving the erosion and retreat of Israel's Mediterranean sea cliffs.

## Seismotectonic characterization of southern Israel: Implications for $CO_2$ sequestration options in the Jurassic saline aquifer

**Calvo, R. (1), Salamon, A. (1)**

1. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501

Earthquakes may disrupt potential carbon storage reservoirs and thus need special attention. Accordingly, this study evaluates the natural seismic activity which may disturb the long-term and large-scale $CO_2$ storage potential of several saline aquifers in southern Israel. This work is part of the characterization of the proposed sequestration sites in Israel and is based on all the existing seismological and earthquake related data. All the historical and modern earthquake catalogs were gathered and the pattern of seismicity in space and time in relation with the study area was examined. Our perspective was extended beyond the limited term exhibited by these records, and resorted to all the available neo-tectonics elements, namely geomorphic features, stress field indicators and geodetic measurements. Based on the seismotectonics of the research area, the areas relevant to $CO_2$ storage is constrained in accordance with the following leading criteria: (1) farther than 10 km away from any Md>3 seismic event, and (2) at least 10 km away from potential surface rupture (active faults in terms of the Israeli building code) and other major fault zones. These were integrated with the additional criteria of: (1) more than 800 m depth to the top of the aquifer, and (2) more than 100 m thickness of the capping sealing aquitard that were determined previously. Overall, the area relevant for $CO_2$ storage in Israel is reduced to about 4250 $km^2$. Three proposed storage sites were examined and found to be located well within the reduced area of interest (AOI), at least 36 km away from the nearest recorded Md>3.0 earthquake. These outcomes are presented on a summary map, an effective way to explain this process and outcomes to the decision makers.

## Analyzing the magnitude of error in the effective capacity calculation of the Israeli Jurassic saline aquifer propagated from uncertainties in the thermophysical conditions in the reservoir

**Calvo, R. (1), Taragan, R. (1, 2), Rosenzweig, R. (1)**

1. The Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501
2. Department of Geological and Environmental Science, Ben Gurion University of the Negev, Beer Sheva 84105, Israel

$CO_2$ storage capacity assessment is one of the most important tools for screening and ranking potential aquifers for deep geological storage. The mass of stored $CO_2$ depends largely on the density of the supercritical $CO_2$, which is in turn controlled by the reservoir pressure and temperature conditions along with the selection of the equation of state (EOS). In this study we examine the magnitude of error in $CO_2$ density and total storage capacity arising from uncertainties in subsurface temperature and pressure, and in particular from uncertainties in the surface temperature, geothermal gradient, depth of the piezometric surface and the density of the formation water. We calculate $CO_2$ density with two EOS (the Redlich-Kwong and the Peng-Robinson EOS) in order to assess the magnitude of difference arising from the EOS selection. Using the Israeli saline Jurassic aquifer as a case study, we establish the statistical distributions of the above temperature and pressure components and evaluate the errors using the Monte Carlo method. Our study shows that the piezometric surface depth and the geothermal gradient have a strong effect on the $CO_2$ density and on the depth of the transition to supercritical $CO_2$ whereas the influence of the surface temperature and the density of the formation water are rather small. The influence of the EOS selection on the $CO_2$ density and total capacity was found to have a moderate impact, compared to the other parameters. While the analysis of the storage capacity increases our confidence in the suitability of the Jurassic saline aquifer to store large amounts of $CO_2$, the conclusions concerning the effect of pressure and temperature uncertainties on the $CO_2$ density and on the depth of the transition to supercritical $CO_2$ are general and apply to most of the deep saline aquifers considered for $CO_2$ storage.

## Paleo-hydrologic Interpretation of a Late Pleistocene/Holocene sediment-core archive ( Nizzanim, Israel)

**Carmi, I.(1), Kronfeld, J.(1)**

1. Department of Geosciences, Tel-Aviv University

A 20 meter long sediment core, reaching to the top of the water table, was collected along the southern coastal plain of Israel at Nizzanim. The alternation of the core mineralogy of quartz sand, clay, and carbonate reflected climate changes. Radiocarbon dating of the organic carbon showed two age groups. Ages of in situ carbon indicating the time of deposition, which increase linearly with depth ($r^2$ =0.99). A smaller group of ex situ ages deviated from the age-depth line, being younger than expected are due to the subsequent intrusion of plant roots (e.g., at 3m a live Retamia root was found and a live rootlet at 10.5m)which can penetrate beneath the extant surface an average of 8.6±2.6m. The dating of the core made possible attributing geologic information to different depths: The Little Ice age, the flooding of the Black Sea, and the Younger Dryas, as well as suggesting important local paleo- hydrologic information. For example, a radiocarbon age of 14K years is measured for the depth at 12m. At this time the global sea level was approximately 100m below the present sea surface, while the sediment surface was about 11m lower than that of today (The exposed coastal plain sediment buildup preceded at a rate of approximately 0.8 mm/y). The coastal plain aquifer is phreatic, and is in direct contact to the sea, to which it drains. With lowering of sea level not only was the shore line extended westwards (seawards), but the aquifer discharge initially increased due the increased flow gradient. The sea level lowering caused streams draining to the sea to incise their water courses, while increased groundwater discharge to the sea lowered the water table. A lowering of the water table of such magnitude should have had an inhibiting effect on permanent human settlement, probably restricting settlement to the vicinity of incised river courses or eastwards to the mountain springs; for, the digging of inordinately deep wells would have been required to reach fresh water. At approximately 8K BP the rise in sea level with the concomitant water table rise would have made the digging of fresh water wells feasible. Continuous sea level rise would have at first led to increasing salinization of these wells followed by full sea water flooding, causing human migration eastwards.

## The effect of heterogeneity and correlation length on $CO_2$ storage in the saline Jurassic aquifer of the Negev

**Cohen, E. (1, 2), Holtzman, R. (2), Rosenzweig, R. (1)**

1. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501.
2. The Hebrew University, The department of Soil and Water Sciences, Rehovot, 76100.

Numerical simulations are amongst the most efficient tools for understanding the migration and trapping of injected $CO_2$ in saline aquifers. In Israel, the Jurassic middle aquifer in the Negev was identified as the prime target for $CO_2$ storage. The aquifer consists of a highly porous and permeable sandstone layer overlaid by alternating shale, sandstone and carbonate layers, partially fractured, and sealed by thick shale units that are likely to act as a barrier for $CO_2$. Guided by previous works that have identified porosity and permeability as the dominant parameters, we investigate their effect on injection and consequent spreading of $CO_2$ in spatially-correlated and uncorrelated heterogeneous permeability fields using two dimensional simulations (with TOUGH2 simulator).
We find that the type of heterogeneity in the permeability field significantly affects the dynamics of the injected $CO_2$: lateral spreading of the $CO_2$ plume decreases with the correlation length, with an intermediate value obtained for homogenous fields and high values obtained for the uncorrelated fields. Consequently, increasing correlation length decreases the amount of $CO_2$ that penetrates into the caprock, thus improving storage security. Our results so far suggest that $CO_2$ storage in the Jurassic saline aquifer of the Negev is feasible and safe option for reducing Israel's greenhouse gas emissions. This opens the way for future research focusing on $CO_2$ injection at specific sites.

## Nano iron particles transport in fractured rocks: laboratory and field scale

**Cohen, M. (1), Weisbrod, N. (1)**

1. Department of Environmental Hydrology & Microbiology, Zuckerberg Istitute for Water Research, Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev

This study deals with the transport potential of nano iron particles (NIPs) in fractured media. Two different systemswere used to investigate transport on two scales: (1 )a laboratory flow system of a naturally discrete fractured chalk core, 0.43 and 0.18 m in length and diamater, respectively; and (2) a field system of hydraulically connected boreholes located 47 m apart which penetrate a fractured chalk aquifer.
We started by testing the transport potential of various NIPs under different conditions. Particle stability experiments were conducted using various NIPs and different stabilizers at two ionic strengths. Overall, four different NIPs and three stabilizers were tested. Particles and solution properties (stability, aggregate/particle size, viscosity and density) were tested in batch experiments, and transport experiments (breakthrough curves (BTCs) and recovery) were conducted in the fractured chalk core. We have learned that the key parameters controlling particle transport are the particle/aggregate size and stability, which govern NIP settling rates and ultimately their migration distance. The governing mechanism controlling NIP transport was found to be sedimentation, and to a much lesser extent, processes such as diffusion, straining or interception. On the basis of these experiments, composite NIP - Carbo-Iron® particles (~800 nm activated carbon particles doped with nano zero valent iron particles) and Carboxymethyl cellulose (CMC) stabilizer were selected for the field test injection.
In the field, Carbo-Iron particles were initially injected into the fractured aquifer using an excess of stabilizer in order to ensure maximum recovery. This resulted in high particle recovery and fast arrival time, similar to the ideal tracer (iodide). The high recovery of the stable particle solution emphasized the importance of particle stability for transport in fractures. To test mobility manipulation potential of the particles and simulate more realistic scenarios, a second field experiment was conducted where the CMC – Carbo Iron ratio was reduced from 0.8:1 to 0.05:1. As expected, the lower stabilizer ratio resulted in lower recovery of the particles, demonstrating that particle mobility can be manipulated by changing stabilizer concentration. Additionally, a sudden increase in the hydraulic gradient between the injection and pumping well resulted in the release and remobilization of Carbo-iron particles which had settled within the fractures, indicating thatparticle settling is reversible within the aquifer.

## An Israeli haboob: Sea breeze activating local anthropogenic dust sources in the Negev loess

**Crouvi, O. (1), Dayan, U. (2), Amit, R. (1), Enzel, Y. (3)**

1. Geological Survey of Israel, 30 Malkhe Israel St., Jerusalem 95501
2. The Department of Geography, The Hebrew University of Jerusalem, Mt. Scopus, Jerusalem 91905
3. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of Jerusalem, Givat Ram, Jerusalem 91904

Meso-scale weather systems, such as convective haboobs, are considered to be an important dust generation mechanism. In Israel, however, rather than of meso-scale weather systems, most dust storms are generated by synoptic-scale systems, originating from Sahara and Arabia. Consequently, only distal sources of suspended and deposited dust in Israel are currently reported. Here we report the first detailed study on the merging of synoptic- and meso-scale weather systems leading to a prominent dust outbreak over the Negev, Israel. During the afternoon of May 2nd, 2007, a massive dust storm covered the northern Negev, forming a one kilometer high wall of dust. The haboob was associated with PM10 concentrations of 1,000-1,500 $\mu g\ m^{-3}$ that advanced at a speed of 10-15 $m\ s^{-1}$ and caused temporary closure of local airports. In contrast to most reported haboobs, this one was generated by a sea breeze front acting as a weak cold front enhanced by a cold core cyclone positioned over Libya and Egypt. The sea breeze that brought cold and moist marine air acted as a gravity current with strong surface winds. The sources for the haboob were the loessial soils of the northwestern Negev, especially agricultural fields that were highly disturbed in late spring to early summer. Such surface disturbance is caused by agricultural and/or intensive grazing practices. Our study emphasizes the importance of local dust sources in the Negev and stresses loess recycling as an important process in contemporary dust storms over Israel.

## Progressing resource efficiency in the Israeli mineral sector

**Danon, M.(1)**

1. Quarries and Mines Department. Natural Resources Administration. Ministry of National Infrastructure, Energy & Water Resources. 14, Hartum St. POB 36148, Jerusalem 9136002, Israel.

Increasing Resource efficiency is vital to preserve our limited resources, utilize them in a sustainable manner and minimize impacts on the environment. Efficient use of resources is essential for any sectors sustainability simply because it allows us to create more with less input and to deliver greater value.

Improved efficiency in the utilization of natural resources such as minerals is nowadays an imperative requirement for sustainability. This is because of rising costs for essential raw materials, the scarcity and depletion in quality of most available minerals. Price volatility having a damaging effect on the economy is a concern for many countries. In Israel, another major factor for consideration is making efforts to avoid future land-use conflicts. These are already common and intense, however could intensify with increase of population which creates competitive demands for the use of the land.

Most mining and the associated processing operations inevitably lead to the production of mineral byproducts. The quantity and quality these would depend on the site geology, the extraction methods, the processing operations and the market for products. Stockpiling byproducts which were not marketed is always costly, but could also charge land surface designated for mining and limit access to the resources beneath the piles.

Markets for the byproduct depend on economic factors, technological limitation and regulatory constraints. Developing the market and overcoming such limitations could reduce the need for stockpiling these sub-economic materials. These materials include overburden and inter-burden, or processing byproducts. For example, in the production of construction aggregates from crushed rocks, large volumes of fine grained material are made in the crushing, screening, washing and other processing activities. Quarry fines from aggregates production are normally inert; the quantities produced vary greatly from site to site. Few quarries do not need to stockpile byproducts, but most quarries produce such large volume of bulky materials that must be stockpiled, usually clay and silt are accumulated, potentially causing dust nuisances or an eyesore.

The demand for raw materials is expected to further grow with increased globalization, economic proliferation, strains on existing infrastructures and greater housing needs for population growth. With increasing local and global pressure on natural resources, current patterns of resource use are not good enough to sustain growth. Therefore changes in the production and the consumption phases are both essential. Technological breakthroughs together with regulatory reforms may well be required to enable this.

## Mapping active faults from 3-D model based on drone's photos

**Darvasi, Y. (1), Agnon, A. (1), Shemesh, R. (1,2)**

1. Institute of Earth Sciences, The Hebrew University, Jerusalem 91904, Israel
2. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem 95501, Israel

Drones - gadgets leading the new technologies - are becoming an efficient tool in the industry and also for environmental sciences, including tectonics and geomorphology. With the rise of drones, the prohibitive costs of aerial geological surveys have dramatically diminished. We use this indispensable instrument for high-resolution mapping of some antithetic active faults near Ye'elim Creek at the Dead Sea fault escarpment, Israel.
This area, on the western fault escarpment of the Dead Sea Valley, exhibits antithetic faulting expressed as narrow and elongated horsts and grabens. The elevation spans from 270 to 380 meters below mean sea level, and the surface is lined by beach sediments from the receding Lake Lisan, deposited between 14 and 15 ka. Hence, except in east-west running rills, the topography is a proxy for the geological structure that was formed by active faults. Exposure of the underlying Judea Group bedrock supports the structural interpretation.
We took hundreds of photos with DJI's Phantom 3 Pro and also measured 25 landmarks with differential GPS. With this data we created our final high resolution 3-D model that covers an area of about 300,000 square meters and have a negligible error of 12 centimeters.
Based on some ArcMap algorithms we located three straight lineaments within this model that suggest fault structure with a strike of 030° and a typical spacing of about 100 meters. Slips on faults measured in this survey reach approximately 10 meters. This suggest an average slip rate of about 0.66 millimeter per year. These slip rates are likely reflecting slope instability on a large scale, in line with open crevices reported north of the Ye'elim Canyon and fault plane solution for 4.1M earthquake.

## Calibrating a new attenuation curve for the Dead Sea region using surface wave dispersion surveys in sites damaged by the 1927 Jericho earthquake

**Darvasi, Y.(1), Agnon, A. (1)**

1. Institute of Earth Sciences, The Hebrew University, Jerusalem 91904, Israel

On 11 July 1927 a crustal rupture generated a moderate 6.2 earthquake in the northern part of the Dead Sea. Up to five hundred people were killed and extensive destruction was recorded, even at places as far as 150 km from the focus. We consider local near-surface properties, in particular the shear wave velocity, as an amplification factor. Where the shear wave velocity is low, the seismic intensity at places far from the focus might be greater than expected from a standard attenuation curve. In this work we used the Multi Analysis of Surface Waves (MASW) method to estimate seismic wave velocity at anomalous sites in Israel.

In order to allow for site effect in the equation of Hough and Avni (2011), we incorporate an additional term (logarithmic with Vs30) with two coefficients. These coefficients (a pre-logarithmic factor and a reference velocity) are constrained by a fit to Vs30 measured from 25 anomalous sites (twenty from the present work and five from GII reports). The amended equation is:

Of the measured sites 68% are fitting to the equation (with 60% prediction boundary). Better fitting is achieved in comparison to any other attenuation equation.

To validate this new equation we need to measure a more significant number of sites and assess fit to the equation. This research considers only site conditions, meaning that there is no reference to other issues such as: rupture directivity, building quality, topography, etc. Despite this, the data collected is useful for further research and should be taken into consideration for improving maps of seismic risk.

## Paleomagnetic and mechanical investigation of the Dead Sea Fault in northern Israel

**Dembo, N. (1,2), Granot, R., (1), Hamiel, Y. (2)**

1. Department of Geological and Environmental Sciences, Ben-Gurion University of the Negev, Beer-Sheva, Israel
2.Geological Survey of Israel, 30 Malkhe Israel St., 95501, Jerusalem, Israel

The rotational deformation field around the northern segments of the Dead Sea Fault in Israel is addressed. We perform a detailed paleomagnetic investigation of Neogene-Pleistocene basalts surrounding segments of the fault that extend between the Sea of Galilee and the Hula Valley. The results from 27 new paleomagnetic sites reveal significant (>20°) vertical-axis counterclockwise rotations within a right step-over between two prominent segments of the fault: the Jordan Gorge section and the Hula East Boundary Fault. In the vicinity of the step-over small clockwise rotations are observed. Sites located further (>2.5 km) away from the step-over generally experience negligible to minor rotations. These results reveal localized zones of anomalous rotations that together with mechanical modeling provide constraints on the structural, mechanical and kinematic behavior of the Dead Sea Fault in this region.

## Geomorphic response of a long channel to a modern, decades-long, continuous base-level lowering: Nahal HaArava, the Dead Sea

**Dente, E. (1,2), Lensky, N. (2), Morin, E. (1), Grodek, T. (1), Sheffer, N. (3), Enzel, Y. (1)**

1.The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of Jerusalem, Edmond J. Safra Campus Givat Ram, Jerusalem 91904, Israel.
2. Geological Survey of Israel, 30 Malkhe Israel St., Jerusalem 95501, Israel.
3. ICL\ Central R&D Institute, Geology group, 10140 Haifa Bay, Haifa 26111, Israel.

Geomorphic response to base-level lowering dominate landscapes evolution, among them the formation of valleys across continental shelf. In this study, we utilize the unprecedented and detailed data available for the newly incising, kilometers-long, perennial reach of Nahal (Wadi) HaArava that responds to rapid and continuous lowering of its base-level, the Dead Sea (~30 m during the last ~35 years; ~1 m/yr in the last two decades). The detailed documented changes in the channel during the last decades point to the factors controlling general channel evolution in this continuous disequilibrium state. High-resolution LiDAR-based DEMs, aerial and ground photographs, Landsat imagery, and field observations were applied in this sub-annual to decade-long documentation of detailed channel changes including past longitudinal profiles, width, sinuosity, and knickpoint retreat. We identified three stages of channel evolution, which were primarily controlled by the evolving slope at the channel mouth and lithologic factors. These include (a) Lengthening and minor incision, maintained by rapid delta progradation on top of relatively low slopes of the emerging shelf-like southern Dead Sea basin. (b) Spatially discontinuous evolution, triggered by steeper mouth slope, in which lithologically (rock salt) induced vertical knickpoints divided the channel to incising, narrow, and meandering reach downstream and upstream reaches without changes. (c) Spatially continuous evolution following the rapid knickpoint retreat phase; in this stage, the entire studied channel responded to the high mouth slopes, incising relatively homogeneous substrate. i.e. the channel shifted from vertical knickpoint retreat phase to a more diffusive phase along the entire channel.

## National active faulting hazard map

**Dor, O. (1), Davis, M. (1)**

1.Ecolog Engineering Ltd. 3 Pekeris st. Rehovot, Israel 76702

The SI 413 active/potentially active fault map (Sagy et al., 2016) is not an active faulting hazard map in the sense that it only documents surface-traces of fault segments that ruptured the ground surface during the last 13,000 years (for "active" faults; and up to 35,000 years for "potentially active" faults). This is because the SI 413 map was generated for standardized engineering design and can only include explicit evidence for surface faulting. The full length and width of active fault zones – according to commonly used definitions in national hazard maps - are not presented on the SI 413 map, and it is therefore insufficient for urban planning and as a base map for seismic hazard models. Geological mapping of surface ruptures show broad shear zones with numerous previously un-mapped faults and sometimes faulted alluvial surfaces having no expression in post-earthquake mapped trenches (e.g. Landers 1992, Mw=7.3). Paleoseismic mapping of the San-Andreas fault in Central California shows ~10 fault branches that ruptured the surface in six earthquakes over a 21 m wide fault zone (Grant and Sieh, 1994). These evidence imply that the location of future surface displacement within a fault zone cannot be predicted with certainty even with detailed mapping. In addition, the evidence for surface displacement can deteriorate in timescales well below the criteria for active faulting (e.g., Begin, 1992; Gardosh et al., 1990) even in areas that have not been disturbed by anthropogenic activity. Surface rupture hazard therefore prevail, potentially, in areas much larger than those delineated in the SI 413 map. Of 28 earthquakes that ruptured the surface in California during 1974 to 2007, 3 occurred on previously un-mapped faults.
As part of the generation of an active faulting hazard map for Israel, we present a new set of criteria for active faults, and propose that surface faults and hazard zones for planning (vs. design) should include faults (vs. traces) and shear zones that are neotectonically active. Such a map will facilitate safer development prioritization during urban planning, and will allow reliable estimation of the cost and duration of specific site surveys and construction. Also, the mapped faults are defined as seismogenic sources and can be incorporated into ground motion assessment models. Examples for such non-standardized hazard zones include the Carmel fault southeast of Yokneam, some sections of the Arava fault, and broad marine active shear zones at the continental slope.

## Reconnaissance for precariously balanced rocks in the Negev and their preliminary constraints on the region's maximum historical ground motion

**Dor, O. (1), Davis, M. (1), Finzi, Y. (2), Ganz, N. (2)**

1. Ecolog Engineering LTD, Rehovot
2. Dead Sea and Arava Science Center, Mitzpe Ramon

Precariously Balanced Rocks (PBRs) are strong-motion seismoscopes that can provide important information on the long term maximum ground motion and seismic hazard from large earthquakes (e.g. Bell et al., 1998). PBRs in the western United States provided important constraints on national ground motion maps (e.g. Brune et al., 2006) and the determination of their toppling accelerations was calibrated by rocks toppled during large earthquakes. However, PBRs in carbonate terrains were barely studied so far. Our study is focused on the adaptation of the PBR methodology to the typical carbonate terrains along Israel's mountainous backbone; specifically, we use PBRs to develop constraints on the seismic hazard predicted by local seismotectonic models, and in particular on the seismic activity of the large traverse faults in the Negev.

PBRs in carbonate rocks are expected to be found along cliff exposures of relatively thick hard layers that are interbedded with thin soft, easily eroded layers. Those layers would be preferably near-flat, and dissected by near vertical orthogonal joint set, forming free-faced rock columns. We select areas in the Negev that meet the above criteria using the Top Judea structural map and the geological map, and scout for the existence of potential PBRs in those areas using aerial photos. Here we present general characterization of PBRs that were found during reconnaissance trips in those areas.

In order to demonstrate the utility of the Negev PBRs, we generated a map of maximum PGA due to the SI 413 Maximum Credible Earthquakes on the region's faults (Zin, Saad-Nafha, Ramon, Arif-Bator: M=5.5; Faran, Temed: M=6; Arava: M=7.5) and standardized parametrization of the attenuation relations. We show that some of the PBRs have an estimated preliminary toppling acceleration below the map value for their location, hence providing useful constraints for the level of maximum seismic shaking in the studied area.

## Modeling raw sewage leakage and transport in the unsaturated zone of carbonate aquifer using carbamazepine as an indicator

**Dvory, N.Z (1,2), Kuznetsov, M. (1), Livshitz, Y. (3), Gasser, G. (3), Pankratov, I. (3), Lev, O. (4), Adar, E. (1), Yakirevich, A. (1)**

1. Zuckerberg Institute for Water Research, J. Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Israel
2. Etgar A. Engineering Ltd.
3. Israel Hydrological Service, Israel Water Authority
4. The Hebrew University, Israel

Contamination of groundwater in karst aquifers can be caused due to leaky sewers, for example, or overflow from sewer networks. When flowing through a karst system, wastewater has the potential to reach the aquifer in a short time. The Western Mountain Aquifer (Yarkon-Taninim) of Israel is one of the country's major water resources. During late winter 2013, maintenance actions were performed on a central sewage pipe that caused raw sewage to leak into the creek located in the study area. The subsequent infiltration of sewage through the thick (~100 m) fractured/karst unsaturated zone led to a sharp increase in contaminant concentrations in the groundwater, which was monitored in a well located 29 meters from the center of the creek. Carbamazepine (CBZ) was used as an indicator for the presence of untreated raw sewage and its quantification in groundwater. The ultimate research goal was to develop a mathematical model for quantifying flow and contaminant transport processes in the fractured-porous unsaturated zone and groundwater system. A quasi-3D dual permeability numerical model, representing the 'vadose zone – aquifer' system, was developed by a series of 1D equations solved in variably-saturated zone and by 3D-saturated flow and transport equation in groundwater. The 1D and 3D equations were coupled at the moving phreatic surface. The model was calibrated and applied to a simulated water flow scenario and CBZ transport during and after the observed sewage leakage event. The results of simulation showed that after the leakage stopped, significant amounts of CBZ were retained in the porous matrix of the unsaturated zone below the creek. Water redistribution and slow recharge during the dry summer season contributed to elevated CBZ concentrations in the groundwater in the vicinity of the creek and tens of meters downstream. The resumption of autumn rains enhanced flushing of CBZ from the unsaturated zone and led to an increase in groundwater concentrations.

## Constraining the age of the Goliath Slide - a recent submarine slide on the continental slope of Israel

**Elad, M. (1), Makovsky, Y. (1), Almogi-Labin, A. (2), Gadol, O. (1), Bookman, R. (1)**

1. The Dr. Moses Strauss Department of Marine Geosciences, Leon H. Charney School of marine sciences. University of Haifa, Mt. Carmel, Haifa 31905, Israel.
2. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501.

Submarine slides are distributed along the entire continental margin off Israel. To date, none of these slides was directly dated. This study aims to constrain the age of the Goliath Slide Complex offshore Ashkelon, one of the most recent submarine slides on the continental slope of Israel, using sedimentological and $^{14}C$ dating methods. The morphology of the slide complex consists of very sharp gradients, an extended bathymetric step at its head scar (>80m), high roughness of the debris morphology and minor sediment cover that overlie the slide deposits. We investigate sediment cores from the slide's head scar wall and from the distal toe region. In order to reveal the slide structure, stratigraphy and other processes as bioturbation, we combine a detailed CT analysis with a unique CT-driven sampling strategy, and sedimentological and micropaleontological analyses. Our integrated analysis shows ~35cm thick hemipelagic sediments that cover the slide's head scar. The age-depth model indicates a major age-gap of ~20 kyrs between sediments from above (33cm, 6.9-7.5 ka BP) and below (55cm, 26.2 ka BP) the slide scar surface. This age-gap is supported by the planktonic foraminifera assemblage and implies that a significant volume of sediments was removed during the sliding event. Furthermore, the age-depth model suggests the existence of a hiatus in the Holocene sedimentary sequence at ~6 ka BP, which might indicate a more recent and minor sliding event. Results from the toe region show a 1.2m of continuous hemipelagic sequence that represent the last ~14 ka BP. This hemipelagic sequence, which includes sapropel event S1, is underlain by >5m of disturbed sediments interpreted as slide deposits. The planktonic assemblage changes markedly just below 1.2m, whereas species that thrive in the Holocene disappear almost absolutely. The slide deposits were divided into 3 units that are clearly distinguished by the CT analysis and the visual inspection. Radiocarbon ages from within the slide units show an age-inversion, as the upper units are composed of sediments dated to ~27-~29 ka BP while the lower unit was dated to ~18.6 ka BP. The combined stratigraphical and sedimentological analysis and dating suggest multiple sliding events, or the presence of sediment blocks that were translated downslope as units. The minimum age of the slide is different in the head scar (~7.5-8 ka) and the toe (~14 ka). Therefore, we suggest that it is likely that the Goliath slide was formed by multiple sliding events. This study demonstrates the necessity of combining several techniques and sedimentological methods, to properly constrain the age of a recent submarine sliding event.

## A new metallogenic model for sediment-hosted stratiform copper mineralization at the northern margins of the Arabian-Nubian Shield – Preliminary observations and results

**Eliyahu, A.(1), Katzir, Y.(1), Ginat, H.(1), Segev, A.(2)**

1. Department of Geological and Environmental Science, Ben Gurion University of the Negev, Beer Sheva 84105, Israel
2. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem 95501, Israel

Regionally distributed sediment-hosted stratiform copper (SSC) mineralization in southern Israel is hosted by two geological units, the Early/Middle Cambrian carboniclastic and clastic rocks, mainly within the Timna Formation (Lower Orebody), and the Lower Cretaceous sandstones of the Amir and Avrona Formations (Upper Orebody).
This study challenges the current metallogenic perception by using observations from previous studies and preliminary results, and proposes a new metallogenic model showing the genetic relationships, which are typical to SSC deposits worldwide, between SSC deposits in the study area and the large and deep Timna-Faynan sedimentary basin hosting them. Two mineralisation events and two supergene events are proposed: (a) Oxidizing basin fluids leached metals from the Ediacaran-Cambrian red-beds sediments of the Zenifim and Amudei Shelomo arkoses and from the underlying magmatic basement. The fluids were driven up-section along basement topography and basin structures towards the Early Cambrian carbonate sediments, mixing with sulfur-rich interstitial water produced by bacterial reduction of seawater sulfates to precipitate Cu-sulfides. The metal-bearing fluids were blocked from flowing into the shallow Amram-Eilat basin to the south of the Mt Amram - Mt Neshef topographical divide, which explains the lack of Cu mineralisation within that Cambrian basin; (b) Throughout Palaeozoic – Mesozoic times sedimentation in the Timna-Faynan basin was repeatedly interrupted by thermo-tectonic events resulting in uplift and erosion, deformation and basinal-fluid circulation. A deep truncation in the Early Cretaceous exposed the Lower Orebody to groundwater redox changes and the first supergene alteration; (c) A regional, basin-scale, epigenetic hydrothermal event was driven by the intrusion of magmatic bodies into the Timna-Faynan basin around 108 Ma. Highly reactive hot metal-bearing basinal/connate fluids transported through faults, fractures and karst hosted within the already consolidated rocks of the Timna Formation enriched the Lower Orebody with Cu and other metals like Pb and U, typically within dissolution zones and pods with limited dissemination into the adjacent host rocks. Structurally controlled metal-bearing hydrothermal fluids crossed the sandstones of the Shehoret and Amir Formations into the lower contact of the Avrona Formation. A contact-parallel (unconformity) fluid flow commenced, leading to the replacement of diagenetic Fe-sulfides by Cu sulfides or to the precipitation of Fe and Cu sulfides in an organic rich reducing environment; and (d) Regional scale pervasive supergene oxidation and alteration occurred by meteoric fluids. Changes in the redox front were and still are the key to the oxidation seen within both Lower and Upper Orebodies. It follows that the Timna and Faynan Cu deposits formed prior to the DST initiation and should be considered as a single giant (>2

Mt Cu) SSC deposit. This is important for future evaluation of the exploration potential to find new giant SSC deposits within the southern basin-margins along the northern Arabian-Nubian Shield.

## The earth science southern regional class - An upcoming program for earth science teaching derived from the earth science cross-country class

**Eyov, L. (1) (2), Orion, N. (1), Avriel-Avni, N. (2), Finzi, Y. (2)**

1. Department of Science Teaching, Weismann Institute of Science, Rehovot 761001, Israel.
2. The Dead Sea-Arava Science Center, Mitzpe Ramon Branch, Israel.

The Earth Science Cross-Country (ESCC) class is the first distance-learning for matriculation in Israel (5 credit points). This project started in 2011, through collaboration between the science teaching department of the Weizmann Institute and the Davidson Institute. The program of the ESCC class is identical to the earth science high school curriculum, and it applies a constructivist approach in which teachers guide students to learn and process personal-internal information to form knowledge. The teachers, learning materials and the surrounding all encourage the student to interact naturally and actively with the information. Therefore, the learning is based on an independent research process in various learning environments: class, lab, computer and field. The ESCC students work with an internet platform "Moodle" (Modular Object-Oriented Dynamic Learning Environment) and with experiment kits, which are sent to their home. The same learning materials such as books and workbooks which are used in schools, uploaded to the "Moodle" and divided to different lessons. The students access the "Moodle" in their own time and follow the lessons. Each lesson is an independent inquiry activity performed by the student in his home, so that the table in his house is converted to a "laboratory" environment. The outdoor learning environment is combined integrally with the inquiry learning process. The program includes nine mandatory field trips, which consist one assessment component of the final matriculation. At the end of each field trip, students process their observations and conclusions in logical sequences as part of field reports. During its six years of operation, the ESCC class attracted about 200 student (10th to 12th grade) from all around Israel, but mainly from the center region. In addition to the difficulty in attracting students from the peripheral areas from north and south of Israel, students in the program who came from these regions indicated difficulties such as long distance travel and financial difficulties. Therefore, it was found necessary to lunch regional classes, which will cater for students from peripheral areas, and allow them to study earth sciences as science extension outside school, at a subsidized cost. The Earth Science Southern Regional (ESSR) class will be the first regional project, upcoming in September 2017 through the Dead Sea-Arava Science Center, as part of a Computerized Learning Center initiative at Mitzpe Ramon.
The ESSR class will be based on the ESCC program, utilizing the Davidson Institute internet platform in the pilot phase. The ESSR will provide a framework for Earth Science Studies (five scientific units) for students from Eilat to Be'er Sheva, and as such will establish a model for scientific distance-learning for matriculation in the South Israel.

## Geoheritage, geodiversity and the Makhteshim country geopark project

**Finzi, Y. (1), Avni, S. (1), Avni, Y. (2), Zaarur, S. (3), Limon, Y. (4), Kedem-Silbert, E. (5)**

1.Dead Sea and Arava Science Center
2.Geological survey of Israel
3.Hebrew University of Jerusalem
4.Mitzpe Ramon tourism council
5.BATEVA – desert nature adventure

Geoheritage encompasses global, national, and local geologic features, at all scales that are considered to have significant scientific, educational, cultural or aesthetic value. Such sites may offer information or insights into the evolution of the Earth, the history of science, or that can be used for research, teaching or recreation. Geoheritage is increasingly being harnessed to develop and celebrate the connection between people, landscape and Earth history, with the ultimate goal of reconnecting humans to the remarkable planet we call home. The story of Earth, our geoheritage, is preserved in its geodiversity - the variety of earth materials, forms and processes that constitute and shape Earth, its surface and any specific site on it. Geodiversity also provides the foundation for life on Earth and the diversity of species, habitats, ecosystems and landscapes. It is a vital link between people, nature, landscapes and cultural heritage.

The UNESCO Global Geoparks Network (UGGN) is leading global efforts to increase awareness and support geoconservation and Geoheritage. UGGN consists of 120 territories with geological heritage of international significance that implement strategies for holistic management, promotion and sustainable development. Geoparks provide geo-scientific knowledge as a substantial elements for nature conservation, geoheritage protection, environmental education, and geotourism development. Many of the geoparks stimulate the locals to participate in activities leading to prosperity of the local economy and preservation of natural resources. Moreover, geoparks create a framework, motivation and support to integrate research, education and training. This is accomplished through protected and interpreted geosites, museums, information centers, trails, guided tours, school class excursions, popular literature, seminars and so on. A geopark also fosters scientific research and cooperation with universities and research institutes.

The Makhteshim Country features numerous unique geologic phenomena and a rich cultural and natural heritage which showcases the everlasting struggle of life in hyper-arid climate conditions. As a result of its exceptional geodiversity, the Makhteshim Country is also home to various endemic plants and animals. To support geoconservation and to strengthen the peripheral communities and their connection to their environment, the Dead Sea and Arava Science Center and the Geological Survey of Israel are promoting turning the Makhteshim Country to a geopark and joining the UGGN. The presentation will describe the UGGN, the scope of 'Geoheritage' a scientific journal devoted to this topic, and key initiatives leading the Makhteshim Country towards recognition as a member of UGGN.

## A regional approach for modeling cliff retreat rate - The 'Makhteshim Country' as a case study

**Finzi, Y. (1), Harlev, N. (1)**

1. Dead Sea and Arava Science Center, Mitzpe Ramon, 80600, Israel

Cliff retreat rate significantly affects the evolution of landforms and cliff stability. Cliff retreat studies also provide intriguing clues regarding past geomorphic conditions and environmental changes. We hereby present a model to calculate cliff retreat rate based on spatial geologic and topographic data. Calculating cliff retreat based on satellite data and a GIS-based model enables analysis and comparison of numerous cliffs in large study areas, simultaneously. The model is applied to numerous cliffs in the arid Makhteshim Country, Israel, and results are calibrated using published rates of two local cliffs. The calculated retreat rates confirm previous assertions that the crater cliffs are receding very slowly, but reveal that the rates vary significantly along the cliffs (1–18 cm $ky^{-1}$). Results also provide first estimates of retreat rates of other major cliffs in the region including fast retreat rates at the Sede Zin cliff (300–600 cm $ky^{-1}$). The proposed model provides a robust analysis to account for local cliff–talus morphology and yields rate estimates representative of current conditions rather than a long-term (geologic) average rate. Furthermore, the model provides a straightforward way to incorporate various local factors such as runoff and crack density (as a qualitative or quantitative factor of the calculated retreat rate). Results presented constitute important new insights into regional geomorphic processes and on the stability of specific cliff sections within the study area.

## Theoretical constrains on the physical factors that affect aragonite precipitation in the Dead Sea

**Fouxon, I.(1) Bookman, R.(1), Belmaker, R.(1)**

1. Dr. Moses Strauss Department of Marine Geosciences, Leon H.Charney School of Marine Sciences, University of Haifa, Haifa 31905, Israel

The physical factors that affect the formation of aragonite laminae in the Dead Sea were theoretically estimated using nucleation theory and precipitation rate constrains. It is assumed, based on the previous studies, that the aragonite precipitates from the upper water mass that is supersaturated for aragonite. Molecules' crystallization of aragonite can form by homogeneous nucleation, where colliding calcium carbonate molecules coalesce to a crystal, and by heterogeneous nucleation, where calcium carbonate molecules deposit on nucleation particles that may be composed of detrital material brought in with floods, dust and, pollen seeds. The process is characterized by the supersaturation degree and size distribution of nucleation seeds. Sedimentation rate depends on cluster size. Too small clusters do not precipitate in a realistic rate.

Our calculations propose that the rate of homogeneous nucleation is so small that it cannot grow a cluster that would precipitate in a rate that can explain the formation of aragonite lamina. Thus, the formation of aragonite laminae requires a sufficient amount of nucleation seeds. However, the Flood Suspended Load (FSL) cannot serve as nucleation seeds because the sedimentation rate of most particles in the FSL is too high to collect sufficient amounts of aragonite. Furthermore, when entering the Dead Sea the FSL tends to form clusters due to the high salinity thus enhancing the sedimentation rate. This explains the good separation between detritus and aragonite lamina and implies that fine dust and pollen are required in order to form the aragonite lamina. Hence, aragonite deposition in the Dead Sea is not solely controlled by the input of freshwater as previously suggested. This elucidates the occurrence of aragonite laminae during the last glacial period and in the last 3000 yr BP when the dust fluxes to the Dead Sea drainage basin were relatively high.

## Formation of intermediate plutonic rocks by magma mixing: the shoshonite suite of Timna, Southern Israel.

**Fox, S.(1), Katzir, Y.(1)**

1. Ben Gurion University of the Negev, Be'er-Sheva 84105, Israel

A recently noticed late Neoproterzoic shoshonite plutonic suite in the Timna igneous complex consists of cogenetic monzogabbro, monzodiorite, monzonite, mesocratic syenite and quartz syenite. Macroscale textures seen predominantly in the intermediate rocks reveal evidence of magma mixing/mingling, including gradational boundaries with mafic and felsic endmembers, large block enclaves and microgranular mafic enclaves (MME). Our petrographic, microtextural and mineral chemistry study delineates the mode of incipient mixing, ultimate mingling and crystal equilibration in hybrid melts.

Plagioclase feldspar is an excellent tracer of the evolution of hybrid rocks, recording chemical variations in the immediate surrounding melt by its An-mol%, Ca/Sr & Ca/Eu ratios. An electron micro-probe study of plagioclase from rocks across the suite provides a quantitative evaluation of cursor magma mixing/mingling textures, e.g. Boxy/sponge cellular texture, recurrent/patchy zoning, Ca spike and anti-rapikivi texture. Each texture has an affinity to a particular mixing region. A modal count of these textures leads to a kinetic mixing theory involving multi temporal and spatial environments necessary to form the hybrid intermediate rocks, while mixing occurred to a lesser degree within the end-member mafic and felsic counterparts.

A 'shell'-like model for varying degrees of mixing is developed with the more intensive mixing at the core and more abundant end-members towards the outer layer. Plagioclase textures formed though magma mixing are corroborated by (a) REE in zircon from the hybrid intermediate rocks and (b) whole rock chemical analysis. Chondritic normalized REE patterns underline the zircon affinity of both mafic and felsic parent melts. While a whole rock Fe-tot vs Sr plot of suggests a two-stage mixing between the monzogabbro and quartz-syenite producing first mesocratic syenite, and subsequent mixing with a fractionating monzogabbro resulting in monzonitic compositions.

A fractionating monzogabbro intruded into a (partial-melting derived) syenitic melt sequentially throughout its fractionation. While slowly cooling, the monzogabbro heated the immediate syenitic melt lowering the viscosity and rheological obstruction to overturn the boundary and facilitate mixing. Increasing melt hybridization, tandem with crystallization, produced mixing textures in the turbulent crystal mush zone, synchronously with 'pure end-member' crystallization. As a result, a large volume of intermediate rock was created through a hybridization process, providing a link in understanding Shoshonite suite petrogenesis.

## Investigation of the tsunami of the 1995, Mw7.2 Nuweiba earthquake

**Frucht, E. (1), Grigorovitch, M. (1), Erez, G. (1), Ginat, H. (2), Shem Tov, R. (2), Salamon, A. (3)**

1. Department of Structural Engineering, Ben-Gurion University of the Negev, Beer Sheva
2. The Dead Sea-Arava Science Center (DSASC)
3. Geological Survey of Israel

The tsunami reported after the strong Mw7.2 1995 Nuweiba earthquake, together with prehistoric tsunamites found along the head of the Gulf of Elat-Aqaba (GOE) and the adjacent Red Sea, emphasize the natural hazard there. The Gulf is located along the southern part of the Dead Sea Transform, which is an active system that generates frequent strong and destructive earthquakes. The presence of a water body inside the Gulf produces a potential for tsunami, not only because of a sudden coseismic deformation in its bathymetry, but also due to submarine slumps. Moreover, close to 200,000 people are living in Elat and Aqaba cities along the northern edge of the Gulf. These cities support intensive and continuously developing marine and touristic industries, including the proposed Peace Conduit, relocation of the Aqaba Port, and the construction of the Elat Canal Port. Nevertheless, a thorough and systematic evaluation of the tsunami hazard to this area has not yet been done.

Here we investigate the 1995, Nuweiba tsunami as part of the preliminary evaluation of tsunami hazard along the Head of the Gulf. First, we constructed the bathymetry and topography grid of the Gulf. Next, we adopted the GeoClaw tsunami modeling program, which can solve 2D depth-averaged shallow water equations, simulate wave propagation and compute tsunami wave heights and inundation. We then simulated the 1995 Nuweiba tsunami and produced time series of the expected wave height in several artificial gauges along the northern part of the Gulf. In addition we determined the relevant input and output formats and developed the required processing tools.

The results of the simulation of the 1995 Nuweiba tsunami show relatively small waves, in the order of and in accordance with the field observation that were reported at the time, the recorded mareogram and the strike slip mechanism of this earthquake. These findings allowed us to trust on the GeoClaw as a reliable modelling program and use it for the computation of different tsunami scenarios in the Gulf. The gained capabilities will enable the modeling of a wide spectrum of simulations, both for the present shape of the coast as well as for future configurations.

This research is focusing on preliminary evaluation of the potential for tsunamis in the northern Gulf of Aqaba-Elat and its associated hazard. We use its results to raise the awareness and preparation to a tsunami in Elat and Aqaba.

## Far-field deep groundwater systems predating the Dead Sea depression: evidence from hypogenic caves

**Frumkin, A.(1), Amrani, A.(1), Langford, B.(1), Lisker, S.(1)**

1. Cave Research Center, Institute of Earth Sciences, The Hebrew University of Jerusalem, Israel 91904

Maze caves and associated hydrogeology are analyzed at the northern Negev - Judean Desert in Israel, to provide insight on fluid migration and porosity development, with relevance to groundwater and petroleum reservoirs at the Arabian Platform flanks. The caves occur specifically in the arid region of the southern Levant, with no equivalent in the moister climate areas further to the north. The karstified bedrock consists of upper Cretaceous epicontinental carbonates. Caves were formed mainly above deep faults, associated with the Syrian Arc fold system. Hypogenic flow is shown to have formed the maze caves particularly under the confinement of thick chalk and marl caprock. Speleogenesis probably occurred during the Oligocene – early Miocene when the Red Sea dome was rising and erosionally truncated. Calcite deposits depleted in $^{18}O$ point to a connection between the caves and recharge over far-field Nubian Sandstone outcrops, north of the Precambrian basement outcrops on the eastern side of the Red Sea. At early-middle Miocene, the Dead Sea rift began dissecting the region, forming a deep endorheic depression at the eastern margin of the study area, and disconnecting the far-field groundwater flow. This was followed by subsiding groundwater levels and associated dewatering of the caves. Fault escarpments and canyon downcutting have dissected the caves, forming the present entrances. The caves are currently mostly dry, with scarce speleothem occurrences. Gypsum crusts with $\delta^{34}SSO_4$ values lower than other sulfate deposits, point at bacterial sulfur reduction, hydrogen sulfide and sulfuric acid being involved in the speleogenesis.

## High resolution seismic imaging of the continental slope offshore Israel: Detailed investigation of the Goliath mass transport complex and the Dor disturbance region

**Gadol, O. (1), Makovsky, Y.(1,2)**

1. The Hatter Department of Marine Technologies, Leon H. Charney School of Marine Sciences (CSMS), Haifa University, Mt. Carmel, Haifa 31905, Israel.
2. Dr. Moses Strauss Department of Marine Geosciences, Leon H. Charney School of Marine Sciences (CSMS), Haifa University, Mt Carmel, Haifa 31905, Israel.

Detailed geophysical imaging of the seafloor structural integrity and potential geo-hazards is a key element of offshore infrastructure development projects. The desired imaging should be at sub-meter resolution to allow its correlation with direct seafloor sampling (e.g. cores, CPT, etc.), but is usually also required to include the structural context to depths of tens to hundreds of meters below the seafloor. These combined requirements are not easily met by traditional or even modern (e.g. AUV based) imaging techniques, and are particularly difficult when traversing the highly variable depths and structures of the continental slope. Here we demonstrate some preliminary superior results of newly acquired exceptionally high (~0.3 m) resolution multi-channel seismic surveys, obtaining >200 m sub-seafloor imaging across the continental slope of Israel. A total of >500 km of seismic profiles were acquired across water depths of ~100 to 1300 m, focusing on the Dor Disturbance (north central Israel) and the Goliath submarine slide complex (southern Israel). Both features, located along prospective infrastructure development routes, portray the combination of substantial sub-seafloor thin skin faulting, acute bathymetric steps and chaotic debris with substantial thicknesses. Surveying utilized our newly purchased 48 channels, 3.125 m group interval, Geo Marine Survey Systems Geo-Sense streamer and Geo Source 400 sparker, both actually utilizing the frequency content of 0.5 to 3 kHz. Continuous acquisition was combined with multi-pinging to confront the large water depth changes and long travel times, while maintaining a high (every 1 s) rate of shooting to avoid spatial aliasing and maximize the fold. Processing and interpretation, using Paradigm software suite, handles the high positioning resolution and sample rate of these data within an exploration standard desktop environment. A processing workflow developed by us will allow for fast production of surveying results. Of major importance is the high S/N ratio and signal coherence, allowing the effective utilization of pre-stack migration and reconstruction of the seismic image at the full horizontal resolution even in the complex and deep parts of the survey. Preliminary pre stack time migrated sections demonstrate the high fidelity imaging obtained, featuring for example effective imaging of sharp landslide headwalls with gradients >30° and their contacts with landslide detachment surfaces; recent thin skin faulting that appear to control landslide initiation; internal partitioning of interleaved chaotic debris lobes suggesting multi-phase collapse. The demonstrated benefits of this imaging procedure suggest that it should become a standard in future offshore site surveying.

## Deformation bands and compaction localization associated with pre-existing faults in sandstone

**Gaijst, H. (1,2), Shalev, E. (1) Lyakhovsky, V. (1), Wenlum Z. (3), Marcom S. (2) Weinberger, R. (1,4)**

1. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501
2. Department of Geophysics, Tel Aviv University, Tel Aviv, Israel 6997801
3. Department of Geology, University of Maryland, Maryland, USA 20742
4. Department of Geological and Environmental Sciences, Ben Gurion University of the Negev, Beer Sheva, Israel

Highly porous sedimentary rocks accommodate strain by forming deformation bands of different types, which include shear, dilation and compaction bands. Compaction bands or zones with significantly reduced porosity in comparison to the surrounding rock, form low permeability barriers blocking fluid and gas transport. Therefore, it is important to understand the conditions for nucleation of compaction bands and their evolution. Previous laboratory studies have shown that the formation of compaction bands is expected under relatively high confining pressures. However, field observations indicate that compaction bands in sediments were subjected to significantly lower confining pressures than those estimated in the laboratory studies. We show examples of compaction bands that were formed in triaxial loading experiments with pre-faulted Bentheim sandstone and deformation bands with a strong compaction component observed at faulted outcrops of Hatira sandstone in Makhtesh Qatan, Israel. Based on the experimental results and field observations we suggest that zones with localized compaction are associated with pre-existing faults and can form under loading conditions well below those required for their formation in homogeneous sandstone. We present a model in which at low confining pressures the compaction localization is induced mainly by heterogeneous shear resistance of the fault. We further suggest that at high confining pressures compaction localization is governed by geometrical features of pre-existing faults and other local heterogeneities of the outcrop.

## Precariously balanced rocks and rock pillars - preliminary constraints on maximum ground motion and past seismic activity of Negev faults

**Ganz, N. (1), Tsesarsky, M. (1), Finzi, Y. (2) Davis, M.(3), Dor, O.(3)**

1. Ben-Gurion University of the Negev Geological & Environmental Sciences, Be'er Sheva
2. Dead Sea and Arava Science Center, Mitzpe Ramon
3. Ecolog Engineering LTD, Rehovot

Stability analysis of precariously balanced rocks (PBR) enables evaluation of the maximum ground motions experienced in a certain site during the lifetime of the PBR. A 2D stability analysis determines the critical acceleration that would topple the rock, and Optically Stimulated Luminosity (OSL) analysis of loess accumulated under the PBR or in cracks bounding it, provides the duration through which the PBR has been precariously balanced. However, this method was developed for boulders that are detached from the bedrock; to effectively implement the method in the Negev it is necessary to adapt it to include analysis of in-situ, slender rock pillars that are common along sub-vertical cliffs of limestone. Potentially, relatively low resonant frequency of rock pillars make them sensitive to ground movements of distant and strong earthquakes, which can get them into resonance and deflect them from their original position. The deflection induces tension at the base of the pillars, where they are expected to fail even before they reach the critical angle (where the pillar's center of gravity is over its base).

We present recent developments of the PBR methodology and its implementation in a study of the seismic activity along faults of the central Sinai-Negev shear zone. Initial analysis of rock pillars along the rim of Makhtesh Ramon suggests that the strongest ground shaking during the past 10,000 years may have been as low as 0.1g. This would indicate a maximum magnitude of approximately M5 on the nearby Ramon fault and M7 on the northern Arava section of the Dead Sea Transform. In order to make our evaluations more robust and accurate, we plan to deploy instruments on a rock column and measure its natural frequency and analyze stability and age of several other rock pillars and PBRs in the Negev.

# 3D reservoir model construction and estimation of original and remaining hydrocarbon potential for Heletz and Kokhav Sands and Kokhav Dolomite reservoirs at the Kokhav-Heletz-Brur oil field

**Gendler, M. (1)**

1. Geophysical Institute of Israel, POB 182, LOD 7110101

The Kokhav-Heletz-Brur oil field is located in the southern Coastal Plain of Israel, about 12 km east of Ashqelon. The field was discovered by the Lapidoth Oil Prospectors Co. Ltd. at 1955. Since its discovery the field was developed by 88 wells that provide the reservoir mapping and characterization with sufficient detail.

The Kokhav-Heletz-Brur field is located on a faulted anticline, truncated by a pinch-out line to the west. The structure is titled with a gentle dip to the east and is divided by several transverse normal faults with small displacements into a several separate production blocks. These relatively small faults are based on the production anomalies, discrepancies in initial water levels, structural mis-ties and reservoir pressure differences (Gilboa and Fligelman, 1990) that cannot be explained otherwise. Thus, the Heletz-Kokhav-Brur oil field is a combination of structural, litho-stratigraphic and tectonic trap.

The Kokhav-Heletz-Brur oil field produced oil from the Lower Cretaceous Heletz Formation (Heletz and Kokhav Sand Reservoirs; Kokhav Dolomite and LC-11 Limestone Reservoirs) and to a lesser extent from Upper and Middle Jurassic limestone. About 97 % of the production in the Kokhav-Heletz-Brur oil field comes from Heletz Formation and only 3 % from Jurassic beds.

In the framework of the work reservoir analysis, lithostratigraphic and petrophysical interpretation of the geological and geophysical data (well logs data, core and small cuttings description and analysis, well testing, seismic surveys and available geological information), definition of reservoir properties (lithology, porosity, permeability and formation fluid properties) from 88 wells (Heletz field – 42 wells; Kokhav field – 32 wells and Brur field – 14 wells) of the Kokhav-Heletz-Brur structure has been performed.

The result is a 3D geological model of the Heletz Sand ('A', 'W' and 'K' sands), Kokhav Sand ('A' and 'B' Sand) and Kokhav Dolomite reservoirs, represented by a set of tables and images (Expanded Composite Logs, Lithostratigraphic Correlations, Geological Cross-Sections and Structure, Isopach and Petrophysical Maps).

3D geological model for sand and carbonate reservoirs allow construct a comprehensive picture of subsurface geology and estimate reservoirs reserves.

The Total Original Oil in Place for the Heletz and Kokhav Sands and Kokhav Dolomite reservoirs at the Kokhav-Heletz-Brur oil fields is 43,379,306 bbl.

The Total Estimated Cumulative Production for the Heletz and Kokhav Sands and Kokhav Dolomite reservoirs at the Kokhav-Heletz-Brur oil fields is 16,273,201 bbl.

The Total Remaining Oil in Place for the Heletz and Kokhav Sands and Kokhav Dolomite reservoirs at the Kokhav-Heletz-Brur oil fields is 27,106,105 bbl.

Percent Produced is 37.5 %.

## Further improvement of an empirical method of explosion parameters estimation based on secondary shock delay measurements

**Gitterman, Y. (1), Rigby, S.E. (2)**

1. Seismology Division, Geophysical Institute of Israel, POB 182, 7110101 Lod, Israel
2. University of Sheffield, Mappin Street, Sheffield, United Kingdom

The research presents results from surface blast tests where accurate seismo-acoustic measurements of secondary shock delay were obtained for various explosives. It was shown previously from data of large scale Sayarim ANFO explosions that the delay, scaled by the cube-root charge weight, correlates with the scaled distance, and the appropriate relationship depends on type of explosives (velocity of detonation).
Recently small tests with other explosives were conducted by the University of Sheffield. Acoustic records of shock waves were collected and a new method was developed for normalising the secondary shock delay time against the geometry and velocity of detonation of the explosive. The relationship between normalised secondary shock delay and scaled distance is then found to be consistent for all explosives considered. This gives a new empirical method for estimating the explosion yield, or determining the velocity of detonation and type of explosive, based only on the secondary shock delay, measured by cheap acoustic and seismic sensors.

## The use of rainfall simulations to study the erodibility of post-mining reclaimed lands in hyper-arid areas in southern Israel

**Golan, A. (1), Argaman, E. (2), Ben-Hur, M. (3), and Laronne, J.B. (1)**

1. Ben-Gurion University of the Negev, Beer Sheva, Isreal
2. Soil Erosion Research Station, Ministry of Agriculture & Rural Development, Israel
3. Institute of Soils, Water & Environmental Sciences, the Volcani Center, Israel

Disturbed landscapes, such as mining areas, appear to experience accelerated erosion rates in comparison to natural mature landscapes. This implies a difficulty of these landforms to reach equilibrium and allow the rehabilitation of bio-diversity. Despite previous studies of post-mining reclamation in other locations, still little is known about the behavior of such landscapes in hyper-arid climates.

Our goal is to obtain initial data related to erosional processes in post-mining hillslopes in a hyper-arid environment by using rainfall simulations. Such new knowledge may serve to design reliable reclamation procedures that will satisfy erosional stability criteria.

Rainfall simulator experiments were carried out under lab and field conditions in natural soils and in reclaimed post-mining lands in the hyper-arid region of 'Rotem Amfert Negev' phosphate plants in the Negev, Israel. The objectives were to examine infiltration rates and soil loss in disturbed material (>4mm aggregates from 0-20 cm soil layer) in lab conditions, and to examine runoff rates, runoff-rainfall relationships, and soil loss in small plots (0.8 $m^2$) of undisturbed soils (in situ).

In the Lab experiment, the effects of stone cover, slope gradient (9 and 15 degrees), and physical crust formation on infiltration, runoff, and soil loss were tested.

Lab results show that final infiltration rates of the crusted materials from reclaimed and natural areas were ~5 and ~2 mm/h, respectively, regardless of stone cover or slope gradient. In contrast, final infiltration rates of the non-crusted materials were ~20 and ~5 mm/h, respectively, for reclaimed and natural materials. Soil loss amounts were higher for natural material regardless of rainfall simulation conditions. The lowest soil loss in the natural material was ~32 [g / ($m^2$ mm)], and, in comparison, the highest soil loss in the reclaimed material was ~21 [g/($m^2$ mm)].

In the field, the runoff threshold was significantly higher in reclaimed plots (~16 mm) than in natural plots (~4 mm). During rainstorms with low rain intensity (~21mm/h) on dry soil, runoff rates and soil loss were lower in the reclaimed plots. However, during high intensity rainstorms (~55 mm/h) on wet soil, in the reclaimed plots, runoff rates were still lower, but soil loss was similar or higher to that of natural plots.

It appears that small scale rain simulations give good initial information about the erosional processes on reclaimed slopes. Consequent research is required to study larger scale erosional processes of rill and gully formation on reclaimed hillslopes in this hyper-arid area.

## Rutile (U-Th)/He thermochronology constrains the initial emplacement of the Troodos ophiolite, Cyprus

**Golan, T. (1), Haviv, I. (1), Katzir, Y. (1)**

1.Ben Gurion University of the Negev, Beer-Sheva 84105

The Eastern Mediterranean and its passive margins are interpreted to have formed by several continental rifting phases during late Palaeozoic - Mesozoic times. The Levant margins remained out of reach of orogenic deformation and have preserved structural continuity with the bordering land. However, the northern and western parts of the Levant basin were later reworked by Alpine subduction and collision and the history of rifting and the identity and original location of the detached continental blocks still remain incompletely understood.

In this study we focus on a fragment of rifted margins of probable NW Levantine origin that occurs in the Mamonia complex, SW Cyprus. The Late Triassic igneous and sedimentary rocks of the Mamonia Complex are juxtaposed against the Turonian (91.6 ± 1.4 Ma) Troodos ophiolite along a high angle serpentine-decorated shear zone. Caught in this shear zone are ≤ 500 m sized slivers of rutile-bearing amphibolite, the Ayia Varvara formation, which might hold information on the initial emplacement of the ophiolite.

13 Rutile grains from the Ayia Varvara amphibolites yielded an average (U-Th)/He age of 86 ± 7 Ma independent of grain-size (Req of 45-90 μm) and an isochron age of 89 ± 3 Ma. Metamorphism of Agia Varvara was thus nearly synchronous with the igneous crystallization of the Troodos oceanic crust at late –Turonian – early Coniacian times. The newly formed supra-subduction oceanic crust was probably the heat source for metamorphism when juxtaposed against the older protoliths of the amphibolites.

Similar hornblende 40Ar-39Ar ages (90-83 Ma; Spray and Roddick, 1981) and the lack of age – grain size correlation in rutile indicate fast cooling from peak metamorphic conditions to <220°C. This rapid cooling may delineate the cessation of spreading activity in Troodos due to initial emplacement against the Mamonia continental margin.

## Foraminifera in tsunami deposits

**Goodman Tchernov, B.N.(1)**

1.University of Haifa, Department of Marine Geosciences, Leon Charney School of Marine Sciences

Foraminifera have long been recognized as an excellent environmental marker with a wide range of applications with geological research. Tsunami sedimentological research focuses on better characterizing and understanding the appearance of tsunami deposits using a wide range of analytical tools and proxies. Foraminifera are within that varied toolbox, and have shown to be extremely valuable as a tsunamigenic indicator. Modern studies following recent tsunami events (e.g. Indian Ocean Tsunami 2004, Tohoku 2011, Chile 2010) further expanded the understanding of how foraminifera in tsunami deposits are distinctive and unique relative to non-tsunami deposits. Characteristics that make them distinctive vary, but can include staining, size distributions, erosion, corrosion, and unusual sorting. This information has been invaluable for the discovery and identification of paleo and historical tsunami deposits. Here, examples from modern studies will be described and compared to ancient deposits including studies from the Mediterranean and Red Sea.

## Remote detection of thermal maturation in source-rocks using seismic anisotropy

**Gordin, Y. (1), Hatzor, Y.H. (1), Vinegar, H.J. (1, 2)**

1. Department of Geological and Environmental Sciences, Ben-Gurion University of the Negev, Be'er Sheva, Israel.
2. Afek Oil and Gas Ltd. Jerusalem, Israel.

We investigate velocity anisotropy of organic-rich chalks (ORC) assuming Vertical Transverse Isotropy (VTI). The chalks in this study, from the late Cretaceous Ghareb and Mishash formations of the southern Golan Heights and Shefela basins, have a wide range of porosity (up to 45 PU), high kerogen content (5 – 15 wt % TOC) and exhibit varying degrees of thermal maturation, from immature to early maturation – entering the oil window stage. Ultrasonic P and S velocities were measured in the lab in three different directions (0°, 45°, and 90°), using the ultrasonic transmission method, while increasing and decreasing confining pressures. The elastic constants were calculated, as well as Thomsen's anisotropy parameters, in order to quantify the degree of anisotropy.

Using velocity hysteresis measured during cycles of pressurization and depressurization of the confining pressure, we found that microcracks affect the mechanical deformation of the early matured samples from the Golan Heights basin, whereas they are completely absent from the immature samples from the Shefela basin. In the Golan Heights basin the microcracks tend to lay in a horizontal orientation thus slowing the vertical P-wave velocity. By studying a set of three samples with similar porosity and kerogen content but different degrees of thermal maturation, we find the P-wave anisotropy increases systematically during early maturation from Thomsen parameter $\varepsilon \sim 0.1$ up to $\varepsilon \sim 0.18$, for both dry and fully saturated samples.

Since the magnitude of anisotropy may be determined in the field from 3D high resolution seismic surveys with wide source-receiver offsets, we plan to study whether VTI obtained from seismic data would be useful for remote detection of thermal maturation of source rocks.

## Forward and inverse models of fluvial landscape evolution during temporally continuous climatic and tectonic variations

**Goren, L. (1), Petit, C. (2)**

1. Ben Gurion University of the Negev, Geological and environmental Sciences, Beer-Sheva, Israel
2. Université Côte d'Azur, CNRS, OCA, IRD, Géoazur, Sophia Antipolis, France

Fluvial channels respond to changing tectonic and climatic conditions by adjusting their patterns of erosion and relief. It is therefore expected that by examining these patterns, we can infer the tectonic and climatic conditions that shaped the channels. However, the potential interference between climatic and tectonic signals complicates this inference. Within the framework of the stream power model that describes incision rate of mountainous bedrock rivers, climate variability has two effects: it influences the erosive power of the river, causing local slope change, and it changes the fluvial response time that controls the rate at which tectonically and climatically induced slope breaks are communicated upstream. Because of this dual role, the fluvial response time during continuous climate change has so far been elusive, which hinders our understanding of environmental signal propagation and preservation in the fluvial topography.

An analytic solution of the stream power model during general tectonic and climatic histories gives rise to a new definition of the fluvial response time. The analytic solution offers accurate predictions for landscape evolution that are hard to achieve with classical numerical schemes and thus can be used to validate and evaluate the accuracy of numerical landscape evolution models. The analytic solution together with the new definition of the fluvial response time allow inferring either the tectonic history or the climatic history from river long profiles by using simple linear inversion schemes.

Analytic study of landscape evolution during periodic climate change reveals that high frequency (10-100 kyr) climatic oscillations with respect to the response time, such as Milankovitch cycles, are not expected to leave significant fingerprints in the upstream reaches of fluvial channels.

Linear inversion schemes are applied to the Tinee river tributaries in the southern French Alps, where tributary long profiles are used to recover the incision rate history of the Tinee main trunk. Inversion results show periodic, high incision rate pulses, which are correlated with interglacial episodes. Similar incision rate histories are recovered for the past 100 kyr when assuming constant climatic conditions or periodic climatic oscillations, in agreement with theoretical predictions.

## Combination of MASW and HVSR methods for improving the accuracy and reliability of Vs model (in Site Response Assessment)

**Gorstein, M. (1), Ezersky, M. (2)**

1. Geophysical Institute of Israel, P.O.Box 182, Lod 71100, Israel
2. Geotec Engineering and Environmental Geophysics Ltd., PO Box 25031, Rishon Lezion 7502501, Israel

Estimating possible site effect as an integral part of seismic hazard evaluation in regions with low or moderate seismicity in Israel is performed by using an analytical model. The computation of the model requires the knowledge of the shear-wave velocity (Vs) profile up to seismic bedrock. A knowledge of mechanical properties of subsurface obtained from conventional direct method (borehole) for every site of interest is hardly realized in daily practice.

An alternative approach to Vs profile determination is joint implementation of Horizontal-to-Vertical Spectral Ratios (HVSR or Nakamura's) technique, which is based on ambient noise measurements and seismic methods such as S-wave refraction or Multichannel Analysis of Surface Waves (MASW) method. However, S-wave refraction method does not allow deep penetration of seismic waves for several reasons including weak source of the shear waves. The MASW method in its active and passive modifications is more practical and widely applicable; but still common use of 4.5Hz geophones restricts penetration depth of surface waves because of frequency (wavelength) limitations. In this study is proposed applying 2.5Hz geophones and special data processing enable increasing both penetration depth and resolution. Moreover, combination MASW with HVSR technique facilitates constructing Vs sections up to depth of the seismic reflector.

The joint use of MASW and HVSR methods applying 2.5 Hz geophones has been tested at 9 sites on the Dead Sea shore, where subsurface model is represented by two compact salt layers serving seismic reflectors inside the loose sediments. The depth of the upper salt layer is in the range 20-70 m, while the depth of the deeper salt layer is greater the 200 meters. The MASW and HVSR methods were also implemented at two sites in Hashefela region, where soft sediments overlay a hard layer, which is, in turn, underlain by another firmer one. Combination of these methods have also proven their feasibility in conditions of very strong technical noise within the frequency range of site effect.

Our results suggest MASW and HVSR methods are appropriate choice for estimating S-wave velocity profile to depth beyond the capabilities of S-wave refraction and boreholes and should be used especially at sites not accessible for conventional geophysical survey.

## The Mt. Carmel birdshot assemblage: Immiscibility of metal, metal-oxide and silicate melts during basalt-methane interaction in a volcanic plumbing system

**Griffin, W.L. (1), Gain, S.E.M. (1), Huang, J. (1), Toledo, V. (2), O'reilly, S.Y. (1)**

1. ARC Centre of Excellence for Core to Crust Fluid Systems (CCFS) and GEMOC, Earth and Planetary Sciences, Macquarie University, NSW 2109, Australia; bill.griffin@mq.edu.au
2. Shefa Yamim (A.T.M.) Ltd., Netanya 4210602, Israel; gold101@netvision.net.il

Aggregates of corundum crystals (Carmel Sapphire) occur in Cretaceous pyroclastic ejecta on Mt Carmel (Lower Galilee). Melt pockets trapped within and between corundum crystals contain mineral assemblages that require high T and extremely low fO2 (IW -10). Paragenetic studies suggest that the corundum and low fO2 reflect interaction of mafic magmas with mantle-derived ($CH_4$+$H_2$), leading to reduction and desilication of the magma, inducing $Al_2O_3$-supersaturation, the rapid growth of corundum, and deposition of amorphous carbon.

Spherical to drop-shaped metal-rich pellets <100 µm to several mm in diameter are common in the pyroclastics, and are interpreted as melts separated from basaltic magma. Four general types of melt can be identified.

1. Fe melts: Generally ca 90% Fe, but some contain much higher Mn, Cr and Ni). Many contain micro-inclusions of type (2) below. Typically rimmed by types (2-4).
2. Fe-oxide melts: Example: $SiO_2$ 6%, $TiO_2$ 2%, $Al_2O_3$ 2%, MgO 1%, FeO 87% CaO 1.5 %. These typically consist of skeletal crystals of stoichiometric FeO (at % Fe= 50-55%), in a matrix enriched in Si, Al, Mg and Ca. Commonly have core of type 1.
3. Ti-oxide melts: Either very fine-grained quenched to long blades of FeTi2O5 in a matrix enriched in Si and Ca. Examples: (1) $SiO_2$ 10%, $TiO_2$ 55%, $Al_2O_3$ 3%, MgO 2%, FeO 20 %, MnO 7%, CaO 3%; (2) SiO2 1%, $TiO_2$ 69%, $Al_2O_3$ 0.3%, FeO 14%, MnO 12%, CaO 0.5%, WO 2%.
4. Iron-rich silicate glass: extremely vesicular, heterogeneous with Liesegang-ring zoning around balls of types 1-3. Mean composition $SiO_2$ 40%, $TiO_2$ 1%, FeO 30%, MnO 11%, $Na_2O$ 2%, $K_2O$ 14%.

Pellets of different types and sizes may be stuck together. Most droplets are vesicular, and in many a large central void comprises most of the drop. These structures suggest that the melts contained high levels of volatiles that exsolved as the melts began to cool.

We suggest that these pellets formed when $fO_2$ dropped to the Iron-Wustite boundary, resulting in the separation of mutually immiscible melts from the host magma. The vesicular nature of the oxide balls, coupled with other data on the corundum system, suggests that mantle-derived methane provided both the reducing power, and the abundant gasses, through reactions such as 4FeO (melt) + $CH_4$ + 4Fe + $CO_2$ +2$H_2O$ and $Fe_2O_3$ + $CH_4$ +2FeO +$CO_2$ +$H_2O$. This immiscibility played an important role in the further development of the Mt Carmel magmatic system: none of the silicate or oxide phases in the corundum aggregates contain Fe, because most of it had been removed earlier. A similar model has been proposed by Grebnikov et al. (2012; Journal of Volcanology and Seismology 6) to explain Fe-cored Fe-oxide balls (type 2) in Yakutian ignimbrites.

## The hibonite-grossite-vanadium assemblage in Mt Carmel corundum: extreme desilication and reduction in a volcanic plumbing system

**Griffin, W.L.(1), Gain, S.E.M. (1), Huang, J. (1), Toledo, V. (2), O'reilly, S.Y (1)**

1. ARC Centre of Excellence for Core to Crust Fluid Systems (CCFS) and GEMOC, Earth and Planetary Sciences, Macquarie University, NSW 2109, Australia; bill.griffin@mq.edu.au
2. Shefa Yamim (A.T.M.) Ltd., Netanya 4210602, Israel; gold101@netvision.net.il

Aggregates of corundum crystals (Carmel Sapphire) are common in the pyroclastic ejecta of Cretaceous volcanoes exposed on Mt Carmel (Lower Galilee). Melt pockets trapped within and between corundum crystals contain mineral assemblages) that require high T and extremely low $fO_2$ (IW -10). Paragenetic studies suggest that the corundum and low- $fO_2$ reflect interaction of basaltic magmas with mantle-derived ($CH_4$+$H_2$) at high fluid/melt ratios, leading to progressive reduction and desilication of the magma, inducing $Al_2O_3$-supersaturation, the rapid growth of corundum, and the deposition of amorphous carbon.

In the melt pockets, a late stage of this evolution is defined by the appearance of hibonite ($CaAl_{12}O_{19}$), coexisting with corundum, Fe-Ti silicides, TiC and a Ca-Al-Si oxide glass. However, the occurrence of coarse-grained (mm to cm crystals) intergrowths of hibonite and grossite (CaAl4O7) shows that silica-deficient melts evolved even further. In these aggregates, relict cores of corundum in hibonite crystals record the peritectic reaction L + Cor + Hib; hibonite is typically enclosed in aggregates of grossite + Mg-Al spinel, reflecting crystallization along the quaternary ($CaO$-$Al_2O_3$-$SiO_2$-$MgO$) cotectic hibonite + grossite +spinel + L. Pockets within the aggregates contain fluorite, native V, Ca-perovskite and a Ca-Al-F-O phase not previously found in nature. Native vanadium occurs as drop-like inclusions in hibonite, grossite and spinel, but not in corundum; this suggests that a melt dominated by V began to separate from the oxide melt near the temperature of the corundum-hibonite peritectic reaction. The melting point of V is >1900 °C, so that a vanadium melt would freeze upon exsolution at magmatic T, which is consistent with the occurrence of some V in networks of filaments, suggestive of quench structures. The existence of native V requires $fO_2 \leq$ IW-8, consistent with the existence of tistarite ($Ti_2O_3$; Griffin et al., 2016 Geology 44, 815), TiC and SiC in the melt pockets.
In the 1-atm. $CaO$-$MgO$-$Al_2O_3$ system the peritectic reaction occurs at ca 1780 °C; grossite appears at ca 1715 °C, and spinel at ca 1690 °C. The presence of fluorine may lower these liquidus temperatures significantly; fluorite+grossite precipitates at ca 1375 °C in the system CaF2-$CaAl_2O_4$. The crystallization of anorthite as a late or quench phase in many melt pockets suggests the peritectic reaction L + Cor + An, constrained experimentally to P > 0.9 GPa and T ca 1500 °C (Goldsmith, 1980, Amer. Mineral. 65, 272). Modelling by Ottonello et al. (2013 Chem Geol. 346, 81.) suggests that grossite is no longer on the liquidus at P ≥1 GPa. If these constraints are accepted, the Mt Carmel corundum system was crystallizing at depths of 35-40 km, near the crust-mantle boundary, when the host basalts erupted.

## What is the real ΔGr function of albite dissolution?

**Gruber, C. (1), Zakon, Y.(2), Ganor, J. (1)**

1. Department of Geological and Environmental Science, Ben-Gurion University of the Negev, Beer Sheva 8410501, Israel
2. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 9550161, Israel

One of the most significant environmental variables that affect albite dissolution rate is deviation from equilibrium (ΔGr). Most of the studies that describe the effect of ΔGr on albite dissolution rate were conducted under alkline pH (8.8-9.2), elevated temperatures (80-300°C) and for Amelia Courthouse (USA) albite. Comparison of the f(ΔGr) derived from those studies to the only f(ΔGr) under conditions of low temperature (25 °C), circum neutral pH and Evje (Norway) albite leads to different ΔGr functions. Yet, except for the study of Gruber et al. (2014), rate laws for silicate minerals dissolution, which are based on experiments conducted under ambient conditions, are lacking.

Here we present new experimental results of two multi point batch experiments (MPBE) of albite dissolution in an isotopically spiked solution. The novel method that use Si isotopes (Gruber et al., 2013) enables detecting rates that otherwise can't be detected under ambient conditions. Both Amelia Courthouse albite and Evje albite dissolution rates were determined under neutral-acidic pH, 25 °C, and a wide range of undersaturation conditions. The dependency of the dissolution rate on deviation from equilibrium (f(ΔGr)) was in agreement with the prediction of previous studies. However, the value of ΔGcrit was found to be significantly different for the two albite specimens, suggesting an effect of intrinsic properties of the albite specimen.

Gruber, C., Harpaz, L., Zhu, C., Bullen, T.D., Ganor, J., 2013. A new approach for measuring dissolution rates of silicate minerals by using silicon isotopes. Geochimica et Cosmochimica Acta 104, 261-280.

Gruber, C., Zhu, C., Georg, B.R., Zakon, Y., Ganor, J., 2014. Resolving the gap between laboratory and field rates of dissolution. Geochimica et Cosmochimica Acta 147, 90-106.

## Isostasy, Flexure, and Dynamic Topography

**Gvirtzman, Z. (1,2), Faccenna, C. (3), Becker, T. W. (4)**

1. Geological Survey of Israel, Jerusalem, Israel
2. Institute of Earth Sciences, Hebrew University, Jerusalem, Israel
3. Dipartimento Scienze, Università Roma TRE, Rome, Italy
4. Department of Earth Sciences, University of Southern California, USA

A fundamental scientific question is what controls Earth's topography. Although the theoretical principles of isostasy, flexure, and dynamic topography are widely discussed, the parameters needed to apply these principles are frequently not available. Isostatic factors controlling lithospheric buoyancy are frequently uncertain and non-isostatic factors, such as lithospheric bending towards subduction zones and dynamic topography, are hard to distinguish. The question discussed here is whether a set of simple rules that relate topography to lithospheric structure in various tectonic environments can be deduced in a way that missing parameters can be approximated; or does each area behave differently, making generalizations problematic. We contribute to this issue analyzing the Asia-Africa-Arabia-Europe domain following a top-down strategy. We compile a new crustal thickness map and remove the contribution of the crust from the observed elevation. Then, the challenge is to interpret the residual topography in terms of mantle lithosphere buoyancy and dynamics. Based on systematic relationships between tectonic environments and factors controlling topography, we argue that crustal buoyancy and mantle lithospheric density can be approximated from available geological data and that regions near mantle upwelling or downwelling are easily identified by their extreme residual topography. Yet, even for other areas, calculating lithospheric thickness from residual topography is problematic, because distinguishing variations in mantle lithosphere thickness from sub-lithospheric dynamics is difficult. Fortunately, the area studied here provides an opportunity to examine this issue. Based on the conjunction between the Afar Plume and the mid-ocean ridge in the nearby Gulf of Aden and southern Red Sea, we constrain the maximal amplitude of dynamic topography to ~1 km. This estimate is based on a narrow definition of dynamic topography that only includes sub-lithospheric processes and using mid-ocean ridges as reference, where mantle lithosphere buoyancy is zero.

## Carbonate facies associations, black shales and $\delta^{13}$Ccarb from the open ocean slope succession of the Manara Core, Lower Cretaceous, Galilee, Israel

**Hadar, D. (1), Bialik, O.M.(2), Simmons, M.(3), Finkelman, E.(1), Benjamini, C.(1)**

1. Dept. Geological and Environmental Sciences, Ben Gurion University of the Negev, POB 653, Beer Sheva 84105
2. The Dr. Moses Strauss Department of Marine Geosciences, Charney School of Marine Sciences (CSMS), University of Haifa, Mount Carmel, Haifa 31905
3. Halliburton, 97 Milton Park, Oxford, OX14 4RW, UK and Natural History Museum, London, SW7 5BD, UK

The continuous core of the Lower Cretaceous succession at Manara (Manara Pumped Storage Project, Ltd.) has enabled assessment of the full range of paleoenvironments in this carbonate/fine siliciclastic succession, based on high-resolution sedimentological, micropaleontological and stable isotope analyses on 250 m of core. This study focuses on facies associations of the carbonate phase, identification of microfossils stressing orbitolinid foraminifera, paleoenvironmental interpretation and correlation to the Early Cretaceous oceanic isotope curve.

Carbonate-dominated mid- and outer shelf facies associations are represented, although their depositional settings were often in the proximal basin. Bedding features and nature of the contacts with fine siliciclastics indicate multiple episodes of mass-transport, detachment and resedimentation governed by high-gradient slope and bypass, into a setting where deep-water shale and marl are indigenous.

The intimate connection with the Tethyan Ocean is borne out by the high-resolution $\delta^{13}$C curve directly comparable to curves of known oceanic sites. Biostratigraphic data based mainly on orbitolinid foraminifera from the late Barremian (Palorbitolina lenticularis) to early Albian (Mesorbitolina texana/subconcavata transition), and the $\delta^{13}$Ccarb curve, are used to correlate systematic shifts in zonal facies in the carbonate phase to high- and low orders of sea level change on the northern Arabian margin. Notably, occurrences of black shales may then be correlated to OAE 1a and to parts of the OAE1b series of events known from offshore Tethys and the global ocean.

This open-ocean paleoenvironmental interpretation challenges previous interpretations of shallow-shelf to off-shelf transition on the margin of the north Arabian platform.

## Geodetic investigation of slip and creep rates along the northern sections of the Dead Sea Fault in Israel

**Hamiel, Y. (1), Piatibratova, O., (1) Mizrahi, Y. (1)**

1. Geological Survey of Israel, 30 Malkhe Israel St., 95501, Jerusalem, Israel

The current deformation along two sections of the Dead Sea Fault in northern Israel is addressed and a first clear evidence for shallow creep along the fault is presented. We obtain the velocities of near-fault GPS campaign stations across the northern section of the Jordan Valley Fault and the Jordan Fault that were surveyed each year between 2009 and 2015. Observations from 44 permanent GPS stations operating in Israel and the surrounding area and 29 campaign stations, including dense near-fault campaign network, are used in this study. We infer a slip rate of 4.1mm/yr and a locking depth of about 10 km for both sections. Data analysis indicate that while the Jordan Fault is found to be fully locked above the locking depth, the northern section of the Jordan Valley Fault is found to be creeping from a depth of 1.6±1.0 km to the surface, with a creep rate of 2.5±0.8 mm/yr. We also find that the majority of the interseismic deformation occurs along the eastern margin of the valley Jordan, in a fault zone width that is smaller than 700 m, and the contribution of the subparallel faults to active tectonics is found to be minor, less than the velocities uncertainties.

## Defining and identifying proxies for fluvial network reorganization in the western Arava Valley

**Harel, E.(1), Goren, L.(1), Ginat, H.(2)**

1. Ben-Gurion University of the Negev, P.O.B. 653 Beer Sheva, 8410501
2. The Dead-Sea and Arava Science Center, Tamar regional council, Dead-Sea mobile post

The fluvial drainage network set the backbone of non-glaciated landscapes and serves as a routing system for transporting sediment particles from the high mountains to oceanic basins. The geometry of drainage basins is, in many cases, considered to be a static feature of the landscape, despite ample evidence showing otherwise. Indeed, river reorganization have been demonstrated in many locations worldwide, and causative relations between variations in the tectonic or climatic regimes to reorganization are commonly invoked. Understanding fluvial reorganization processes is essential for assessing landscape evolution, surface mass redistribution, and speciation and biodiversity, but so far the genetic relations between changes in the tectonic and climatic conditions and the occurrence and mode of fluvial reorganization are far from being well understood. A prerequisite for resolving these relations is to be able to identify reorganization in the field and define its mode.

We study evidence and modes of reorganization along the western margins of the Arava Valley and the Negev desert. Previous research has shown that the current drainage pattern in the area is in a transient stage, as the cliffs along the western shoulders of the Arava valley are actively receding. Furthermore, the current drainage configuration is relatively new as in the Pliocene, large rivers have crossed the currently subdued Arava Valley, and joined a northward flowing drainage network. Our field site is thus a prime location for studying fluvial reorganization and its surficial proxies.

To define different modes of drainage reorganization and to relate them to field observations, we have performed an extensive literature survey of documented reorganization examples both in our field site and worldwide. Following this survey, we have extended previous work of categorizing reorganization modes based on the initial drainage geometry, and on the general type of disturbance that has induced them. The major categories are: river capture, water divide migration, drainage reversal and river diversion. We propose that each of the modes could be identified based on an inimitable combination of features that can be recognized in the field and in digital elevation models. Most of the features are geomorphic in nature and include knickzones, elbows, irregular angles of tributaries, and windgaps, which form along abandoned drainage pathways and mark the location of river channel beheading. Additionally, we posit and observe in the field that beheaded rivers have wide valleys, disproportional to their drainage area. Other observations include sedimentary deposits that are indicative of paleo surface gradients.

## Micro- and macro-scale petrophysical characterization of a Lower Cretaceous sandstone unit simulated in a real geometry obtained with μ-CT Imaging

**Haruzi, P. (1), Katsman, R. (1), Waldmann, N. (1), Halisch, M. (2).**

1. Leon H. Charney school of marine sciences - University of Haifa
2. Leibniz Institute for Applied Geophysics (LIAG) - Hannover, Germany

Lower Cretaceous sandstone serves as hydrocarbon reservoir in some places over the world, and potentially in Hatira formation in the Golan Heights, northern Israel. The purpose of the current research is to conduct a petrophysical characterization of these sandstone units. The study was carried out by two alternative methods: using conventional macroscopic lab measurements; and using a 3D microscopic imaging a modeling. The latter included μ-CT scanning, segmentation of the pore-network, image processing, image analysis of pore network,, followed by fluid flow simulations at a microscale. Upscaling the results of these micro-scale flow simulations allowed obtaining macroscopic rock parameters that are conventionally measured in the lab. Comparison of the upscaled and the measured properties were conducted, showing a good agreement. Results of this study will provide necessary parameters for the future macroscopic fluid flow modeling in the Lower Cretaceous sandstone, applicable for the fields of petroleum production and $CO_2$ sequestration.

## Study of observed microearthquakes at Masada deep borehole

**Hofstetter, R. (1), Malin, P. (2)**

1. Geophysical Institute of Israel, Israel
2. Southern Methodist University, USA

Seismological measurements, conducted at great depths of several hundred of meters or even a few km, can provide useful information that one cannot get while conducting the measurements on the surface. We take advantage of Masada Deep borehole (MDBI), an abandoned oil well, for the installation of a seismometer at a large depth of 1,256 m (1,516 bsl). The station is located in the near vicinity of the East Masada fault, part of the Western Boundary Fault of the Dead Sea basin. We present seismic observations of microearthquakes which occurred along the Dead Sea fault (DSF). Many of them were not recorded by the Israel Seismic Network (ISN). The quiet site of the station has an obvious advantage in detection and identification of earthquakes and explosions. For example, the station detects about 30% more quarry explosions as compared to observations of the ISN. We demonstrate that borehole seismograms are clearer than the on-surface observations of nearby seismometer. We lowered the magnitude scale of observed events down to about M≈-3. Many of the earthquakes, sometimes clusters, occurred underneath the MDBI at depths of 10-25 km, having special signature. Using the cross-correlation technique we present several series of seismic activity either underneath the station or along the DSF. Frequency-magnitude relationship, known also as Gutenberg-Richter relationship, is somewhat higher than the determined value for the whole Dead Sea Fault. Plots of phasor sum suggest a detection limit of M=0.9.

## Moissanite (SiC) in Mt Carmel pyroclastics and Kishon River alluvial deposits: Super-reduced conditions in volcanic systems

**Huang, J.X. (1), Griffin, W.L. (1), Gain, S.E.M. (1), Toledo, V. (2), O'reilly, S.Y. (1)**

1. ARC Centre of Excellence for Core to Crust Fluid Systems (CCFS) and GEMOC, Earth and Planetary Sciences, Macquarie University, NSW 2109, Australia; jinxiang.huang@mq.edu.au
2. Shefa Yamim (A.T.M.) Ltd., Netanya 4210602, Israel; gold101@netvision.net.il

A striking feature of Cretaceous pyroclastic ejecta on Mt Carmel and Kishon river alluvial deposits in the Lower Galilee is the presence of abundant moissanite (SiC) in crystals up to 4.41 mm long. Experimental data and theoretical calculations suggest that SiC is only stable at log $fO_2 \leq (\Delta IW-6.5)$ at upper mantle conditions. Its occurrence in the volcanic products indicates that either the volcanic system experienced a reduced stage or that at least parts of the wall rocks of the volcanic conduit contained reduced minerals.

Moissanite is a highly covalent compound of Si and C in a ratio of 1:1 in hexagonal-cubic crystal system. It is rarely found in terrestrial rocks, but has been reported in diamonds, kimberlites, ophiolites, eclogites, serpentinites and xenolithic carbonatites; the natural occurrence of some of these has been debated. However, it is the best-studied type of presolar grain, providing critical information on nucleosynthesis and stellar evolution. Moissanite can have more than 200 polytypes. SiC grains from Mt Carmel and other terrestrial rocks are mainly the 6H polytype; a few are the 4H and 15R polytypes. The polytype of the grain does not have any obvious correlation with its petrographic or geochemical characteristics.

Moissanite from Mt Carmel may contain inclusions, such as native Si, Fe-, CaAl-, FeAl-, FeTi-silicide and TiV, similar to those reported from kimberlitic and ophiolitic SiC. The occurrence of such alloy inclusions indicates that they were formed in reduced conditions: log $fO2 < \Delta IW-8$.

Mt Carmel moissanite and Ti-, Fe-silicides are also found as inclusions in corundum (Carmel Sapphire) with melt pockets containing reduced phases. Paragenetic studies suggest that the corundum and low $fO_2$ reflect interaction of mafic magmas with mantle-derived ($CH_4$+$H_2$) at high fluid/melt ratios, near the crust-mantle boundary leading to progressive reduction and desilication of the magma, and ultimately to Al2O3-supersaturation, the rapid growth of corundum, and the deposition of abundant amorphous carbon.

The Si- and C-isotope compositions of Mt Carmel moissanite were analyzed in-situ by SIMS (CAMECA 1280). The data show a large variation in both $\delta^{30}Si$ (-0.68 to +1.42 ‰) and $\delta^{13}C$ (-25 to -32‰) among different grains. Individual grains generally have homogeneous isotopic compositions. Such variation is not related to differences in polytypes or the occurrence of inclusions, suggesting it may be related to heterogeneity of the source(s) or unidentified fractionation processes that operated during crystallization.

Moissanite from this area is highly likely to be a direct volcanic product of the interaction of $CH_4$+$H_2$ with the basaltic magma. However, it cannot be completely excluded that some of the grains are xenocrysts from the mantle, which were formed by other processes such as mantle metasomatism by reduced fluids.

## Urban runoff and transmission losses in a Karstic Mountain Environment- The City of Ariel

**Inbar, M.(1), Anker, Y.(2), Gimburg, A.(2)**

1. Department of Geography and Environmental Studies, University of Haifa
2. Eastern R&D Center

Urban impervious areas produce a large amount of water during rainy storms which may be an alternative water resource for municipal or regional environmental and recreational needs. Knowledge on the impact of urban development and patterns of building is critical to understanding the threats to the environments as well as the benefits of an expanding water resource for local infrastructure development

The city of Ariel is located in the Yarkon river watershed area, at an altitude of about 700m.The region is characterized by a developed karstic terrain. Rainfall annual average is 500mm. Several building patterns are found, from single houses to apartment blocks and public large buildings. The percent of impervious area ranges from 15% to 45% in the different sub-basins.

The main objective of the study is to find the runoff/rainfall relationship for a medium size town under different physiographic and urban patterns, to find the discharge peak flow concentration time and its relationship to the urban pattern of impervious area and to define transmission losses in the natural open channels of the sub-basins and water recharge to the regional aquifer. Another objective is to assess the urban water quality and to identify pollution sources.

The 13 years of measurement shows that the potential storm water volume that may be harvested from the city of Ariel areas ranges between 80,000 m3 to 500,000 $m^3$ over the course of an average year, depending on the contributing area, amount of precipitation and evaporation depth. In the 2007/2008 rainfall season transmission losses were 50% of the total runoff volume and up to 70% of the flood peak discharges. However we have to explain that the flowing into the aquifer is not a loss to the water resources of Israel, but a vital source of water for the Yarkon-Taninim aquifer.

Chemical analysis of the runoff water showed that the quality of the water was good, with the exception of the first storm (first flash effect), and in general the urban runoff water may be used as a source for the enrichment of ground water, and for municipal use as well.

## Advanced methods for stratigraphic mapping and geological imagery's

**Isaac, J. (1), Farber, E. (2), Livshits, J. (3)**

1. CRS Environmental Models. Herzl 117 Jerusalem.
2. Hydrogeology and Geochemistry of water- Consulting services. Alomut 16 Ramat Efal.
3. Water Authority, the Hydrological Service - Jaffa 234, Jerusalem

During the recent years, there has been a real "data" revolution in the natural sciences world. This revolution has three main components. Starting with the volumes of information analyzed in each project. passes through advanced analysis methods, methods that previously required computing resources and databases that did not exist, and advanced display capabilities to enable better accessibility to this information. In the natural science worlds, several sectors, including sectors of geology and hydrology are in a unique situation. On the one hand, the information revolution and renewed analysis tools are very relevant but on the other hand knowledge characteristic of those sectors are conservative and there are not automatically coordinating existing tools on the market today. This tension between the desire to examine width processes and the fact that every aspect of the pump well, geological formation or even oil field is an independent entity that needs individual treatment can create a situation in which the entire analysis process is wrong and tented lose out. Therefore, proper use of these tools requires a deep understanding of the worlds of knowledge that characterize these areas on the one hand and control and renewed existing tools in the area of "data since" on the other hand.
CRS Environmental Models specializes in the characterization of geological and hydrological projects and adjust for any project analysis and presentation tools according to the characteristics of the project and its goals.
In three projects that conducted in the recent months have been developed and adjusted "data science" tools and methods to the geology and hydrology worlds.
1. Stratigraphic Model – "Lavan" ridge, Jerusalem.
2. Stratigraphic Model – "Elaad", The Golan Heights.
3. Hydrogeology Survey – "Zita" Pond, "Hadera" River.
In "Lavan" ridge project developed and implemented a new innovative method for construction of a stratigraphic model based on geological maps, DEM, wells, and springs. This for analysis and three-dimensional description of the shallow ground water flow system. In "Elaad" project developed a high-resolution stratigraphic model for evaluating of minerals volume. This, using and adapting of a large number of mapping tools. In "Zita" Pond project activated a new hydrogeological Cross Section model system that development in CRS company. This system builds a full hydrogeological Cross Section base on existing national databases.

## Mineral replacement reactions alter wettability in carbonate rocks

**Israeli, Y.(1), Emmanuel, S.(1)**

1. Institute of Earth Sciences, Hebrew University of Jerusalem, Israel

In carbonate reservoirs, oil can be strongly bound to rock surfaces. Adhesion of oil to rocks is dependent on wettability which is controlled by interfacial forces between the oil, water, and mineral surfaces. Enhanced recovery methods extract tightly bound oil by injecting solutions which change the properties of the fluid phases and the interfacial forces. During injection, mineral alteration can also occur. Here we show that mineral replacement changes wettability in limestone, using the model of calcite replacement to calcium oxalate. Contact angle measurements of crude oil on limestone that was replaced by Ca-oxalate, is on average higher (24.1°) than on pristine limestone (14.9°). The higher contact angle is due to the increase in roughness or to changes in surface tension. An atomic force microscope (AFM) fluid cell was used to scan surface changes during mineral replacement. Ca-oxalate crystals grow and coarsen, so that roughness increased from 26 nm to 98 nm after two hours of reaction. To isolate surface tension impacts, we are developing a method to measure nanoscale contact angles using AFM. Once the mechanism is known, our results could guide the development of new enhanced oil recovery techniques using mineral replacement to control wettability.

## Magnetic fabrics of carbonate rocks as strain proxy near the Dead Sea Fault

**Issachar, R. (1,2), Levi, T. (1), Marco, S. (2) Weinberger, R. (1,3)**

1. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501
2. Department of Geosciences, Tel Aviv University, Tel Aviv, Israel 6997801
3. Department of Geological and Environmental Sciences, Ben Gurion University of the Negev, Beer Sheva, Israel

Knowledge of the local strain field close to plate boundaries is important for better understanding of the mechanical properties of the faults and the geological history of the plate boundaries. Yet, the properties of the strain field near plate boundaries in general and next to the Dead Sea Fault (DSF) in particular is not well known. Magnetic fabrics are petrofabric tool, providing information of mineral and particle preferred orientations. Magnetic fabrics of rocks may indicate the cumulative strain in rocks, including directions and relative magnitudes. Studies show that rocks develop magnetic fabric under tectonic strain. In this current work, we study the magnetic fabrics of Eocene carbonates, outcropping within the DSF. We choose to study Eocene carbonates because they wildly expose throughout the DSF and slightly predates its formation. We measured and analyzed the magnetic fabrics of ~600 chalks and limestones samples from 40 sites in Golan Heights, Jordan Valley and Arava. The interpretation of the magnetic fabrics of the studied rocks is challenging due to the competing effect of different mineralogical groups and due to its weak magnetic response. Therefore, we developed advanced methods and algorithms in order to separate the contribution of each mineralogical groups within the rocks to the bulk magnetic fabric. The Anisotropy of Magnetic Susceptibility (AMS) method averages the contribution of all minerals and presents the whole rocks magnetic fabric. The low temperatures AMS (LT-AMS), which measured after the samples cooled to liquid nitrogen temperature (77K), enhancing the magnetic fabric of paramagnetic minerals such as clays. The Anisotropy of Anhysteretic Remanent Magnetization (AARM) allows isolating the magnetic fabric of ferromagnetic minerals (e.g. magnetite). Magnetic properties, geochemical and mineralogy studies infer that three main mineralogical groups contribute to the AMS of the chalks. Diamagnetic calcite coccoliths compose the rock matrix and constitute ~95% of the rock mass. The chalks contain ~3% of paramagnetic clay minerals and a fraction of a percentage of ferromagnetic sulfides and iron oxides. Preliminary results suggest that the magnetic fabrics comprise information of tectonic strain as an outcome of the activity along the DSF.

## Geophysical study of flooed landscapes at the ancient Maritime Maya site Vista Alegre, Yucatan peninsula, Mexico

**Jaijel, R. (1), Goodman, B. (1), Kanari, M. (2), Glover, J. (3), Rissolo, D. (4), Ben Avraham, Z. (1)**

1. Leon Charney School of Marine Sciences, University of Haifa, Israel ,
2. Israel Oceanographic and Limnological Research Institute
3. Department of Anthropology, Georgia State University, Usa,
4. Center of Interdisciplinary Science for Art, Architecture, and Archaeology ,University of California, San Diego, Usa

Throughout history, worldwide, a major part of the human experience has been to adapt to changing landscapes, and environments. These adaptations can take many forms, sometimes as innovation, manipulation of the conditions, behavioral or technological changes; and in some cases the decision to abandon the area. The northeastern Yucatan peninsula, home of the Maritime Maya port site Vista-Alegre, shows signs of such human changes, though little is known about the corresponding landscape and environment. Vista Alegre is located on the meeting point of the Caribbean Sea and the Gulf of Mexico, at the north-eastern tip of the Yucatan peninsula, in the back of the Holbox lagoon. The site was inhabited from the 9th century B.C until the mid 16th century A.D., with an apparent two century abandonment phase from the mid 7th to 9th century A.D. A multidisciplinary effort ("Costa Escondida project") has been investigating the life of past Mayan inhabitants and the broader connections of the site to the Maritime Maya trade network. One of the questions that has arisen is what were the mutual influences between the inhabitants to their surrounding environment. In order to answer that question the site's shoreline geomorphology and climate history is being reconstructed for the past 2-3000 years. The reconstruction is based on multiproxy analysis of marine sediment cores and surface samples, combined with archaeological data and geophysics. The study presented hereby focuses on a small scale geophysical survey conducted on site, revealing buried features along the modern shoreline. Previous work on sediment cores from the site revealed that part of the historical site lays today underwater, in a flooded landscape. The area of the geophysical survey presented was flooded 1570±40 yr B.P, meaning that that area was used in its terrestrial phase by the ancient inhabits. The flooding of the survey area was rapid, and it is not clear yet was it naturally or anthropogenically induced. The features revealed by the survey will be a target to future marine archeological excavations- first of its kind in this area, which might reveal marine infrastructures and marine vessels. Combining the geophysical survey results with previous results from sediment cores, will make it possible to locate underwater and subbottom targets of interest, to complete the story of the Maritime Maya of Vista alegre.

## From exposed lake margin seismites to deep lake mass transport deposits: Lisan Fm., paleo-Dead Sea

**Kagan, E. (1), Stein, M. (2), Marco, S. (1)**

1. Department of Geophysics, Tel Aviv University, Tel Aviv, Israel
2. Geological Survey of Israel, Jerusalem

The lacustrine formations exposed at the Dead Sea shores comprise a unique archive of late Quaternary environmental and paleoseismic history due to high sedimentation rates (e.g. ~0.5-1 m/kyr), laminated mode of deposition, and the precise and high resolution chronologies by U-Th dating of the primary aragonite or radiocarbon dating of organic debris. Here, we focus on the time interval of the last glacial period (~70-14 kyrs) when Lake Lisan filled the Dead Sea basin and expanded over its margins where sedimentary sequences of the Lisan Formation were deposited comprising the marginal terraces. Previous works described the temporal patterns of appearance of disturbed sedimentary layers in these marginal terraces (e.g. Perazim Valley, Masada Plain) to produce a first profile of temporal occurrence of paleo-earthquakes during the Lake Lisan time. Cores drilled at the abyssal plains of the Dead Sea during the 2010-2011 by ICDP (International Continental Scientific Drilling Program) recovered a continuous record of the deep environment of the Dead Sea during the past 220 ky, including a ~ 110 thick sequence of the Lisan Formation (compared to 30-40 m at the marginal terraces).
The core reveals various types of disturbed lake sediments: turbidites, homogenites, slumps, and other deformations, interspersed with lamination familiar from the marginal outcrops. These deformed units range from cm-scale up to m-scale, with the most prominent being an 8 m thick mass-transport deposit. The transported sediments are the main source of the thickness tripling of the Lisan Formation at the depocenter of the lake. We document, characterize, and discuss these units.
In addition, new lake margin sites were investigated, and a multi-site seismite chronology was rigorously produced. The moderate differences in the number of disturbed units at the various lake margin sites divulge possible site effects and localized events. We correlate all lake margin seismites and major deep-lake events. The similarities and differences in the records are discussed. Units missing in some of the marginal sequences are correlated to mass-transport deposits at the abyssal plain core. Earthquake recurrence and slumping recurrence records are produced. The study of the two end-members of this basin system illustrates the depositional-erosional dynamics and seismicity-induced sediment transfer. A major result of this study is an integrated recurrence pattern of paleo-earthquakes in the vicinity of the Dead Sea basin during the last glacial period, a pattern that completes and fills gaps in that obtained from the marginal terraces.

## Fault detected during seismic hazard assessment survey in the planned Eilat Golf neighborhood

**Kagan, E.J. (1), Eyal, A. (1), Porat, N. (2), Ronen, A. (3)**

1. Geo-prospect Ltd. 3a Uruguay St. Jerusalem. P.O.B. 9313, Israel
2. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem 95501, Israel
3. Geotec Engineering & Environmental Geophysics Ltd. P.O.B. 25031 Rishon-Lezion 7502501, Israel

The city of Eilat straddles the faults of the Avrona-Arava segment of the Dead Sea Transform system. The city is susceptible to earthquake damage, as revealed by modern, historical, and geological sources. Paleoseismic trenching in the Arava and Aqaba has yielded earthquake Holocene return rates of ~1200 yrs on normal faults (Amit et al., 2002) and 300-500 yrs from multi-site interdisciplinary studies in Jordan (Niemi, 2011). The Ministry of Construction and Housing is planning a new neighborhood (Tzel Tmarim-Golf), adjacent to the current northern extent of Eilat and requested Geo-prospect Ltd. to conduct a geological and earthquake hazard assessment survey.

There are active and suspiciously active faults close to the planned neighborhood, but no faults from the Geological Survey of Israel (GSI) active and potentially active fault map are situated within the plan's boundaries. However, based on a previous GSI comprehensive study north of Nahal Roded (Zilberman et al., 2001), previous geophysical surveys, and on our field observations, we deduced the need to further investigate for possible faults, especially at the southeast corner of the plan.

We present here the fault-related portion of the seismic hazard survey. We completed a photo-geological study on aerial photographs from 1965, revealing abundant lineaments trending mainly NS and NE-SW. Proceeding from there, we carried out fault mapping at the outcrops, a new very high resolution seismic reflection survey, and paleoseismic trenching. The reflection survey (three lines, total length 428 m) showed deformation reaching close to the surface, increasing offset with depth, and deformation width of 3-16 m.

Two trenches in the Holland Park, 15m and 3m long, 2.5m deep, oriented ~NW/SE, exposed almost identical sequences: Units A and B consisting of sand, conglomerate, and marls are faulted and tilted; Unit C with alluvial sand and pebbles, 20 - 95cm thick, is not faulted and caps units A and B. Units A and C were sampled for OSL dating. Faulted unit A yielded a burial age of >100ka while capping Unit C yielded a burial age of 4.8±0.3ka, implying that faulting occurred 5000 years before present or earlier. Therefore, it is impossible to define if faulting occurred earlier or later than 13ka (the threshold age for "active" faults according to the 2016 Israel Standard no. 413).

We defined a 120m wide strip, oriented NE-SW that incorporates the surface faults, deformations identified by reflection, and faults exposed in the trenches. This strip is in similar orientation to and might be the continuation of the Shakhamon Fault; we termed it the "Six-Day Fault". For current planning purposes the Six-Day Fault strip is a no-building zone.

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## Shelf-edge exposure at the receding Dead Sea: Syn-deposition landsliding

**Kagan, E.J.(1), Lensky, N.(1)**

1. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem 95501, Israel

Globally, continental shelves, shelf-edges, and slopes are where sediment transfer from the continents to the ocean abyssal plains occurs, directly or via interim depositional and erosional areas. Channels on the slopes are significant conduits for sediment transfer from shallow marine environments to deep-water basin-floor settings. Slumping at the shelf-edge and on slopes shapes and moves vast quantities of sediment down continental slopes on both active and passive margins and their deposits hold an abundance of proxy information about past climate and seismicity Normally, shelf-edge areas are submerged, and therefore investigated by seismic and bathymetric techniques, and sometimes by coring, but outcrops of well-preserved modern and Holocene shelf-edges are practically unknown.
A window of opportunity has opened following the active exposure of the Dead Sea floor morphology, due to the extreme level decline of the terminal lake (~1m/yr). A typical architecture of a flat shelf, shelf–edge, and slope, shifted from a submarine to a subaerial environment. This morphology is analogous to global shelf-edge zones. The current Dead Sea western margin shelf-edge is located at about -405 to -417 m amsl, and is expressed as the transition zone from a sub-horizontal plain to the slope (tens of degrees), and characterized by bays and pointed peninsulas.
Extensive outcrops now exist in the numerous erosional gullies continuously forming and deepening in the muddy coastal plains. The exposures provide evidence for various stages of shelf-edge slumping. Until now, evidence for slumping was identified in on-shelf Glacial-age lake sediments or by coring into transported deposits on the distal abyssal plain, and indirectly by slumping scars on the slope. This study presents the first investigation into the characteristics and chronological framework of slumping events unveiled at the shelf-edge, where significant transport might originate, and is imperative for the understanding of the cores from the deep basin. From the mapped outcrops, the paleo-shelf edge during the Holocene was located within a few meters east or west of the current shelf-edge. Slumping head cuts reach the shelf-edge. Criteria for submarine slumping are defined. Almost exclusively, slumping-scars, slumped sediments, and tilted lacustrine laminated beds are documented east of the paleo-shelf-edge, while sub-horizontal beds are documented west of the paleo-shelf-edge. Submarine-slumping scars can appear covered by draped lacustrine beds or with slumped and deformed lacustrine deposits. We suggest that during the Late Holocene the shelf-edge was laterally stationary at its present location, amid sediment accumulation at the shelf from the west, and syn-depositional slumping at the shelf edge and slope.

## A capillary-bundle model for evaluating the damping of pressure waves in unsaturated porous Media.

**Kalisman, D. (1,2), Yakirevich, A. (2), Sorek, S. (2), Kamai, T. (1)**

1. Institute of Soil, Water and Environmental Sciences, Agricultural Research Organization, Volcani Center
2. Zuckerberg Institute for Water Research, j. blaustein institutes for desert research, Ben-Gurion University

An analytical model for evaluating the damping of pressure waves in unsaturated porous media is proposed.
The model leans on the capillary-bundle approach, which enables to obtain a simple geometrical representation of a porous media, required for the analytical model in hand. By viewing the porous media as a bundle of capillaries, characterized by different groups of capillary tubes that differ in their number, size, and length, the analysis of the damping of pressure waves in the media is conducted by analyzing the damping in capillaries.
Propagation and damping of pressure waves in pipes is a simpler and more deterministic configuration than a porous medium associated with geometrical uncertainties.
We propose a small alteration to the common capillary bundle model, allowing the setting of a specific tortuosity factor to each capillary size. Once the geometry is established, the pressure impulse is analyzed as the damping of a sound wave's amplitude propagating through a fluid in a pipe. The changes between different saturations levels are easy to establish in this model, simply by assessing which capillaries are active in each particular saturation level. The mechanical and geometrical properties that are used for calculating the wave propagation in the pipes are adjusted to mimic the conditions that characterize the porous media.
The motivation for this model is to follow solute displacement in porous media as a result of pressure waves. Field observations imply that pressure waves have a significant effect on the solutes movement in the soil water. Observing the balance equations for the fluid and the solutes, it is apparent that a perturbation in the pressure will affect the momentum of the flow. Therefore, the displacement of the solutes can be related to two main mechanisms: 1) Instant increase in velocity encourages non flowing pores to participate in the flow. 2) The momentum change carries with it a change in kinetic energy affecting the adsorption equilibrium between the fluid and the solid leading to the release of adsorbed particles.

## Reconstructing a flash flood record from the late Holocene in sediment cores from the Gulf of Aqaba (Eilat)

**Kalman, A. (1, 2), Katz, T. (2), Hill, P (3), Mathalon, A (3), Zirks, E. (1), Goodman-Tchernov, B. (1)**

1. Leon Charney School of Marine Sciences, Moses Strauss Department of Marine Geosciences, University of Haifa, 199 Aba Khoushy, Mt. Carmel, 31905, Israel
2. Department of Marine Geology, Israel Oceanographic & Limnological Research Ltd. Tel-Shikmona, P.O.B. 8030, Haifa 31080, Israel
3. Department of Oceanography, Dalhousie University, 1355 Oxford Street, PO BOX 15000, Halifax NS, B3H 4R2, Canada

The hyperarid surrounding Gulf of Aqaba –Eilat (GOA) experiences episodic flash floods that damage infrastructure and endanger lives. Some floods reach the head Gulf and their sediments deposit on the shelf where they play an important role in structuring the ecosystem, such as limiting the distribution of coral reefs. Much of these sediments are later transported further offshore to the deep basin. To date, there is no continuous record of flash floods that may provide a long term perspective of the frequency and magnitude of flash floods in this region and their shifts over time; anticipation of future risks caused by local flash floods (or prolonged droughts) is therefore largely speculative. This ongoing study aims to reconstruct to the best possible resolution a late Holocene flood record in the GOA and trends therein. The methodology includes chemical and physical characterization of the flood deposits and their recognition in the microstratigraphy (1 cm intervals) of dated cores from the shallow and deep seafloor. Our results show that characteristics of suspended flood sediment, e.g. grain size distribution and elemental composition are distinguishable and recognizable in the stratigraphy of the cores. Flood sediment concentration changes are clearly detectable in 20-40 cm push cores and a 312 cm long pneumatic core from the shelf (at 13 m depth in front of the floods' drainage outlet) as well as in a 80 cm long core from 450 m depth. Flood sediment stratigraphy in a 312 cm long pneumatic core shows recurring fluctuations, but also three more long term environmental shifts that require further explanation. These promising results will be complemented with micropaleontological analysis of the cores as well as additional dating to reconstruct a long term record of floods and related climatic conditions in the area of the GOA making it available to hydrologists, oceanographers, decision makers and the public.

## Comparative analysis of site amplification characteristics at stations of Earthquake Early Warning System (EEWS) for Israel based on geological data and seismological observations

**Kalmanovich, M. (1), Gitterman, Y. (1)**

1. Seismology Division, Geophysical Institute of Israel, P.O. Box 182, Lod 71100

Seismic survey was conducted recently by the GII for establishment of the Earthquake Early Warning System (EEWS) for Israel. Background noise was measured at numerous candidate sites by 3C seismometers and accelerometers, facilitating evaluation of the site-effect. The detailed spectral-statistical characteristics of the background seismic noise, recorded at surveyed sites, were obtained.

During the first year of the project we selected 35 new (without any station before) sites that were chosen for deployment of EEWS seismic stations, and provided geological characterization of the sites.

The geological features of each site present important information for estimation of seismic response to strong earthquakes. The detailed geological characterization at each EEWS site, in comparison with background seismic noise measurements, allows to elaborate geological models and evaluate possible site-effect for correction of the EEWS system work parameters.

We analyzed the detailed spectral-statistical characteristics of the background seismic noise and geological parameters related to seismic features of the site.

During the analysis of each site we revealed 14 sites where the site-effect is observed. Most of the sites are characterized by a minor amplification with the factor Aa about 2-3. Only two sites Ein Gev (HKN14) and Ramot (HKN15) show a high amplification about 4.5, and one site Hamra (HKN15) demonstrates a very high amplification about 6-8 at the frequency fa = 10 Hz.

The obtained results should be accounted for during establishment of the EEWS for Israel, for improvement its warning capability.

## Biogeochemical cycling of redox-sensitive elements in Aha reservoir, Guizhou province, China

**Kamyshny, A. (1), Findlay, A. (1), Boyko, V.(1), Guo, Q. (2), Yang, X.(2)**

1. Department of Geological and Environmental Sciences, The Faculty of Natural Sciences, Ben-Gurion University of the Negev, P.O. Box 653, Beer Sheva 84105, Israel
2. Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, 11A Datun Road, Beijing 100101, China

Aha Reservoir is located in the Guizhou province, southern China. It has a total area of 4.5 km2 and a maximum depth of 24 m. The sources of water to the resevoir are polluted with iron and manganese from the surrounding coal industry, and the reservoir water column becomes stratified durng the summer.
The main goal of our research was to elucidate the cycling pathways of redox-sensitive elements, including sulfur, iron and manganese, in the water column and sediments of Aha Reservoir with high hypolimnetic concentrations of dissolved metals, possibly similar to those believed to have prevailed in the world's oceans before and after the Great Oxygenation Event (GOE).
Four distinct layers were detected in the water column of the lake in August, 2016. In the upper 9 m, temperature slowly decreases and conductivity increases with depth, and dissolved oxygen concentrations decrease with depth to below detection. The second layer, between 9 m and 15 m, is characterized by a sharp thermocline, the conductivity maximum and a sharp increase in total manganese concentrations. The third layer, between 15-21 m is a well-mixed layer with high conductivity, low temperature, and high manganese concentrations. The fourth layer, the benthic boundary layer (below 21 m), contains both manganese and hydrogen sulfide. Isotopic composition of sulfate in the lake is δ34S = -7.3‰ - -12.3‰ between 1-22 m, then sharply increases to 0.6‰ at 22 m. The apparent isotopic fractionation between hydrogen sulfide and co-existing sulfate is δ34Ssulfide-sulfate= -17‰ - -30‰ and Δ33Ssulfide-sulfate = 0.04-0.09‰, which is consistent with microbial sulfate reduction.
Concentration profiles from the sediment and water column indicate that sulfate and Mn2+ diffuse from the sediment into the water column, whereas, H2S likely diffuses from the water column into the sediment. The concentration of hydrogen sulfide in the water column is likely controlled by chemical oxidation with Mn(IV). The concentration of dissolved manganese is further controlled by manganese oxidation between 7-10 m by chemotrophic and possibly phototrophic microorganisms.

## Spatial and temporal characterization of sea-cliff erosion and retreat along Israel's Mediterranean Coast between 2006-2016 using five repeat airborne LiDAR campaigns

**Katz, O. (1), Mushkin, A. (1), Crouvi, O (1), Alter, S. (1), Bustan, I. (1), Shemesh, R. (1,2)**

1. Geological Survey of Israel, 30 Malkhe Israel St., Jerusalem 95501, Israel
2. Institute of Earth Sciences, The Hebrew University of Jerusalem, Givat Ram Campus, Jerusalem 91904, Israel

Coast parallel ridges, comprised of a late Pleistocene to early Holocene sequence of Nilotic eolianites and buried soils characterize Israel's coastline south of Haifa. Sand-dominated beaches typically separate the water line from the coastal plains or sea cliffs, which occur along ~50 km of the coast. These sea cliffs are late Holocene erosional features carved into the eolianite ridges. Here, we focus on the coastal cliffs north of Herzlia, termed the 'Sharon Escarpment', where they form a fairly continuous, ~30-km long generally linear NNE-striking, sea-cliff escarpment, with an average height of 26 m. The background retreat rate of the Sharon escarpment is less than 0.1 m/yr since the mid Holocene. Retreat is primarily driven by individual cliff collapse events that are commonly triggered by wave-driven cliff-base scouring that induces gravitational instability in the cliff-face above. Cliff-collapsed material is typically deposited as talus material along the cliff base and transiently stored until continuous wave scouring ultimately erodes the talus material seaward from the shore platform to allow for a new cycle of cliff-base wave scouring and subsequent gravitational cliff collapse.

Here, we analyzed the spatial and temporal distribution of cliff activity between 2006-2011-2014-2015-2016 using high resolution (0.5 m/pixel) topographic rasters derived from airborne LiDAR data. Topographic changes in the vertical direction were measured by differencing time-sequential rasters from each other, with erosion/deposition defined as negative/positive, respectively. We then manually mapped the three primary processes that governed the erosion and retreat of the sea cliff, i.e., cliff collapse, talus deposition and talus erosion during each of the four time intervals examined. Having mapped 953 cliff-collapse events, which range over four orders of magnitude between $10^0$-$10^3$ $m^3$ we show that individual cliff failure events can result in up to 10-15 m of cliff-top retreat. The LiDAR data also reveal complex and dynamic patterns in the spatial and temporal behavior of cliff and cliff-base erosion and deposition processes and that cliff collapse events affect ~5% of the cliff length annually. The measured volume of talus erosion exceeded the volume of cliff collapse during each of the studied periods and demonstrates that retreat rates along the entire Sharon escarpment during the recent decade remained comparable to the cliff's background retreat rates, i.e. <0.1 m/yr.

## Dynamics of suspended sediment fluxes and their composition over the shallow shelf of Israel in the Mediterranean Sea

**Katz, T. (1), Crouvi, O. (2)**

1. Israel Oceanographic & Limnological Research Ltd., Tel-Shikmona, P.O.Box 8030, Haifa 31080, Israel
2. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501

This research presents quantitative assessments of the settling fluxes and composition of suspended particles over the shallow (25 m in depth) shelf of Israel in the Mediterranean Sea. Two sediment traps were deployed next to the continuous monitoring station at the far end of the Hadera coal pier (2.1 Km offshore) for 12 one-month periods between Sept 2015 and Sept 2016. In order to study the dynamics and control mechanisms of the particle fluxes and their composition we examined their changes with respect to time and to variations in the environmental conditions. The research revealed large differences (up to ~50 fold) between the sediment fluxes measured during different sampling periods, with the highest values measured mid-winter. The integration of the heights of the significant waves that exceed 1.5 m correlated tightly with the sediment fluxes. On average, approximately 70% of the particles in the traps were fine (<63μm). However, in winter, the resuspension caused by the currents and waves was so intense that 65% of the particles that entered the traps, which were placed 10 meters above the seafloor, were sand particles (mostly quartz) >63μm. Underneath the traps, fine particles constituted only <1% of the sediment, suggesting major winnowing by the currents and waves. The net water flow at the study site was northwards during most of the year, with an annual average of approximately 4 km d-1. From the C:N and $\delta^{13}C$ ratios we concluded that in summer, most of the suspended organic matter was of a marine source. In the winter and part of the spring, the marine organic matter was diluted by terrestrial organic matter, likely from floods, eroded Eolianite rocks (Kurkar) and some coal from the power plant. Measurements of the $\delta^{13}C$ and $\delta^{18}O$ showed that the suspended particles contained mixtures of marine and terrestrial carbonates whereas the carbonates along the shoreline and in the coarse sediments underneath the traps were mostly precipitated in seawater. This finding suggests that most of the terrestrial carbonates reach the study area as fine-grained (<63μm) particles which are then effectively winnowed seawards.

## Provenance of the Miocene sequence in southern israel, geochemistry of the Hazeva Formation

**Kedem, N.(1), Harlavan, Y.(1), Calvo, R.(1), Avigad, D.(2).**

1. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501
2. Institute of Earth Sciences, The Hebrew University, Jerusalem, 91904

Ascertaining the provenance of sedimentary rocks is imperative for understanding the continental-scale processes that took place from the time of formation until deposition. The early Miocene in southern Israel was a highly active tectonic and fluvial environment following an extensive erosional period. During this time the deposition of a massive clastic sequence named the Hazeva Formation took place, this sequence has been classified many times and extensively studied. Its distribution was correlated across vast regional exposures and sub-surfaces, thus shedding light on the paleogeography and the environmental processes of the region. However, the sources and long scale drainage pathways which contributed the siliciclastic sequence of the early Miocene have yet to be determined. Utilizing isotope geochemistry combined with a mineralogical study, will add to the understanding of the large scale tectonic setting during the Miocene era. Sr, Pb, and Nd isotopes systems are common methods used in provenance studies to identify contributing end members, magma reservoirs, and mantle extraction ages. In our region, this approach is powerful in distinguishing between sediments derived from juvenile Neoproterozoic basement rocks of the Arabian-Nubian Shield and sediments derived from its Phanerozoic cover sequence across North Africa and Arabia. Establishing a geochemical data-base will also enable to compare the mineralogical and geochemical properties of the inland sequence of Hazeva Formation, with those of the deep Levant Basin, such as to obtain a better picture of the overall sedimentary transport system that prevailed at that time. Clays were separated from eleven samples representing the Hazeva Formation type sequence. Mineralogy, REE along with Sr and Pb isotopes were determined and compared to results from the Paleozoic sequences.

## Paleo-environment of the northern Jordan Rift region based on speleothems from Zalmon Cave, Israel

**Keinan, J. (1,2), Bar-Matthews, M. (1,) Ayalon, A. (1), Agnon, A. (2), Frumkin, A. (3)**

1. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem 95501, Israel
2. Institute of Earth Sciences, The Hebrew University, Jerusalem 91904, Israel
3. Cave Research Center, The Hebrew University, Jerusalem 90627, Israel

Speleothems have long been used to decipher paleoclimate, and numerous cave locations in the Eastern Mediterranean have been studied; however the Eastern Galilee has until recently featured no accessible speleothem caves. The newly discovered Zalmon Cave offers an opportunity to study the Eastern Mediterranean paleoclimate in the northern Jordan Rift. The cave is located in the Dead Sea catchment approximately 8 km west of the Sea of Galilee. The study of Zalmon Cave speleothems, based on accurate dating and isotopic records, is giving additional insight into the late Quaternary paleoclimate of the Levant. Speleothems from Zalmon Cave grew during glacial and interglacial intervals, in contrast to Ma'ale Efrayim Cave and Dead Sea Escarpment caves located further south along the Jordan – Dead Sea Rift, in which speleothems deposited mostly during glacial intervals. Comparison of the isotopic records of Zalmon Cave to published isotopic records of speleothems from the Northern Galilee and central Israel shows that the carbon isotopic composition ($\delta^{13}C$) is similar for most of the time interval suggesting similar vegetation types, in agreement with present-day conditions. In contrast, the oxygen isotopic profiles ($\delta^{18}O$) are similar only during interglacial intervals. During the last glacial period, the $\delta^{18}O$ values of Zalmon Cave speleothems are lower than Peqi'in Cave and Ma'ale Efrayim Cave by ~0.5-1‰ and lower than Soreq Cave by ~1-2‰. This suggests warmer temperatures and/or more rainfall in the Eastern Galilee compared to central Israel. Addressing the prominent $^{18}O$ depletion eastward and northward during glacial periods, the possible influence of lower sea level and different synoptic system on the rainfall pattern during these times are investigated. Comparison of the δ18O records from Eastern Mediterranean speleothem caves to planktonic Foraminifera G. Ruber in marine cores located off the Israeli coast ($\Delta\delta^{18}O$sea-land) highlights three behavior patterns during the last glacial period: 1) $\Delta\delta^{18}O$sea-land is greater for Zalmon Cave speleothems compared to Soreq Cave speleothems located in central Israel. 2) There is greater similarity of land records to the marine core located in the southern Eastern Mediterranean Sea, rather than the northern part. 3) The highest $\Delta\delta^{18}O$sea-Zalmon correlate remarkably well with reconstructions of Lake Lisan levels. All three observations support the southern shift of the rainfall track and increasing amount of rainfall in the northern part of the Jordan Rift during the last glacial.

## Numerical simulation of block displacement due to temperature fluctuations

**Keissar, Y. (1), Hatzor, Y. H. (1), Bakun-Mazor, D. (2)**

1. Department of Geological and Environmental Science, Ben Gurion University of the Negev, Beer Sheva 84105, Israel
2. Department of Civil Engineering, SCE - Shamoon College of Engineering, Beer Sheva 84100, Israel

In this research, a thermally-induced wedging-ratcheting mechanism for slope stability is investigated using a three dimensional version of the numerical Distinct Element Method (3DEC). Our goal is to examine whether daily or annual surface temperature fluctuations can induce downslope, irreversible displacement and to create a quantitative model for thermally controlled block displacements. Problems of heat conduction are often too complex to solve using analytical solutions alone. Numerical approaches allow us to study complicated geomechanical problems for which exact analytical solutions do not exist or cannot be obtained. We construct a three dimensional model in 3DEC to simulate the thermal expansion of a sliding block and the resulting block displacement down an inclined frictional slope. According to the proposed wedging-ratcheting mechanism, this displacement is assumed irreversible. Preliminary results show that block displacement down the slope indeed occurs when the block boundaries are subjected to increased temperatures. The sensitivity of the numerically obtained displacement to numerical control parameters and to mechanical parameters of the block and the sliding interface is examined. Results of the numerical model are compared with a semi-analytical approach proposed by Pasten (2013) for the plastic displacement obtained in a single climatic cycle, and with experimental results obtained from a physical model in a climatically controlled room (Feldheim, in prep.) We believe this new failure mechanism may play a significant role in slope stability problems due to the cumulative and repetitive nature of the displacement, particularly in places prone to high temperature oscillations.

References:

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## Comparing alternative proxies for linear site-response estimation in Israel

**Kerpel, B. (1), Kamai, R. (2), Yagoda-Biran, G.(3)**

1. Department of Geological and Environmental Science, Ben Gurion University of the Negev, Beer Sheva 84105, Israel
2. Department of Structural Engineering, Ben Gurion University of the Negev, Beer-Sheva 84105, Israel
3. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem 95501, Israel

During an earthquake the seismic waves that reach the surface are likely to be affected by the shallow geological structure, a phenomenon called site response. There is an obvious need to understand the structure of the ground beneath the building during the design process, in order to calculate the predicted amplification of the ground. Predicting the site response by a site-specific analysis is typically preferred. However, in many cases conducting a site-specific analysis is not possible. Therefore, there is a need for a proxy that will predict the average amplification in the best possible way. Amendment 5 of the Israeli standard (SI 413) uses Vs30 for predicting site-response. The level of amplification in the standard is based on studies which were performed in the US and specifically in California. While this proxy is relatively successful in predicting site-response in California, it isn't necessarily so in Israel. Researchers from the Geophysical Institute in Israel have tested the prediction of site response using this proxy in different civil areas in Israel and claim that the proxy is not sufficiently representative for soil sites in Israel.

The goal of this research is to question the suitability of Vs30 to characterize different sites in Israel, and if necessary - to suggest a proxy that is more suitable. In this research project we statistically analyze a database of sub-surface cross sections in Israel and present the level of amplification that is measured at the first peak resonance frequency and at the maximal resonance frequency for these cross sections. The amplification is calculated using the wave transfer function and the results are presented using the Fourier spectrum.

This project suggests that the proxy being used in Israel - Vs30 - is suited for the amplification measured in Israeli sites where bedrock is deep, and is less suited for areas where it is shallow.

Among the proxies tested in this research, we find that the use of the proxy VsUL presents the best correlation to the amplification. We test to see if it is possible to use the same proxy across the country or if there are essential differences among various geographic areas which would make the use of various proxies necessary. In addition, we check to see if the combination of two physical parameters at the site can produce a better correlation to the level of amplification measured. We conclude that the combination of proxies - Vs30 together with the depth to the reflector at the site presents a better correlation to the level of amplification measured at the first resonance frequency rather than Vs30 alone. We also show that the VsUL yields better results than Vs30 alone.

## National quarries planning - TAMA 14 B

**Koenigsberg, E.(1)**

1. Ministry of Infrastructure Energy and Water Resource, 14, Hartum St. POB 36148, Jerusalem 9136002, Israel

The Ministry of National Infrastructure, Energy and Water Resources and The Administration of Planning, promote TAMA 14 B, the National Outline Plan for quarrying sites. This long-term process (started in 2007) aimed to locate and reserve quarrying sites in order to address the expected demand for raw materials in Israel until the target year of 2045. The implementation of the plan is mandatory in order to support continuous development of the Israeli economy. The construction and paving industries in Israel consumes about 60 million tons a year of limestone, dolomite, basalt clay and sand. Additionally, the Israeli mineral industry requires about 8 million tons of minerals, mainly Phosphates, yearly.

The first stage of the planning process included policy making based on providing forecasts of market demands, mapping of the regulatory framework and examination of the environmental impacts of quarrying activity. This stage included also determining major planning principals and establishing varied policy tools for reduction of demand for primary local raw materials, increasing the efficiency of raw materials production, managing the environmental aspects of quarries, etc. In the second stage, about 130 quarrying sites were located all over the country, with total area of nearly 350 square Km, and outlined in the TAMA's statutory documents. Additionally, the TAMA formed the instructions for the detailed planning stage.

## Influence of submarine ground water discharge on the alkalinity budget of the northern Mediterranean coastal waters of Israel

**Kolker, D.(1,2), Bookman, R.(1), Herut, B.(1,2), Silverman, J.(2)**

1. Department of Marine Geosciences, Leon H. Charney School of Marine Sciences, University of Haifa, Haifa 3498838, Israel
2. Israel Oceanographic and Limnological Research, National Institute of Oceanography, Haifa 31080, Israel

Relatively higher total alkalinity (TA) compared to salinity was measured in the SE Mediterranean Sea surface waters, possibly indicating an external source of TA along the boundaries of the basin. Submarine ground water discharge (SGD) may be an important source of alkalinity to Israeli coastal waters. Moreover, karst activity and SGD along the entire Mediterranean Sea basin land boundary may be a previously overlooked and important source of alkalinity that could explain the persistence of anomalously high TA relative to salinity in surface waters. This research aims to better understand the impact of the fresh water component of SGD on the TA budget of seawater along the northern coast of Israel. Along the Israeli coast SGD flows from either the Cretaceous aquifer or through the overlying Pleistocene aquifer. To determine the magnitude of this TA source, water samples were collected from springs emanating at the waterline along Shikmona, and Betzet beaches and from the seawater beyond the edge of the relatively wide abrasion platforms (10-20m) that border the beach at these sites since December 2015. Water samples were analyzed for salinity, TA, dissolved inorganic nutrients ($NO_3$, $SiOH_4$ and $PO_4$) and will be analyzed for dissolved inorganic carbon (DIC) in the near future. So far, the measurements show a clear TA gradient with peak levels measured in the spring emanations (n=32, 6792±3 μmol/kg) and decreasing seaward to characteristic coastal water levels. However, the lowest TA measured at the edge of the abrasion platform (n=26, 2672±2 μmol/kg) is significantly higher (3%) than the average TA in the SE Mediterranean (n=41, 2600±3 μmol/kg). In addition, spring water TA appears to vary seasonally between 6857±3 (n=19) and 6732±3 (n=11) μmol/kg with the peak value during the winter. Thus, the consistent excess TA over salinity observed at the national monitoring abrasion platform stations over the last five years could be easily explained by TA input along the entire coast of Israel via SGD and most likely in the entire Mediterranean Sea basin. Despite its important role in controlling the buffering capacity of the oceans with respect to atmospheric $CO_2$ the TA budget of the oceans and its potential sources have received little attention in previous studies. This may prove to be an important feed-back mechanism contributing to past glacial-interglacial variations in atmospheric CO2, oceanic pH levels and climatic variations as well as to the ongoing anthropogenic processes of global warming and ocean acidification.

## Oil sands and the different ways to explore them

**Kolodner, K. (1), Frid, V. (2), Lyon, A. (1)**

1. Geo-Prospect LTD, 3a Uruguay st. Jerusalem, 9109201
2. Isotop LTD, 20 Hayarok st. Canot Industry area.

Oil sands are a mixture of clay, sand and water with 10-20 percent bitumen. More than 2 trillion barrels of the world's petroleum is contained in oil sands, which can be found worldwide. Alberta, Canada, has had a booming oil-sand industry since the beginning of the century, and at that time Canada was the second oil producer in the world, after Saudi Arabia.

Geo-prospect Ltd. has been involved in oil sand exploration as consultants of Greensands energy LTD., in China, Albania, Nigeria and Kazakhstan. The major exploration campaigns have been in China and Albania and two case studies from those sites are presented here.

The China exploration project was near one of the largest petroleum-producing basins in the country, where oil migration took place upward, toward the local structural highs. The exploration campaign included roughly 150 boreholes and an airborne electromagnetic - magnetic survey. Residual magnetic data was used to identify major basement blocks and fault systems, to comprehend oil migration paths. The basin exhibits a typical rift basin structure with a series of NE-SW oriented narrow blocks, gradually descending to the basin and a system of faults with small lateral shifts, perpendicular to the normal faults. The faults probably form oil migration conduits.

Maps of electrical resistivity were drawn, proving that resistivity values and lithology are related. Criteria for oil prospecting were developed and two main oil domains were indicated.

In Albania, two deposits were explored. The oil sand horizons are part of a Tortonian molasse deposit formed in coastal terrestrial, estuarine or shallow marine environments. Previous exploration activity included extensive campaigns by the Albanian government (1980's). Geo-Prospect conducted two drilling campaigns (2012, 2015), collecting data for a 3D model and for geochemical and geotechnical analyses. In all, twenty-nine drill holes with a total depth of 2734 meters which penetrated 997 meters of oil sand layers.

Analytical results of all oil sand units in the deposit have showed weighted average bitumen content of 7.8%, with maximum of 17.8%.

The results were used to create composite logs and 3D geological surfaces of the deposit, which were then used to populate a block model. Geological surfaces of the deposit were developed using the software MineSight. After modeling of oil sand layers in 3D space, the bitumen grades were interpolated into the block model. Resource classifications were applied with reference to the Committee for Mineral Reserves International Reporting Standards (CRIRSCO) code, which is based on the level of geological knowledge and confidence of the geological data. This allowed for the definition of the boundaries of the three resource classes, measured, indicated and inferred, which represent a high, medium and low level of confidence respectively.

## How major earth-life crisis and recovery attempts are reflected in stable isotope profiles in tropical marginal marine environment affected by massive terrestrial influxes; some new regional insights

**Korngreen, D. (1) Zilberman, T. (1)**

1. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501

The modern science considers marginal marine zones under the influence of an adjacent land-supply to be with significant impact on oceans and atmosphere in global scale, much more than their actual total size. However, in major earth-life transitions, these zones are still largely left out of the scientific debate. Three Late Permian – early-Middle Triassic successions from southern Israel (Avdat 1, Pleshet 1 and David 1 boreholes), located in relatively proximal and distal order from land within a broad tropical mixed carbonate/siliciclastic open marine zone, were studied using stable isotopic composition of carbon and oxygen, in order to demonstrate the degree of the land-marine teleconnection on the isotopic signatures at the depositional environment.

1. The recorded carbon and oxygen isotopic values are well correlated with worldwide C-cycle perturbations and warming/cooling reported events.
2. Carbonate content recorded frequent expansions (humidity) and contractions (aridization) of the ITCZ during the late Permian- Early and early-Middle Triassic.
3. The proximal recorded organic carbon isotopic values are higher, indicating terrestrial OM contribution.
4. The recorded carbon (organic as well inorganic) and oxygen isotopic profiles of the proximal position consistently differ in magnitude from the distal ones, indicating a high contribution and involvement of meteoric water rich in terrestrial OM derived from the nearby supercontinent and affecting also the oxygen isotopic ratio of the original water to be more negative in relation the higher values characterising the distal successions.
5. During time periods of maximum ITCZ contraction, the OM delta carbon 13 values of -31‰ to -33‰ in the distal succession exhibit the end-member values of the regional marine OM, while values of -22.5‰ to -25‰ of the proximal succession are considered to represent the regional terrestrial signature.
6. Our data show good correlation between the proximal/distal location of a succession and the disparity of carbon (organic and inorganic) isotopic values that may explain the differences in reported worldwide values.

## Grain detachment during shale-water interaction causes water contamination

**Kreisserman, Y.(1), Emmanuel, S.(1)**

1. Institute of Earth Sciences, Hebrew University of Jerusalem, Israel

The exploitation of shale gas and oil has revolutionized the global energy sector. As well as having widespread financial implications, shale oil and gas have raised much environmental concern. The hydraulic fracturing technique that is central to these plays leads to water-rock interaction in the subsurface that can cause contamination in groundwater aquifers. It is often assumed that the main mechanism by which shales contaminate water is via the dissolution of mineral phases in the rock. However, the physical detachment of mineral grains from the rocks could also be a significant source of contamination. In this study, we found that the dissolution of carbonate minerals in shales leads to the detachment of embedded pyrite grains. To quantify the total contaminating particles removal from the rock surface we carried out a series of experiments. Two separate systems were built to measure the changes of the rock surface due to water interaction. Atomic force microscope was used to measure in-situ detachments in the micro scale during the water-rock contact. For a bigger scale imaging each rock sample was placed in a flow-through chamber and was imaged before and after interaction with water using environmental scanning electron microscope. Both of the measured scales showed pyrite grains detachment coupled with carbonate minerals dissolution. These measurements demonstrate new mechanism which delivers contaminating particles into formation water.

## Stability of thiocyanate in natural aquatic systems and sediments

**Kurashova, I. (1), Kamyshny, A. (1)**

1. Ben-Gurion University of the Negev, P.O. Box 653, Beer Sheva 84105, Israel

Despite the importance of thiocyanate transformations in biogeochemical sulfur cycling in aquatic systems, the quantitative parameters of its formation and degradation in natural environments are poorly constrained [1, 2]. The main aim of this research was to understand the role of the bacterial community and impact of chemical and physical factors on the degradation rates of SCN- for a broad range of their concentrations in natural aquatic and sedimentary systems.

The rates of thiocyanate decomposition were measured in waters and sediments of marine and limnic systems under various redox and chemical settings (oxic, ferruginous, and sulfidic). Incubation experiments on degradation of thiocyanate in non-sterilized samples of Mediterranean Sea water, Lake Kinneret water, and Milli-Q water were performed during up to 175-day period. The study of thiocyanate degradation in non-sterilized samples of the Red Sea and Lake Kinneret sediments was conducted during incubation period of up to 121 days. The initial concentrations of SCN- in the solutions were in the range 3-200 $\mu mol \cdot L^{-1}$. Control experiments on the degradation of SCN- in the autoclaved samples were performed under conditions identical to those in non-sterilized samples. The results of incubation of the autoclaved samples showed that the concentration of thiocyanate in all samples changed by less than 3% of initial concentration without a significant trend during 175-day incubation period.

In non-autoclaved samples, no thiocyanate decomposition was observed during the first 22-85 days of incubation. In oxic sediment samples decrease of SCN- concentration was observed without any lag time. After the lag times, decrease in thiocyanate concentrations was observed in all non-sterilized samples. These observations indicate that thiocyanate decomposition in natural aquatic systems is controlled by microbial processes under both oxic and anoxic conditions.

For estimation kinetics parameters of thiocyanate decomposition, the Michaelis-Menten model was applied [3]. In oxic samples higher rates of decrease in thiocyanate concentration were observed compared to anoxic samples. The SCN- degradation in sediment samples was faster than in water samples. Under anoxic conditions, it has been found that SCN- was degraded slower in the presence of Fe(II) than in the presence of hydrogen sulfide.

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## Reexamining the mode of formation of the Eastern North American continental Margin based on seismic stratigraphy and subsidence analysis: Preliminary results

**Lang, G. (1), ten Brink, U. (1, 2), Schattner, U. (1)**

1. Dr Moses Strauss Department of Marine Geosciences, Charney School of Marine Sciences, University of Haifa, Israel
2. U.S. Geological Survey, Woods Hole, Massachusetts

The Atlantic margin of North America is widely cited as a classic example for rifting processes, thermal subsidence and maturation of a passive continental margin. The margin developed between the middle-late Triassic and early Jurassic, when oceanic crust began to emerge. It comprises three main geological units, separated by unconformities (from bottom to top): (1) crystalline basement, (2) syn-rift volcano-sedimentary unit, and (3) sedimentary succession. Most of the studies focusing on the structure and development of the margin were conducted during the 1970's and 1980's. Recent release of datasets allows reexamination of the fundamental paradigms using modern methods and theories. The current study aims at reconstructing the stratigraphic architecture, subsidence patterns and crustal deformation of the margin as well as to constrain the timing of events leading to its formation. By modelling the development sequence the study will address the evolution of divergent margins in general (i.e. tectonic mode of divergence) and this margin in particular. The study area extends across the entire Atlantic continental margin of the United States. Data used include ~5000 2D multichannel seismic reflection profiles from several vintages covering ~314,000 square km and data from 46 exploration boreholes. The interpretation is based on standard seismic stratigraphy methodologies, constrained by the borehole data. In addition, 3D back-striping will be applied to depth converted structural maps. Early results show a multi-layer structure of the continental margin; its thickness and composition varies along the margin from Massachusetts to N. Carolina. The current stage of the research examines the possibility that the variability was formed by a segmented divergence of the North Atlantic.

## Seasonal variations of halite saturation in the Dead Sea

**Lensky, N. (1), Sirota, I. (1,2), Arnon (1,3)**

1. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem 95501, Israel
2. Institute of Earth Sciences, The Hebrew University, Jerusalem 91904, Israel
3. Department of Department of Geography and Environment, Bar-Ilan University, Ramat-Gan, 52900, Israel

Hypersaline lakes and seas were common in the past, precipitating thick evaporitic salt deposits. The only modern analogue for the paleo-limnology of deep salt-saturated aquatic environments exists in the Dead Sea. In this study we present new insights from the Dead Sea on the role of seasonal thermohaline stratification and water balance on the seasonal and depth variations of the degree of saturation of halite (salt) and the rate of halite growth along the water column. We developed methodologies to accurately determine the empirical degree of halite saturation of the lake based on high accuracy densitometry, and to quantify halite growth rate along the water column. During summer, the epilimnion is undersaturated and halite is dissolved, whereas during winter the entire water column is supersaturated and crystallizes halite. This result is not trivial because the variations in the water balance suggest the opposite; summer is associated with higher loss of water by evaporation from the lake compared to the winter. Hence, the thermal effect overcomes the hydrological balance effect and thus governs the seasonal saturation cycle. The hypolimnion is supersaturated with respect to halite and crystallizes throughout the year, with higher super saturation and higher crystallization rates during winter. During summer, simultaneous opposing environments coexist – an under-saturated epilimnion that dissolves halite and a supersaturated hypolimnion that crystallizes halite, which results in focusing of halite deposits in the deep hypolimnetic parts of the evaporitic basins and thinning the shallow epilimnetic deposits.

## Large scale bathymetry generation from satellite data

**Levenson, S. (1), Hall, J (2), Agnon, A (1)**

1. Institute of Earth Sciences, The Hebrew University, Jerusalem 91904, Israel
2. Geophysical Institute of Israel, P.O.Box 182, Lod 71100, Israel

The generation of bathymetry data by direct, on-site, measurements tends to be time and resources consuming – especially when conducted on large areas. Remote sensing methods, such as satellite derived bathymetry (SDB), can be substantially cheaper and faster and may also be used in areas that are unreachable otherwise. The SDB algorithm is based on the difference in the attenuation of blue and green wavelengths in clear water, which is directly proportional to the water depth. Two parameters – the gain and offset – need to then be calibrated in order to convert the algorithm results into depth data. In this study, we implemented the SDB method using semi-automatic scripting tools and Landsat 8 scenes for the generation of near-shore bathymetry over large areas, including the Red Sea, the Persian Gulf and the southern shores of the Arab Peninsula. We also introduced a manual picking technique for calibration in areas that lack reliable depth measurements. Visual inspection of the results show that the generated bathymetry data is consistent with visible underwater structures. Moreover, when analyzing the SDB for the study of tectonics and similar research fields, the accuracy of the absolute depth has less significance than its patterns and spatial derivatives, making the manual picking technique more applicative.

## New seismic database at the National Geophysical Archive

**Levi, E. (1), Zisholz, R. (1), Sagy, Y. (1), Gardosh, M. (2), Lipmann, S. (2), Goldberg, I. (2)**

1. Geophysical Institute of Israel, POB 1123, Lod 7019802, Israel
2. Ministry of Infrastructure Energy and Water Resource, 14, Hartum St. POB 36148, Jerusalem 9136002, Israel

Large amount of seismic and well data was collected onshore and offshore Israel, most of it in the framework of oil and gas exploration. This extensive data set is stored and managed at the National Archive in the Geophysical Institute of Israel. In 2015 the Ministry of Infrastructure, Energy and Water Resource initiated a project designed to restore, backup and modernize this important source of information on the subsurface of Israel. The project led by the Geophysical Projects division at the GII is aimed at establishing a new and accessible data platform suitable to 21st century.

Seismic digital data (raw and processed) stored on old tapes were copied to new media and backed up. Films of seismic sections and well logs were scanned, as well as boreholes reports and observers logs.

Metadata characterization was performed according to international standards. Following characterization metadata was collected and loaded to tables for all the files and surveys. The new database include Shape files of the seismic 2D and 3D seismic surveys and oil and gas boreholes location. The SQL database is linked with a GIS platform allowing data querying on location maps.

This project, currently at its final stage, marks significant improvement in data quality and accessibility. It will further allow integration of data within the National Data Repository (NDR) for oil and gas which is being established in the Ministry of Infrastructure, Energy and Water Resources.

## Can a marine Ex-Bz transient system be used for delineating near-shore hydrocarbon targets?

**Levi, E. (1,2), Goldman, M. (2)**

1. Geophysical Institute of Israel, POB 1123, Lod 7019802, Israel
2. The Dr. Moses Strauss Department of Marine Geosciences, Leon H.Charney School of marine sciences. University of Haifa, Mt. Carmel, Haifa 31905, Israel

Offshore geophysical exploration in transition zone is very challenging issue due to severe limitations that all high resolution geophysical methods experience in this dynamic and complex environment. Marine time domain electromagnetic (TDEM) broadside Ex-Bz system has been found feasible for detecting sub-seafloor resistive targets in transition zone, where the CSEM method becomes inefficient due to the air-wave phenomenon.
The abnormal sensitivity of the system to sub-seafloor resistive structures is caused by the multidimensional resistivity contrast between seawater and submarine sediments that increase the target response under certain geoelectric conditions and transmitter-receiver configurations and offsets.
The influence of the near-shore bathymetry was investigated using multidimensional modeling for different near-shore bathymetries encountered around the globe.
It is found that the above mentioned coastal effect is very sensitive to bathymetric changes. In general, the target response increases with increasing the bathymetric gradient. The latter also affects the optimum transmitter-receiver configuration and offset for obtaining the highest target response.
The first study of the coastal effect in question was dealing with shallow groundwater problem under specific geoelectric, hydrogeological and geomorphological conditions of the Mediterranean coast of Israel. For deep targets and sharp near-shore bathymetry, the influence of the effect on target response might be significantly different. More general analysis carried out here comprises various geoelectric scenarios including both shallow and deep resistive targets at different distances from the shore line as well as geometries of the target and near-shore bathymetries. In addition to signal detectability, the study includes both lateral and vertical resolution of the system in question. Taking into account a limited lateral resolution of the classical frequency domain CSEM and its inefficiency in shallow sea, the described broadside transient Ex-Bz system might represent a desired alternative for delineating shallow and deep resistive targets in transition zone.

## Economic loss estimation for earthquake hazard in Eilat

**Levi, T. (1), Finzi, Y. (2) Davis, M. (3), Dor, O. (3), Cohen-Shrem, S. (1, 2)**

1. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501
2. Dead Sea and Arava Science Center, Kibbutz Qetura, Hevel Eilot 88840, Israel
3. Ecolog Engineering LTD (Ecolog) 3 Pekeris St., Edison Entrance, Tamar Park, Rehovot 76702, Israel

One of the most effective ways to lessen the impact of earthquake disaster on people and property in cities and villages is by pre-planned risk assessment; this includes also economic loss estimates that are based on modern damage simulations.
The present study focuses on direct economic losses in the Eilat region, an area with a high probability for the occurrence of large earthquake. Eilat was chosen as a case study for evaluating the economic loss on a local scale, as it is located in a remote area, within the Dead Sea Fault system, and constitutes a center of great tourism attraction in Israel. In order to evaluate the economic loss in Eilat and to understand its significance, the level of seismic shaking throughout Eilat was evaluated based on an advanced seismotectonic model, considering spatial variations in site effects and directivity effects. Given the local economic data of Eilat, several economic models were established, such as replacement value of structures, business inventory losses, building repair and replacement costs. Preliminary results simulated in the new version of the HAZUS software (MH 3.2, 2016) related to synthetic earthquake of magnitude MW=6.5 in Eilat indicate that the weight of the debris could reach a number of million tons and the direct economic loss could reach several billions of dollars.
Our planned advanced simulations of economic loss in Eilat, will be based on the new economic models, calculated ground motion due to several earthquakes scenarios related to different probabilities of occurrence and on detailed economic data files that were prepared in the course of the present year's research.

## Characterization of the Jurassic reservoir potential in the Eastern Levant margin using reconstruction of the depositional environment and the diagenetic history

**Levin, A. (1,2), Calvo, R. (2), Katzir, Y. (1) Korngreen, D. (2)**

1. Department of Geological and Environmental Sciences, Ben Gurion University of the Negev, Beer Sheva 84105, Israel.
2. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501.

Structural and seismic studies of the Levant Basin margins indicate a variety of potential structural and stratigraphic oil-traps offshore Israel. Several offshore and onshore boreholes showed oil marks and oil accumulation in the Jurassic section, especially in the Barnea, Sderot and Zohar formations. Nevertheless, the diagenetic history of the cements in the Jurassic section has never been studied.

The current study focuses on the diagenetic evolution of potential reservoir rocks within the Jurassic sedimentary section along the Levant margin in Israel in order to track evidence for the accumulation of hydrocarbons within these rocks. Paragenetic sequence study is a useful tool for the reconstruction of burial history of sedimentary rocks. Guided by lithostratigraphic description and electric logs, sampling efforts targeted rock cuttings and drill cores from the richest clastic intervals recovered from boreholes in the coastal plain and offshore central Israel. A petrographic examination of the cement phases suggests their relative age and paragenetic sequence.

Twenty-seven samples had been studied, using optical polarizing microscope, Scanning Electron Microscope (SEM) and specialized cathodoluminescence microscope (CL). Massive cement is noticed in most of the samples and the porosity in most of the samples is very low, and no hydrocarbons have been detected in them. Among the observed authigenic minerals, the most significant are the carbonate minerals. Four authigenic carbonate minerals were observed: calcite, siderite, ankerite and dolomite. Calcite is the most common cement mineral, and appears in different phases, of eogenetic and mesogenetic formation to late fracture-filling cementation. The other three carbonate cement minerals are of eogenetic to mesogenetic formation. Additional authigenic minerals are: pyrite, quartz, chalcedony, oligoclase, clay minerals and gypsum.

Comparing the Jurassic cementation of the current study and the Lower Cretaceous rocks cementation of the Heletz Formation, it seems that the Jurassic rocks had experienced most of the cementation in its early burial stages, and prior to the Middle Cretaceous burial cementation found at the Heletz-Kokhav oil field. The Jurassic rocks diagenesis shows signs of ferrous-dolomitization in places, though it is considerably less than the hydrocarbon-related ferrous-dolomitization that the Heletz Formation diagenesis recorded.

## Applications of stereoscopic photography and structural analysis using 3D software in tunneling and for blast design

**Levin, M. (1), Wahnon, A. (1)**

1. Geotope Ltd.

Stereoscopic photography is a well-known and useful tool for geologists in the procedure of geological mapping. In the last years the use of calibrated digital cameras with stereoscopic photography promotes better collecting and analyzing structural data, especially in slopes or other locations where there is a limited accessibility or at high risk for the geologist. Geotope has implemented the stereographic photography in its work and two applications will be present. The first application is using stereographic photography as a tool for geological documentation during tunneling of the northern section of the Cross Israel Highway, and the second use is in blast design for a quarry located by a railway line and road no. 85.

The system consist of a calibrated SLR camera (Canon EOS D70) based on a tripod and two lenses (regular and wide angle), a set of two range poles and two delimiters.

The camera is positioned in front of the object (slope, tunnel face, or excavated slope) in a distance that will allow getting a high resolution image, and then the geologist takes 2-3 pictures from different locations which are relative to the distance from the object.

Using the software Shapemetrix®, two images are transformed to one 3D image which is scaled and geographically oriented. Further analyses with the JMX analyst allows marking and measuring discontinuities (length, orientation and roughness profiles) and to define the joint sets and bedding inclination. The structural data is then implemented in the classification of the rock mass (Q or RMR methods). The method has two advantages which are: reducing the risk for the engineering geologist by reducing the time required for mapping beneath the unsupported section and improving the structural data by enlarging the mapped area to full face relatively to the common mapping which is focused on the more accessible area at the bottom of the section.

The second application uses the same procedure but the image is transformed to a 3D surface which helps to find the optimal locations for the hole drilling as part of the blast design. The result is drilling pattern which shows the length, inclination and the distance of each drilling hole and improve the control on the final slope geometry.

## Pipes to the earth subsurface: The role of atmospheric conditions in driving air movement along a large-diameter borehole

**Levintal, E. (1), Dragila, M. (2), Lensky, N.G. (,(3 Mushkin, A.(3), Weisbrod, N.(1)**

1. Environmental Hydrology and Microbiology, The Zuckerberg Institute for Water Research, The Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Israel
2. Department of Crop and Soil Science, Oregon State University, USA
3. Geological Survey of Israel

Understanding air dynamics in different types of boreholes is of great significance for the exploration of gas transport at the earth-atmosphere interface. Here, we investigated the role of atmospheric conditions on air transport inside a Nabatien borehole located in Avdat national park. The borehole is 60-m deep and 3.4-m wide. The observation setup included temperature, relative humidity and velocity sensors along the borehole and a standard meteorological station located a few km from the borehole. Two separated one-month observation periods were tested to quantify seasonal changes (September and February). Absolute humidity, calculated from the measured temperature and relative humidity, was validated as a robust marker for assessing air transport inside the borehole examined. Two regions were identified inside the borehole: an upper dynamic region in which the borehole air transport is affected by the atmospheric conditions and a lower stable region in which air is stable. The transition between the two regions was at depth of ~25 m. The air transport inside the upper dynamic region was found to be related to temperature instability (thermal-induced convection) and to changes in barometric pressure or wind velocity (wind-induced convection). A newly 2D developed conceptual model is presented to examine the airflow inside the borehole with the goal of improving our understanding of gas transport and its dependence on atmospheric conditions.

## Encouragement of natural learning in a various learning environments (field, class and lab) through an innovative Web-based platform

**Liberty, S.(1), Orion, N.(1)**

1. Weizmann Institute of Science

In 2011 The Earth Science Cross-Country (ESCC) class was launched. The ESCC is a web based program allowing high school students to major in Geology, climate science and oceanography under the approach of earth systems. The program graduates are entitled to a formal state scientific mager. The ESCC's most unique feature is its pedagogic core. Distinctive features in it are: (1)Inquiry based learning in the lab and the field. (2)Persistent dialog between student and teacher. (3)Passing responsibility of learning to the learner. (4)Creating a live functional learning community. This pedagogic core has two main tangible expression in everyday studying routine: (1)Syllabus (e.g content and educational methodology). (2)learning environments (e.g classroom, outdoor field trips, labs). The syllabus of the ESCC has been kept intact from the corresponding program running for over two decades in public high schools. Learning environments, naturally, have changed dramatically with the shift to a web base program. This study Looks into the knots between the technological environment and the pedagogical core. Questions such as: How do we bringin and allow a natural process of learning to occur in a fint digital learning environment ? have led our study and have also led us to an EdTech company based in manhatten NY. Today this company is our partner in research and development. Together we assemble and disassemble our notions and platform. Preliminary findings from 6 month of piloting the platform in the ESCC program along with public schools and PBL projects show an almost frictionless implementation process and a personalised learning process in the lab and field. Future challenges under work now are creating a true representation and harness the socialization mechanisms within the private and public learning process.

## The kinematics of the Dor disturbance: A case example for the shaping of continental margins by focused salt tectonics

**Lifshiz, I. (1), Makovsky, Y. (1)**

1. The Dr. Moses Strauss Department of Marine Geosciences, Leon H. Charney School of marine sciences. Haifa University, Mt. Carmel, Haifa 31905, Israel

Thin skinned salt tectonic mechanisms and patterns of extension at passive continental margins are usually related to sedimentation at the margins and its inclination. The motion is established in response to sedimentary load accumulation combined with the seaward tilt of the salt layer, while the extensional patterns are influenced by the slope directions of both the present and past morphology. Due to the complex 3D movement of the salt and overburden, restoration is not always easily delineated. Therefore, the mechanisms and contribution of each of these elements are still under debate. The Dor Disturbance is a pronounced thin skinned deformational feature offshore Israel, where the Plio-Quaternary sediments are displaced on top of the Messinian evaporites. Past studies that were conducted at the Disturbance area discussed mainly a 2D extension in the slope direction, and did not fully resolve the effects of the 3D motion. Our interpretation of 2D and 3D seismic data combines key marker horizons and indicative structural and surficial features, and addresses the controls of the Dor Disturbance deformational style.
The research area, a rectangle of c. 60x70 km from offshore Netanya to offshore Haifa Bay, is subdivided into two sub areas - north and south. These sub areas differ in their surface morphological expressions, and sub surface kinematic patterns. Specifically long and semi-linear seafloor trenches appear in the southern sub area. The pre-kinematic unit thins considerably from north to south. Three main families of faults are found within the southern sub area. These families delineate three different domains of the Disturbance: (1) a slope domain, which is dominated by normal faults that are rooted into a pre kinematic Pliocene unit; (2) a bulged domain, which is dominated by normal faults that are rooted into the Miocene erosional surface N; and (3) a marginal domain that is dominated by oblique slip faults with normal and strike slip components, or pure strike slip faults. Some of the normal faults at the bulged domain are cut by a later phase of faulting. Our observations of strike slip motion at the marginal domain imply a major component of radial extension in the kinematics of the Dor Disturbance. Furthermore, the transition between the two families of normal faults suggests that focused salt tectonics has implications on the margins stability. Our conclusions are made based on preliminary results of an ongoing study, which aims to construct a kinematic model for the Dor Disturbance.

## Proven and new plays in the Levant Basin - The next step in developing hydrocarbon resources offshore Israel

**Lippman, S. (1), Gardosh, M. (1)**

1. The Petroleum Unit, Natural Resources Administration, Ministry of National Infrastructures, Energy and Water Resources, Jerusalem 9136002, Israel

The southeastern Levant Basin offshore Israel is a proven hydrocarbon province, as evidenced by recent, large gas discoveries in Oligo-Miocene sands (Tamar, Leviathan) and light oil shows found nearshore.
The characteristics of the Levant petroleum systems have been analyzed through 1D, 2D and 3D basin modeling techniques, and led to the definition of two mega-systems:

- The Mesozoic, thermogenic system, which is mainly light oil prone, with associated thermogenic gas.
- The Neogene biogenic/early gas system.

On the margin/slope of the Levant basin, the Mesozoic; Jurassic – Cretaceous system is characterized by active, mature marine source-rock layers (Upper Jurassic, Bathonian - Kimmeridgian), when buried below 3500m. These sources are associated with light oil and gas shows observed in the nearshore, Yam wells (> 5000 m).
In the deep offshore, Upper Jurassic source-rocks are likely present and has entered the late oil window in most of the area. This source can efficiently charge Lower Cretaceous sands or carbonate build-ups on structural highs (Jonah ridge). The significant oil shows found offshore Sinai within Cretaceous sands (Mango-1 well) may be related to the same system. Upper Cretaceous source-rocks can also be present and within the oil window in the deep basin, but are likely isolated within shaly/silty formations without reservoir potential.
The Neogene biogenic/early gas system appears almost disconnected from the deeper, Mesozoic system. Indeed, the modeling indicates that the observed, vertical overpressure compartmentalization impedes an efficient vertical hydrocarbon migration from Jurassic – Cretaceous source rocks into Cenozoic strata. Modeling further shows that gas accumulations in Oligo-Miocene sands can be reproduced through early, biogenic gas generation and expulsion from Oligocene source rock and a lean, Miocene source-rock. The results suggest that a remaining gas potential in the Oligo-Miocene sands is expected between the deep offshore and the Levant slope, given an efficient lateral connection between these areas.
The modeling of petroleum systems indicates significant quantities of gas and oil that are yet to be found offshore Israel; and most likely also in other parts of eastern Levant Basin.

## Seismically induced large-scale disturbances in lake depocenter: Example from the Dead Sea

**Lu, Y. (1, 2), Waldmann, N. (2), Marco, S. (1)**

1. Department of Geosciences, Tel Aviv University, Tel Aviv 6997801, Israel
2. Dr. Moses Strauss Department of Marine Geosciences, Leon H. Charney School of Marine Sciences, University of Haifa, Mount Carmel 3498838, Israel

Disruptions of unlithified sediments in subaqueous environments provide archives for paleoearthquake reconstruction. Long-term earthquake records spanning ~70 kyr have been reconstructed based on observation of disturbed sediment layers in the Dead Sea margin. While, the limited exposure of much older strata in the margin area hinders the extension of the records, the deep drilling in the lake's depocenter provides new clues as for the morphology of such disturbed units at a much longer time scale. Here we report two sequences of 4-22 m thick disturbed units in the Dead Sea depocenter dating back to the late Pleistocene. We propose a seismic triggering through the temporally correlation with well-established earthquake record in the Dead Sea margin. We define three basic types of disturbed units: Type I includes folded and slightly deformed aragonite-detritus laminae; Type II is severely deformed aragonite-detritus laminae; and Type III represents mud layers contains coarse sands and gravels. We propose a schematic model to illustrate mechanisms for seismic triggering of disturbances in the Dead Sea depocenter. Our results suggest that Type I represents deformation in situ, Type II disturbance is slope area sourced, and Type III disturbance is lakeshore sourced. Our results have wide implications for studies of sediment disturbance in seismically active lakes. We further suggest that long sequences of disturbance in a seismically active lake depocenter, for which we could not have credible age control, can be used to infer earthquake clusters.

## Hydraulic fracking - Opportunity or threat

**Magal, E. (1)**

1. Ministry of Infrastructure Energy and Water Resource, 14, Hartum St. POB 36148, Jerusalem 9136002, Israel

Hydraulic fracking (or fracturing) is a process frequently used to enhance oil and gas production from underground rock formations. During the process, fluid is injected through a borehole into the targeted rock formation under pressures great enough to fracture the oil- and gas bearing rock. This activity may occur once or more than once, during the life-span of an oil and gas production well.

The process has been vastly used in the last 15 years in many countries and most of all in the USA. Hydraulic fracking is considered responsible for 51% of all oil produced and 67% of all natural gas produced in 2015 in the USA. Leading the US to be the top oil producing country, even greater than Saudi Arabia.

Notwithstanding great economic benefits, a major concern has been raised following cases where the application of the hydraulic fracking method led to negative environmental impacts. The possible threats of the method have been examined by several committees in the USA, leading to recommendations for better regulation of the process. In the lecture we will review these findings and try to learn from the experience of others.

# SEMSEEPS Eurofleets international cruise investigated deep sea corals and seeps environments offshore Israel, September 2016

**Makovsky, Y. (1,2), Rüggeberg, A. (3), Bialik, O. (1), Foubert, A. (3), Herut, B. (4), Almogi-Labin, A. (5), Sisma-Ventura, G. (6), Silverman, J. (4), Rahav, E. (4), Adler-Sela, M. (4) Karagregoris, A. (7) Baso, D. (8) and the other EUROFLEETS2 SEMSEEP Project Participants**

1. Dr. Moses Strauss Department of Marine Geosciences, Charney School of Marine Sciences (CSMS), University of Haifa, Haifa 31905, Israel.
2. Hatter Department of Marine Technologies, Charney School of Marine Sciences (CSMS), University of Haifa, Haifa 31905, Israel.
3. Department of Geosciences, University of Fribourg, Chemin du Musée 6, CH-1700 Fribourg, Switzerland.
4. Israel Oceanographic & Limnological Research, Tel-Shikmona, P.O.Box 8030, Haifa 31080, Israel.
5. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501, Israel.
6. Georg-August-Universität, Geowissenschaftliches Zentrum, Abteilung Isotopengeologie, Goldschmidtstraße 1, D-37077 Göttingen, Germany
7. Hellenic Centre for Marine Research, Institute of Oceanography, 46.7 km Athens-Sounio Avenue, 19013 Anavyssos, Hellas, Greece
8. Università degli Studi di Milano, Dipartimento di Scienze della Terra, Via Mangiagalli, 34, 20133 Milan, Italy

EUROFLEETS2 Expedition SEMSEEP with R/V AEGAEO and ROV Max Rover started on 20th September 2016 in Piraeus and returned to Piraeus on the 1st of October 2016. The cruise set forward to investigate seafloor gas seeps, associated carbonate structures and deep-sea corals in the Israeli offshore. Research objectives focused on studying (i) the setting, context, rate and environmental impact of gas seepages, and particularly their relation to the possible current and past presence of methane hydrates, (ii) the particular environmental conditions allowing the growth of deep-sea corals, and (iii) the relations between the two phenomena in the context of recent global and local environmental changes. The cruise investigated in detail seepage and corals areas recently discovered by E/V NAUTILUS 2010 to 2012 ROV surveys in Palmahim Disturbance, and explored additional targets. This cruise carried out detailed controlled collection of geologic, biologic and sediment samples through the operation of ROV Max Rover, and examined the sediment-water interaction through targeted box corer and CTD sampling. All together ten ROV dives were carried out at five different working areas totaling in ~47 hours video data across a total of 50 km of dive tracks, thirteen box cores and eleven CTD casts. We obtained an extensive set of samples for a variety of analyses including geochemistry on pore water and sea water, identification of the internal sediment structure and composition using computer tomography and core logging on the box cores, micro and macro fauna investigation on and in the sediments and biogeochemical characterization of bottom waters. New features discovered include chemoherms habituated by deep sea corals and associated ecosystem at water depths of 400 to 450 m; and gas seepage associated with

carbonate chimneys within the Levant Channel, at the western bound of Palamhim Disturbance, and in a major pockmarks system etched to a pressure ridge in Gal-C exploration block, ~40 km to the west. Analysis of the samples collected is underway. However, our discoveries already corroborate the presence of a pervasive shallow sub-seafloor gas reservoir within buried lobes in the eastern deep sea fan of the Nile.

## The lower Jordan river geomorphological response to active tectonics of the Dead Sea Transform

**Marder, E. (1), Bookman, R. (1), Filin, S. (2)**

1. Department of Marine Geosciences, Charney School of Marine Sciences, University of Haifa, Mt. Carmel, Haifa 31905, Israel
2. Mapping and Geo-Information Engineering, Technion - Israel Institute of Technology, Haifa 32000, Israel

The Jordan Valley Fault is an active morphotectonic segment of the Dead Sea Transform (DST) that was left relatively unexplored due to its rough terrain and location along a political border. The ability to characterize the morphology of the valley surface by remote sensing methods opens new opportunities to trace spatial and temporal geomorphic processes, which have shaped the valley since its exposure at the early Holocene after the desiccation of Lake Lisan (~14.5 Ky BP). In an effort to understand the impact of active tectonics on the Jordan Valley, we present results from our GIS analysis, which explores the relation between the geomorphology of the Lower Jordan River (LJR) basin, and active tectonics of the DST system. Different geomorphological parameters are interpreted in relation to mapped faults, geophysical measurements, and seismic data. The geomorphological parameters of sinuosity, slope, and the flood plain width show a power law fitting, with slope percentage of $\sim 10^{-2}$, and curvature values of $\sim 10^{-1}$, which agrees with other tectono-fluvial systems worldwide in which tectonic uplifting is observed. The soft bedrock platform of the Lisan Formation on which the LJR is incised in, defines a meandered-braided channel pattern with sinuosity of 1-2.2, and slope < 0.05%, an order magnitude less than non-tectonic hard-bedrock fluvial systems. Comparison of the geomorphological parameters to gravity and magnetic anomalies shows an increasing trend of the LJR curvature and decreasing in the LJR sinuosity, as gravity and magnetic anomalies increase, which suggest on tectonic vertical movements that impact the LJR morphology. By using a statistical approach, we divulge the tectonic controls from non-tectonic factors, such as climate, hydrology, and land-use, and show that slope values between 0.01-0.05% correspond with narrowing of the LJR flood plain and high gravity anomalies. The recent active tectonics appears to impact the entire basin landscape, and longitudinal profiles along the main geomorphological structures of the LJR basin (escarpments, mid-terraces, and flood plain) show up to ~35 meters deviations from the expected N-S downstream concave profiles. Our results suggest that the tectonic impact along the basin is differential and result in basin asymmetry along a W-E axis. The basin asymmetry is influenced by the DST, Syrian Arc, and Bet She'an Complex fault systems and the recent active tectonics, which deviates the LJR course up to 6 Km from the N-S axis of the basin escarpments center, and correspond with areas of recent seismic activity concentrated near transitions between positive and negative gravity and magnetic anomalies.

## Novel experimental study of bioturbation activity in flood-like sediments in the northern Gulf of Eilat-Aqaba, Red Sea

**Mathalon, A. (1,2), Hill, P. (1), Katz, T. (3), Kalman, A. (2,4), Goodman-Tchernov, B.(4)**

1. Dalhousie University - Halifax, Nova Scotia, Canada
2. Interuniversity Institute of Marine Sciences (IUI)- Eilat, Israel
3. The Israel Oceanographic and Limnological Research- Haifa, Israel
4. Haifa University- Haifa, Israel

In the hyperarid environment of Eilat, Israel, ephemeral flashfloods can occur in the winter months, transporting the majority of sediment into the Red Sea. This study focuses on identifying conditions for flashflood deposit burial and preservation in the shallow Gulf of Eilat- Aqaba. The rate and depth of surface sediment mixing via bioturbation are being quantified in this study through an in situ experiment, to help infer the conditions for flashflood deposit preservation. The movement of flood-like surface sediments was tracked using 1.5 g of fluorescent sediment tracers <63 µm. Twenty-seven sediment cores (diameter= 4.5 cm, length= 30 cm) were collected from the study region at 13 m water depth. Tracers were positioned on the surface of each core. Using novel instruments, the cores were transplanted into the seafloor at 9 sites, in triplicates of 3 treatments (fenced, caged, and open). Sediment cores were recovered at three intervals (t=1: 1 week; t=2: 19 days; t=3: 6 weeks) from each site. Each core was sliced at cm resolution, and representative subsamples were analyzed through photographs taken under a binocular microscope to quantify the presence of tracer vertically down each core. The observed bioturbation depth was ~ 5 cm. There was no significant difference in the tracer distributions between treatments. Tracer distributions in cores from t=1 and t=2 exhibited diffusive profiles, while some core profiles from t=3 exhibited an accumulation of the tracerss at depth within the cores. A varying amount of the initial tracer was conserved within each core from each treatment and time interval. Our results are revealing that in this hyper-arid, active bioturbation environment, flashflood deposits do not appear to have the opportunity to be preserved as definitive layers, unless they are subjected to burial by subsequent floods.

## Free energy dependence of labradorite dissolution kinetics under close-to-natural weathering conditions

**Melnikov, G. (1), Gruber, C. (1), Zakon, Y. (2), Ganor, J. (1)**

1. Department of geological and Environmental Sciences, Ben-Gurion University of the Negev, P.O. Box 653 Beer-Sheva 8410501, Israel
2. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 9550161, Israel

Plagioclase minerals are the most abundant minerals in the earth crust. As albite (the Na rich end member plagioclase) is a pure phase, the thermodynamic treatment (calculation of activities and degree of saturation) of its dissolution is straightforward. Therefore, previous studies focused on dissolution of albite, as the representative of weathering process in the earth crust. Nevertheless, the intermediate members of the plagioclase solid solution are dominant in natural environments. However, rate laws that describe the dependence of the intermediate members' dissolution rate on deviation from equilibrium are lacking. Moreover, previous laboratory experiments were conducted under conditions that are significantly different from natural weathering conditions. Therefore, a rate law that describes labradorite dissolution rates dependency on deviation from equilibrium under close-to-natural conditions is needed.

In the present study, three multi point batch experiments (MPBE) of labradorite dissolution were conducted at pH ~5 and 25 °C in different ranges of degrees of under saturation: 1. under far-from-equilibrium conditions 2. very close-to-equilibrium and 3. deviating from close-to-equilibrium conditions towards far-from-equilibrium conditions. The measured dissolution rate in experiment 1 is based on the elemental Si and Al concentration in the experimental solution, while the dissolution rates in experiments 2 and 3 are based on measurements of the change of Si isotopes ratio in isotopically spiked solutions (enriched with $^{30}Si$).

Preliminary results show that labradorite dissolves congruently and the dissolution rate under far-from-equilibrium conditions is independent on deviation from equilibrium. The dissolution rate under close-to-equilibrium conditions is slower by a factor of 3.22 than the far-from-equilibrium experiment.

## Breaking biogeographic barriers: Molecular and morphologic evidences for the Lessepsian invasion of foraminifera to the Mediterranean

**Merkado, G, (1), Titelboim, D. (1), Oron, S. (1), Hyams-Kaphzan, O. (2), Holzmann, M. (3), Pawlowski, J. (3), Almogi-Labin, A. (2), Abdu, U. (1), Abramovich, S.(1)**

1. Ben Gurion University of the Negev, Beer Sheva, Israel.
2. Geological Survey of Israel, Jerusalem, Israel.
3. Department of Genetics and Evolution, University of Geneva, Genève, Switzerland.

This study focused on symbiont-bearing larger benthic foraminifera (LBF) that are indicative of tropical and subtropical regions and serve as an excellent biomonitoring tool for the marine ecosystems of these environments. Red Sea LBF species that are suspected to have recently invaded the Eastern Mediterranean were used as a model system for assessing the extent of the ongoing Lessepsian invasion in foraminifera. This was done by a comparison of the genetic diversity (small subunit rDNA-SSU) and ecological and physiological characteristics of selected species from the Israeli Mediterranean coast and the Red Sea (Gulf of Eilat).

This study provides the first molecular evidence for the Lessepsian invasion of foraminifera. Specifically, this study documents the invasion of three larger benthic foraminifera that are important constituents of tropical shallow water environments: *Sorites orbiculus*, *Textularia agglutinans* and *Operculina ammonoides*.

The species *S. orbiculus* has become very dominant in the shallow rocky habitats along the northern coast of Israel and has been observed in numerous locations in the Mediterranean. Our study revealed that it consists of two haplotypes separated by habitat preferences in the Gulf of Eilat. Only one of these haplotypes was found to invade the Mediterranean coast of Israel. The symbionts that were found in both the Mediterranean and Eilat soritids belong to Symbiodinium clade F5, which is common in the Red Sea and not in the Mediterranean.

The species *T. agglutinans* showed a different mode of expansion in the Mediterranean with a single widespread genetic population that was identical to the Red Sea population. This species appears to have a large morphological variation with very little genetic variation. The molecular investigation provided the first ribosomal DNA sequences of *T. agglutinans* complemented with morphological and ecological characterization. The phylogenetic analyses of this species show that all specimens along the Israeli coast belong to the same genetic population, despite some morphological variability. It also reveals that T. agglutinans has an epiphytic life mode, which probably enabled its successful colonization of the hard-bottom habitats that consist of a diverse community of macroalgae. This study further indicates that the species does not tolerate high SST (> 36 °C), which will probably limit its future expansion in the easternmost Mediterranean in light of the expected rise in temperatures.

*Operculina ammonoides*, which is very common in the Red Sea, is reported here for the first time from the Mediterranean. This species is a close relative of the nummulitids, which are among the most important fossils markers of the Cenozoic carbonate platforms. It displays a remarkable phenotypic plasticity in respect to its planispiral shells, from an inflated

involute to strongly flattened relatively large evolute coils. Molecular analyses of living specimens from the Red Sea, Japan and the Mediterranean reveal a surprising genetic homogeneity between geographic locations, and no distinction between involute and evolute forms. CT images exclude the possibility of sexual dimorphism, as indicated by the presence of megalospheric prolocuIs (indicative of asexual forms) in both involute and evolute specimens. Molecular analyses of the diatom symbionts demonstrate that they belong to two clades within the cosmopolitan genus *Thalassionema* with no correlation to habitats' water depths. These results suggest that genetic homogeneity of the host foraminifera is accompanied with strong symbiotic specificity, in contrast to previous reports on diverse endosymbiosis within nummulitids.

This study suggests that the genetic homogeneity could be related to the ability of *O. ammonoides* to phenotypically adjust to different environmental conditions. Such phenotypic plasticity possibly allows the existing genotype to expand to new environments without imposing reproductive barriers that will promote cryptic speciation. This understanding has a direct implication for our interpretations of the paleoecology and taxonomy of fossil nummulitids. Moreover, the case of genetic homogeneity within *O. ammonoides* is an excellent example for the notion that genetic diversification is not obliged in every widespread species.

## Using Hyperspectral Spectroscopy to Characterize the Dead Sea Sinkholes by their Physical and Biological parameters- case study: Einot Samar

**Meroz, A.(1, 2), Ben Dor, E.(1), Avni, Y.(2)**

1. Remote sensing laboratory, Geography and human studies department, Tel Aviv University

2. The Geological survey of Israel

Hyperspectral remote sensing (HRS) data in the visible-near infrared-shortwave infrared (VNIR-SWIR, 0.35-2.5 μm) spectral regions and in the longwave infrared (LWIR, 8.5-11.5 μm) range were acquired over Einot Samar in the Dead Sea (DS) valley, to study the sinkholes dynamics with the surrounding environment. Three airborne campaigns were conducted, with different sensors: Specim's AisaOWL LWIR sensor (May 2013), Telops' Hyper-Cam LWIR sensor (Jun 2014) and Specim's AisaFENIX VNIR-SWIR sensor (Sep 2014). Field surveys were done using a field spectrometer, Analytical Spectral Devise (ASD) (Jun 2015, Jan 2016) for ground validation. Emissivity spectra, calculated from the LWIR images, were used for spatial change detection that occurred between the years 2013 to 2014. Apparent thermal inertia (ATI) was calculated for different surface coverage (soil, water and vegetation), combining the VNIR-SWIR and LWIR data. The VNIR-SWIR region data enabled to classify different water bodies' chlorophyll and salinity levels in the sinkholes. The ability of HRS data to identify and map changes in the surroundings of sinkholes was shown, and with further studies will contribute to the understanding of sinkholes dynamics resulting from the interaction between underground water input, biotic environment and of the geological aspects of the area.

## Chemostratigraphy integrated with biostratigraphy as method to advance the chronostratigraphy of the Late Cretaceous sequence of Israel

**Mizrahi, N. (1,2), Harlavan, Y. (3), Abramovich, S. (2), Ashckenazi-Polivoda, S. (1)**

1. Dead Sea and Arava Science Center, Neve Zohar, Dead Sea mobile post 86910, Israel
2. Department of Geological and Environmental Sciences, P.O. Box 653, Ben Gurion University of the Negev, Beer Sheva 84105, Israel.
3. Geological Survey of Israel, 30 Malkhe Israel St., Jerusalem 95501, Israel.

The Late Cretaceous was a time of great climatic and paleocanographic changes that had major impact on the global marine ecosystems. The timing of these events must be accurately determined based on a reliable chronostratigraphic framework that can be readily applied in various environmental settings. The Late Cretaceous planktic foraminiferal biostratigraphic zonation is mainly based on tropical-subtropical species that are typically found in normal pelagic settings. However, during this time, unique conditions of high water column productivity and oxygen deficiency prevailed throughout the Levant region, including Israel, causing a partial to total exclusion of some of these species. Consequently, establishing age framework based on biostratigraphic correlation of the Levant region is a challenging task, emphasizing the need to apply additional method to advance regional chronostratigraphy. Among these, is chemostratigraphy based on the $^{87}Sr/^{86}Sr$ ratio in of the carbonate tests of foraminifera, which is now widely used for stratigraphic correlation.

The main objective of the present research was to improve the chronostratigraphic resolution for the Upper Cretaceous organic-rich sequence in Israel. This was accomplished by integrating detailed correlation of planktic and benthic foraminiferal bioevents, with $^{87}Sr/^{86}Sr$ ratio, correlated to the global $^{87}Sr/^{86}Sr$ ratio curve. This integration provides a new and much improved chronostratigraphic framework of the Late Cretaceous strata of Israel and the entire Levant region. It allows to integrate sections with poorly preserved or lack of the common biomarkers, define for the biozone. In general this should yield the best age control for economically valuable stratigraphic units (e.g., oil shale) deposited during this time.

The biozonation of the studied sections, RE-2 and RE-6 from the Negev basins (southern Israel), spans from the Late Santonian Dicarinella asymetrica Zone to the middle Maastrichtian Abathomphalus mayaroensis Zone and from the middle Coniacian Dicarinella concavata Zone to the early Maastrichtian Pseudoguembelina palpebra Zone, respectively. The zonation subdivision, and the regional correlation to Aderet borehole from the Shefela Basin, Central Israel, is based on 23 secondary and main planktic biomarkers and based on the LOs of seven benthic species and the acme event of Elhasaella alanwoodi. Sr isotopes curves from the RE-2 and Aderet sections show a remarkable correlation to the global Sr curve and with good agreement with the biostratigraphy datum.

We took great measures to ensure that the analyzed $^{87}Sr/^{86}Sr$ ratio on ca. 200 tests per sample will represent the tests themselves and not impurities.

Ultimately, the results of this study assess the accuracy and applicability of the secondary planktic and benthic foraminiferal datum to determine important age intervals and for

determining numerical ages based on the Sr isotope records. Our new chronostratigraphic framework of the high productivity sequence in Israel is not only essential for regional correlation of these economically important sediments but also valuable in a global context.

## Sliding velocity and roughness evolution on limestone discontinuities

**Morad, D. (1), Sagy, A. (2), Hatzor, Y. H. (3)**

1. Department of Geological and Environmental Science, Ben Gurion University of the Negev, Beer Sheva 84105, Israel
2. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem 95501, Israel

Geometrical irregularity of fault surfaces is a fundamental factor controlling frictional sliding. In this research, we investigate the mechanical behavior and roughness evolution of experimental faults during varying slip rates in a laboratory direct shear system. We introduce preliminary results regarding the relationship between shear velocity and the evolution of slip surfaces.

We generate rough tensional joints by fracturing a 8X19X50 cm beam under four-point-bending configuration. The geometry of the two surfaces of this joint is measured using high-resolution laser scanner which can produce millions of measuring points on such a surface. We then put the two mating surfaces in a perfect interlocked position and shear it to fixed displacement length of 10 mm under constant normal load of 5 MPa, thus allowing the sample to dilate during the test. The slip rate is fixed for a given run but varies from 5 microns per second to 100 microns per second in the six tests. Values of friction and dilatation are monitored by LVDT type displacement transducers. In a typical experiment the shear stress increases almost linearly until reaching a maximum, exhibiting a semi elastic behavior, then the stress displacement curve decreases to a constant value, demonstrating the stress drop associated with sliding beyond ultimate shear strength. By analyzing those features we can calculate the friction properties of the sample.

Discrete deformation zones consisted of fractures, grains and fine grainy gouge are recognized on the sheared surface demonstrating that the real contact area during shear is only a portion of the entire surface. We distinguish between three types of deformation modes: uprooting (extraction), fracturing, and climbing of asperities. To quantify the geometrical variations which are associated with the deformation, the surfaces are scanned again by the laser profilometer.

The roughness evolution of the surface is examined using statistical methods which enable us to analyze geometrical properties affected by the shear along a range of scales between ~ 0.01 and 100 mm. Our results in this preliminary stage show that the final roughness in all tests and for the entire measured range of scales is higher than the initial roughness, suggesting that damage is more effective than localization in our present shear conditions. Surprisingly, roughening is more evident in surfaces subjected to lower slip rates.

## Leaching and phytoavailability of trace elements in soils amended with coal fly ash treated biosolids

**Moshe, A. (1,2,3) Fine, P. (2) Kosson, D. (4) van der Sloot, H. (5) Teutsch, N. (1)**

1. Geological Survey of Israel, 30 Malkhe Israel St. 95501 Jerusalem, Israel
2. Volcani Center, P.O.B 15159 Rishon LeZion 7528809, Israel
3. The Hebrew University of Jerusalem, Soil and Water Sciences, Rehovot 76100, Israel
4. Vanderbilt University, PMB 351826, Nashville, TN 37235-1826
5. Hans van der Sloot Consultancy, Dorpsstraat 216, 1721 BV Langedijk, The Netherlands

Two Israeli waste streams generating secondary materials can be combined to an agricultural product suitable for beneficial use: (1) raw sewage sludge (RSS) from treatment of primarily municipal wastewater, and (2) coal combustion fly ash (FA) from electricity production. Raw sewage sludge (RSS) can be pasteurized by mixing with coal combustion fly ash (FA) and calcium oxide (i.e., lime, at approx. 50:5:45 ratio). The resulting N-Viro Soil© (NVS) product is a beneficial soil amendment. It contains plant available essential macro and microelements and improves soil physio-chemical and biological characteristics. However, the FA component of NVS allegedly increases the release and phytoavailability of toxic elements. The overall aim of this study is to examine the relative role of NVS components, FA and RSS, on contaminant uptake by test plants and leaching to groundwater. Leachability was evaluated using two US-EPA Methods: (1) 1313 - liquid-solid partitioning as a function of eluate pH, and (2) 1314 - Liquid-Solid Partitioning (LSP) as a function of liquid-to-solid ratio using an up-flow percolation column. In addition, plant uptake and leaching were studied in mini-lysimeters growing lettuce as the test plant. The same materials were used in all experiments, comprising of two soils (dune sand from Palmahim and the plough layer of a clayey vertisol from Revadim) amended with two levels of NVS: Israeli annual maximum permitted load and five times as much. The FA chosen (F type) represents a worst-case contaminants scenario for FAs available in Israel. Materials and leachates were analyzed for the major and trace elements: Al, Ca, Fe, K, Mg, Mn, Na, P, S, Si, Ti, Ag, As, B, Ba, Be, Cd, Co, Cu, Cr, Hg, Mn, Mo, N, Pb, Sb, Se, Th, Tl, U, Zn and V. In all the above three scenarios, elevated leaching concentrations were observed for oxyanions (i.e., As, Mo, Sb, Se and B) under specific pHs and L/S conditions. The primary source of these elements was the FA, while RSS promoted release of dissolved organic matter associated elements. An additional layer of soil in the column test (1314) reduced leaching of elements of concern. All lettuce produced during the mini-lysimeters experiment were found to be safe for human consumption.

## The underground salt layer and sinkholes

**Motsan, Z.(1)**

1. 4 Mishcan Shilo Street Jerusalem 9371902

Beneath the shore of the Dead Sea lies a layer of salt, a few meters thick. The commonly accepted theory is that with the retreat of the shore line, water coming from 'Hahetekim' cliff, that has a lower concentration then the layer of salt described above, causes the dissolution of the salt layer and creates underground cavities which in turn causes the ground above them to collapse, leading the formation of sinkholes.
I want to offer another theory that explains the formation of sinkholes, that does not require that the salt layer dissolve in order for the sinkhole to be formed. In my opinion, once the shore line has retreated, water with any salt concentration and theoretically even with a higher salt concentration than that of the water of the dead sea or the underground salt layer, when flowing toward the sea on the surface of the layer of salt can create underground caverns and cavities in the layer of mud on top of the layer of salt and subsequently the the collapse of the outer layer into these cavities, creating sinkholes.

## Sediment contribution from coastal-cliff erosion into the Nile's littoral cell and its significance to cliff-retreat mitigation efforts

**Mushkin, A. (1), Katz, O. (1), Crouvi, O. (1), Alter, S. (1), Shemesh, R. (1,2)**

1. Geological Survey of Israel, 30 Malkhe Israel st., Jerusalem, 95501
2. Institute of Earth Sciences, The Hebrew University of Jerusalem, Givat Ram Campus, Jerusalem 91904, Israel

In 2013 the government of Israel initiated a national mitigation program aimed to prevent further collapse and retreat of the country's coastal cliffs, which occur along the northern termination of the Niles's littoral cell (NLC) in the eastern Mediterranean. The goals of this large-scale program are to protect infrastructure and property proximal to the cliff and to conduct long-term maintenance and monitoring of this highly dynamic and sensitive land-sea interface that spans ~40 km of Israel's coast line. Here, we examine the possible impact of proposed cliff retreat mitigation efforts on long-shore sediment transport (LST) and coastal dynamics in the region. We used airborne LiDAR spanning a 9-year period between 2006 and 2015 to quantify the annual contribution of sediment eroded from a ~20-km-long segment of Israel's coastal cliffs into the NLC. Our measurements reveal 282±85*103 $m^3$ of sediment eroded from the cliff and delivered into the NLC during the studied period. Considering our study area comprises ~50% of Israel's sea cliffs we infer an average contribution rate of ~30,000-60,000 $m^3$/yr of cliff-derived sediment into the NLC prior to the planned broad-scale implementation of cliff-retreat mitigation measures.
Previous studies report an average net LST flux of ~80,000 - 90,000 m3 that reaches the northern termination of the NLC at Haifa Bay annually. Thus, our results suggest that Israel's actively eroding coastal cliffs are primary contributors (40-80%) to the LST budget along the northern termination of the NLC. It therefore appears that successful implementation of the coastal-cliff protection program along Israel's coastline will result in a significant sand deficit, which may drive LST in this part of the NLC out of its 'background' state. In the likely case that the energy/currents driving LST do not change, a possible outcome of this sediment deficit could be increased beach erosion along Israel's coast line to make up for the lost volumes of cliff-eroded sediments.

# An innovative educational Martian mock habitat near Mitzpe Ramon to conduct analogue planetary geological research and to inspire the next generation

**Naor, R.(1) Petranker, G.(1) Sorek-Abramovich, R.(1) Rubinstein, H.(1)**

1. Davidson Institute of Science Education, Herzl St 234, Rehovot, 7610001

Space simulations in analogue environments is a well developed sector in space exploration disciplines. The use of simulated mission in a mock habitat facility is meant to test the durability of future crews under isolation and harsh conditions. The environment in the habitat's vicinity is used for simulated Extra-Vehicular Activities (EVA), where simulated analogue field work will be conducted.

The Young Israeli Astronaut Academy is an exciting new project from the Davidson Institute of Science Education, the educational arm of the Weizmann Institute of Science. It is aimed at inspiring high school students to take part in scientific research and in pursuing STEM education. Their mission statement for the two year project is to determine the habitability of an analogous simulated Martian environment. Hence, they will be receiving training in geology, biology, physics, engineering, medicine, command and control and use the obtained knowledge to experience in full simulated human Mars exploration mission.

The environment of the Makhtesh Ramon crater holds many similarities to the Martian environment and has therefore been chosen to facilitate the simulated mission.

The Young Israeli Astronaut Academy is a crucial first step in a broader vision to build a permanent space simulations facility near Mitzpe Ramon. In-Situ Resources Utilization (ISRU) 3-D printing technology is being considered for habitat structure. Various Israeli based technologies in agriculture, data gathering, satellite communications, robotics and more are also being considered to be used within and around the facility. This envisioned program can be integrated as part of the GeoPark project and facilitate scientific exploration for future academic and educational purposes, as well as national and international participation.

## Constraining channel steepness index as a proxy for incision rate: Evolution of bedrock channels along the Golan Heights volcanic plateau

**Nativ, R. (1), Haviv, I. (1)**

1. Department of Geological and Environmental Sciences, Ben Gurion University of the Negev, Beer Sheva 8410501, Israel

The eastern Mediterranean Golan Heights volcanic plateau with its extensive Plio-Pleistocene and north-to-south climatic gradient (1000-400 mm/yr) provides a unique opportunity to quantify and decipher bedrock channel evolution where the initial conditions are well constrained by dated lava flows. We utilize this setup to improve our understanding of the normalized channel steepness index (Ksn) as a proxy for erosion rate and to validate the stream power incision model and constrain its parameters. The study combines geomorphic analysis of digital elevation models with moderate resolution (10x10 m), high-resolution field surveys, geochronology of selected key outcrops, and numerical modeling of bedrock channel evolution.

Analysis of topographic data from 20 bedrock reaches in 13 basins support a non-linear relationship between channel steepness index (Ksn) and incision rate, with Ksn ∝ E^0.3. The scatter in the entire dataset seems to be partially related to precipitation gradients, the length of the period over which incision took place and drainage area.

Global compilation of Ksn data vs. erosion rate delineates a broad range of Ksn values, ranging from 10 to 500 [$m^{0.9}$]. For a given Ksn, erosion rates span 1-2 orders of magnitude. Variation in rock strength and climate probably account for much of this scatter but further analysis is needed to demonstrate and quantify the effect of these complex parameters.

We demonstrate that across the Golan Heights the Erodibility coefficient (K) in stream power bedrock incision model vary by a factor of ~20, mostly due to the rainfall gradient. Future analysis of additional bedrock reaches with dated interfluves and characterization of key climatic parameters such as rainfall intensity and its temporal variability is expected to help decipher climatic controls on bedrock incision rates.

## Imaging shallow voids using subsurface acquisition

**Navon, H. (1), Reshef, M. (1)**

1. The Department of Geosciences, Tel-Aviv University, Tel-Aviv 69978, Israel

Cavities and voids in the shallow subsurface are posing a security and safety threat. Therefore, identifying and imaging these voids in the shallow complex subsurface has been a subject to many geophysical studies, yet a solution was not found. Of all the geophysical techniques, seismic methods have demonstrated the most success up to date in detecting and imaging the objects. However, conventional surface seismic surveys (SSP) have yet to achieve consistent success in detecting those objects and creating a clear image. SSP is located on the ground and therefore is highly sensitive to ambient noise and the signal from the target can be completely attenuated by the surface waves. In order to overcome these difficulties subsurface configurations such as crosswell, VSP (Vertical Seismic Profiling) or subsurface-aligned geophones can be applied. These configurations provide the advantages of recording both upgoing and downgoing wavefields, with higher frequency content and better resolution. In addition, these configurations enable to convert time to depth, map the events to their correct location and retrieve more accurately seismic properties such as Vp and Vs.

The main aim of this research is to construct a subsurface operation using the various subsurface configurations in order to enable the illumination of small anomalous bodies, such as voids and karst, buried in the shallow complex subsurface. In order to achieve the main aim different data sets acquired from an experimental site, using different subsurface geometries and different types of geophones (such as 3 components) and sources were processed. Examining the full range of data sets enables to produce a more reliable velocity model, a better differentiation between the different phases and preforming the migration process on the different arrivals, including the converted waves. Preliminary results of integrating all the information from the various data set show more focused and clear result.

## 3D Quantitative seismic fault analysis, a case study offshore Israel

**Navon, N. (1), Agnon, A. (1), Medvedev, B. (1,2), Politi, M. (1)**

1. The Hebrew University, Jerusalem, 91904, Israel.
2. Schlumberger Petroleum Services, Parkstraat 83 Den Haag, the Netherlands.

The variation of displacements on fault surfaces allow to examine their evolution and to distinguish between buried and syn-sedimentary faults. Using quantitative seismic fault analysis, we aim to underscore the relation of fault systems with salt tectonics and mechanical stratigraphy under shelf settings, offshore Israel.
Displacement patterns diagnostic of buried faults, where both tips close gradually, characterize the normal faults of a N-S trending system in the northern part of Gabriella license. However, moving southwards, we detect an increasing asymmetry in the pattern: while the northern tips show a buried fault graduale closure, displacement at the southern tip sharply diminishes. We speculate that the underlying chaotic zone, on the eastern part of ISC (Israel Slump Complex, Cartwright, 2005), controls the displacement patterns and fault evolution.
Information gleaned by displacement contour diagrams is useful for interpreting seismic data, both for quality control of interpretation and quantitative extrapolation of limited data (Barnett, 1987). Also, they can improve prediction of fault geometries in areas of limited resolution (Chapman and Meneilly, 1990). The ISC is considered one of the larger slump complexes in the world, and therefore the present approach holds a considerable promise.

## Solid molecular nitrogen (δ-$N_2$) inclusions in Juina diamonds: exsolution at the base of the transition zone

**Navon, O. (1),Wirth, R. (2), Schmidt, C. (2), Jablon, B.M. (1),Schreiber, A. (2) Emmanuel, S. (1)**

1. Institute of Earth Sciences, The Hebrew University, Jerusalem 91904, Israel
2. GFZ German Research Centre for Geosciences, Section 4.3 Chemistry and Physics of Earth Materials, Telegrafenberg, 14473 Potsdam, Germany

Diamonds originating from the transition zone or lower mantle were previously identified based on the chemistry of their silicate or oxide mineral inclusions. Here we present data for such a super-deep origin based on the internal pressure of nitrogen in sub-micrometer inclusions in diamonds from Juina, Brazil. Infrared spectroscopy of four diamonds, rich in such inclusions revealed high concentrations of fully aggregated nitrogen (average of 900 ppm, all in B centers) and almost no platelets. Raman spectroscopy indicated the presence of solid, cubic δ-$N_2$ at 10.9±0.2 GPa (corresponding to a density of 1900 kg/$m^3$). Transmission electron microscopy of two diamonds found two generations of octahedral inclusions: microinclusions (average size: 150 nm, average concentration: 100 ppm) and nanoinclusions (20-30 nm, 350 ppm). EELS detected nitrogen and a diffraction pattern of one nanoinclusion yielded a tetragonal phase, which resembles γ-$N_2$ with a density of 1400 kg/$m^3$ (internal pressure = 2.7 GPa). We also observed up-warping of small areas (~150 nm in size) on the polished surface of one diamond. The ~2 nm rise can be explained by a shallow subsurface microinclusion, pressurized internally to more than 10 GPa.
Using available equations of state for nitrogen and diamond, we calculated the pressures and temperatures of mechanical equilibrium of the inclusions and their diamond host at the mantle geotherm. The inclusions originated at the deepest part of the transition zone at pressures of ~22 GPa (630 km) and temperatures of ~1640°C. We suggest that both generations are the result of exsolution of nitrogen from B centers and that growth took a few million years in a subducting mantle current. The microinclusions nucleated first, followed by the nanoinclusions. Shortly after the exsolution events, the diamonds were trapped in a plume or an ascending melt and were transported to the base of the lithosphere and later to the surface.

## Offshore oil and gas exploration and production Strategic Environmental Assessment (SEA)

**Nissim, I. (1), Eitan, M. (2), Cohen, S. (2), Tom, M. (3), Kanari, M. (3), Herut, B. (3)**

1. Ministry of National Infrastructure, Energy & Water Resources, 14 Hartum, Jerusalem 9136002
2. Geoprospect, 3a Uruguay, Jerusalem 91092
3.Israel Oceanographic and Limnological Research, Haifa, 31080

In 2014 the Ministry of National Infrastructure, Energy, and Water Resources launched a Strategic Environmental Assessment (SEA) project in the Mediterranean Sea. The SEA is intended to form a knowledge base and act as a decision making tool for the Petroleum Commissioner in granting petroleum exploration and production rights offshore Israel. Like similar projects done world-wide, the SEA is designed to weigh in environmental considerations in sustainable development of offshore oil and natural gas resources, and minimize potential harm to the ecosystem while evaluating other benefits of environmental, social, and economic value.

The SEA encompasses the State of Israel's entire marine area, including sovereign waters and the EEZ.

This SEA is the first of its kind and is setting new standards in the way natural resources are administered in Israel. The content of the SEA complies with international practice and the OECD requirements and European Union directives.

The SEA includes:

- An international review of similar SEA projects related to offshore development.
- Establishing a website dedicated for the SEA.
- Formulating a methodology for sharing all stages of the survey with the public.
- Collecting existing environmental information and mapping habitats and high-value areas.
- Preparing an economic analysis and evaluating the services of the Mediterranean Sea ecosystem in comparison with the benefits of oil and gas development. Assessing the cost of compromising them by developing offshore petroleum and natural-gas resources compared with the benefits of developing these resources.
- Defining and analyzing alternative methods of weighing environmental considerations of sustainable development of offshore petroleum resources.
- Preparing and publishing a final report after implementing the public and stakeholders feedback.

The final report contains maps of habitats and environmentally sensitive areas. It also presents a variety of alternatives for developing offshore oil and gas resources. The report includes an in depth discussion of the potential environmental impacts of implementing each of the development alternatives. The report also provides recommendations for implementing its conclusions, identifying information gaps and ways to improve the knowledge base, and establishing indices for monitoring the recommendations and their implementation.

A steering committee composed of representatives of government ministries,

environmental NGO`s, public professional parties, oil and gas industry and other stakeholders, supervised the preparation of the SEA.
The blocks offered in the first Offshore Bid Round 2016 were delineated in line with the SEA conclusions and are concentrated in areas of low vulnerability and high knowledge gap.

## External factors controlling submarine channels development: a case study from the Late Pliocene interval in the deep Levant Basin

**Niyazi, Y.(1), Eruteya, O.E.(1) and Waldmann, N.(1)**

1. The Dr. Moses Strauss Department of Marine Geosciences, Leon H.Charney School of marine sciences. University of Haifa, Mt. Carmel, Haifa 31905, Israel

In this study we combine a three-dimensional seismic reflection dataset with well logs to analyze a distinct succession characterized by moderate to high-amplitude discontinuous to continuous seismic facies which was deposited during the ~Middle to Late Pliocene offshore central Israel. This interval is characterized by a double-storey submarine channel-belt complex, which are both restricted by the emplacement of a large mass transport deposit (MTD). The channels in both systems trend N-NW and have widths ranging between 150 m to 350 m, while incise up to 50 m within the Pliocene sediments in both levels. Greater populations of well-developed and highly sinuous channels are identified in the upper storey channel complex, suggesting that the interplay between the sedimentary processes and the evolution of channels in the studied interval are heterogeneous. In particular, this may emphasize remarkable changes in spatio-temporal variations in flow volume. Yet, the effect of salt tectonics inflicted by the Messinian evaporites substratum on the morphology of the channel-belt complexes can be downplayed since its associated deformation postdates the evolution of the channels. Considering the available chronology obtained from well-logs and through further comparison with other regional and global climate proxies, we suggest the presence of an apparent periodicity in the evolution of the channels through time. We further propose that the evolution of these channels during the Pliocene is Nile-related during periods of increase water influx. Furthermore, channel systems described here for the Pliocene interval may extend the current understanding of the development of slope channels under the influence of juvenile saline giant. Their volumetric study has important implications for deep-water hydrocarbon exploration as these bodies serve as shallow and transitional hydrocarbon reservoirs.

## Implementing ElarmS for the Israeli Seismic Network – New Tools and Approaches

**Nof, R. M.(1), Allen, M. R. (2)**

1. The Geophysical Institute of Israel, 6 Habbal Shem-Tov, Lod, 7019802
2. University of California Berkeley, Berkeley CA 94703, USA

Israel proximity to the Dead Sea Transform (DST) have led the Israeli government to initiate the building of an Earthquake Early Warning System (EEWS). The prime objective of this research is to implement, adjust and validate the ElarmS EEWS for the Israeli Seismological Network (ISN). Our approach for analyzing ElarmS performances with the non-EEW optimized ISN is threefold: (1) We analyze the system in real-time between April 2015 and July 2015; (2) analyze the results of replaying historical data from 39 events (Md>3.0) between January 2012 and May 2015; (3) analyze 4 simulated earthquake records for magnitudes 5.1<M<7.8. We develop new tools for replaying historical and simulated data and to visually monitor and analyze ElarmS performance.

Historical playback results show near complete detection of all events. We adjusted magnitude estimation equation with a previously developed equation for Israel. Using the adjusted magnitude, the performance of the system shows a good agreement with catalog magnitudes.

The real-time implementation of ElarmS in Israel is performing well. It issued a warning for the widely felt June 27, 2015 M5.5 Nueba, the July 30, 2015 M4.4 Dead Sea and the November 19, 2016 M3.3 Lebanon earthquakes. However, the alert time is very short due to the significant latencies (2-4 sec) and long data packets (up to 10 sec) that exist for the ISN which has still to be optimized for EEWS.

The earthquake simulations results show a very good agreement with data, demonstrating the potential of using earthquake simulated scenarios for developing and testing EEWS. Further work is needed for creating more realistic simulations using more complex 3D velocity models, broader bandwidth and scenarios including foreshock/aftershock or simultaneous events.

The methods and tools developed during this work may be useful for implementing ElarmS in other regions and similar efforts are being made in the US Pacific Northwest, Turkey, Chile and South Korea.

## The origin of the Dead Sea Transform based on calcite age-strain analyses

**Nuriel, P. (1), Weinberger, R. (1,2), Kylander-Clark, A.R.C. (3), Hacker, B.R. (3), Craddock, J.P. (4).**

1. Geological Survey of Israel, 30 Malkhe Israel St. Jerusalem, 95501, Israel.
2. Department of Geological and Environmental Sciences, Ben-Gurion University, Beer-Sheva 84105, Israel.
3. Department of Earth Science, University of California, Santa Barbara, CA 93106, USA.
4. Department of Geology, Macalester College, St. Paul, MN 55105, USA.

The origin and evolution of the Dead Sea Transform (DST) are re-evaluated based on new in-situ U-Pb dating and strain analyses of mechanically twinned calcites. Direct dating of 30 synfaulting calcites from 10 different fault strands of the DST indicates that the oceanic-to-continental plate boundary initiated between 20.8 and 18.5 Ma within a ~10 km wide distributed deformation zone in southern Israel. Older ages from the southern DST relative to the northern DST suggest northward propagation of this classic strike-slip zone. The dominant NNW to NNE direction of horizontal shortening recorded in these dated twinned calcites marks the onset of left-lateral motion along the evolving plate boundary and further suggests for temporal changes in the stress-strain field during the Miocene. The observed changes in the strain field within individual segments cannot be simply explained by local 'weakening effects' along strands of the DST or by gradual changes in the Euler pole through time.

## Prominent mid-Miocene faulting in Mt. Hermon: new U-Pb ages of fault-related calcite

**Oren, O. (1), Nuriel, P. (2), Haviv, I. (1), Katzir, Y. (1)**

1. Department of Geological and Environmental Sciences, Ben Gurion University of the Negev, Beer Shev 84105, Israel
2. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem 95501, Israel

Mount Hermon is a prominent anticlinal structure located at the intersection of the Dead Sea Transform (DST) plate boundary and the Palmyride fold-and-thrust belt. The regional sequence of tectonic events that led to the structural evolution of the Hermon complex and its association with the DST activity is still under debate.
The abundance of fault-related calcite precipitates combined with state-of-the-art laser ablation (LA) geochronology enables to constrain the absolute timing of brittle faulting activity in Mt. Hermon area. We apply LA in-situ U-Pb dating of calcite minerals from three fault zones including the Majdal Shams Quarry (MSQ), Neve Ativ Graben (NAG) and Nahal Arar (NAr). Preliminary results from a total of 17 samples yielded 23 well-constrained Tera-Wasserburg isochron ages of calcite precipitates delineating two key periods of faulting activity: (1) Maastricht to Eocene (70-37 Ma) and (2) mid-Miocene (18-10 Ma). The latter period turns out to be more extensive encompassing the formation of the NAG boundary normal faults and shearing structures in the NAr area, which are probably related to block rotation deformation. Surprisingly, none of the ages obtained so far is late Miocene or younger (<6 Ma). We associate the first phase of faulting with intra-plate deformation related to the closure of the neo-Tethys ocean and the evolution of Syrian Arc fold system and the latter with initiation of the Dead Sea transform plate boundary.

## Cenomanian calcareous nannoplankton biostratigraphy of the Mount Carmel Region (Northwestern Israel)

**Ovechkina, M. (1)**

1. Geological Survey of Israel, 30 Malkhei Israel, Jerusalem, 95501 Israel

One of the largest transgressions in the southern Tethys took place during the Cenomanian, when huge sequences of calcareous sediments were deposited in this region on a wide platform. The Judea Group is the least studied in terms of the calcareous nannoplankton. A detailed foraminifera stratigraphy of these shallow water deposits is impeded by scarcity and poor preservation of forams.

Calcareous nannoplankton from borehole CT8 (744176.8 N/198776.8 E) retrieved in the NW Carmel area were studied. Totally 108 samples were examined for biostratigraphical analysis. The studied sequence composed of the following formations: Yagur (dolomite limestone), Isfiye (dolomitized chalk, tuffaceous layer and micritic carbonates), Bet Oren (indurated chalks), Arqan (chalks with chert nodules).

No calcareous nannofossils have been found in the lowest part of the section (Yagur Fm.). The lower part of the Isfiye Fm. (CT8/5–16) is referred to the Upper Albian Subzone NC9b by the presence of Eiffellithus monechiae. The upper part of the Isfiye Fm. (CT8/17–47) belongs to the transitional Upper Albian – Lower Cenomanian Zone UC0 (equivalent NC10a) by the presence of Eiffellithus turriseiffelii from CT8/17. The interval CT8/48–54 is referred to the Lower Cenomanian Zone UC1 by the presence of Corollithion kennedyi from CT8/48. The interval CT8/55–60 belongs to the transitional Lower–Middle Cenomanian Zone UC2 by the presence of Gartnerago segmentatum from CT8/55. The upper part (CT8/61–108) is referred to the transitional basal Middle–Upper Cenomanian Zone UC3 by to the presence of Lithraphidites acutus from CT8/61.

Thus, for the first time the taxonomic composition (over 65 species) and stratigraphic distribution of calcareous nannoplankton from the Cenomanian of NW Carmel area have been studied. The detail calcareous nannoplankton biostratigraphy of this area has been established. For the first time the age of the tuffaceous layer is biostratigraphically identified and is regarded as the Late Albian (lower part) to the Late Albian – Early Cenomanian (upper part). This tuffaceous layer can possibly be correlated with the tectonomagmatic event C.V.–4 established by Segev (2009).

The project was supported by the Ministry of National Infrastructures, Energy and Water Resources.

## Transportation and deposition patterns of the Plio-Quaternary succession in the southeastern corner of the Levant basin

**Oz, D. (1), Yael, S. (1), Miki, G. (2), Moshe, R. (3)**

1. Geophysical Institute of Israel, P.O.Box 182, Lod 71100, Israel
2. Israel Ministry of Energy and Water Resources, 14 Hartom, Jerusalem, 9136002, Israel
3.The Department of Geosciences, Tel-Aviv University, Tel-Aviv 69978, Israel

Hydrocarbon discoveries in the deep Levant Basin`s Oligo-Miocene sands during the last decade raised the importance of these depositional systems as a major conduit of clastic sediments and as potential reservoirs. The question of the sediments origin and transportation patterns to the deep Levant basin has been the focus of recent studies arguing for either an African or an Arabian origin or a combination of both. However, less attention has been given to the Plio-Quaternary strata in the deep basin. This ~700 m thick section that was deposited contemporaneously with the development of the Nile-river alluvial cone and with Israel's progradation of the Plio-Quatenray sedimentary wedge, contains a series of paleo channels exhibiting various transportation and sedimentation patterns which have not yet been explored in detail. We investigate the origin and deposition of the Plio-Quaternary section of the southeastern deep Levant basin, distinguishing between direct Nile, reworked Nile and eastern Levant margin hinterland sediments.

A series of maps displaying the channel systems within the Plio-Quaternary section were created based on newly computed seismic attribute volumes (spectral decomposition and coherence). Analysis of the spatial and temporal distribution of these channel systems revealed 5 stages of sediment accumulation. At the end of the Messinian salinity crisis event (stage 1), sediments were transported from the Israeli continental shelf north-westward to the deep basin. This channel system ceased its activity during the Early Pliocene (stage 2) and unconfined sedimentation prevailed leading to deposition of parallel and continuous reflectors. This Early Pliocene section represents ~30% of the total Plio-Quaternary section in the deep basin, and only ~10% on the shelf area. Since ~2.3 Ma (stage 3), a channel system originating from the Nile cone slope edge transported sediments to the deep basin towards the north-east. Simultaneously, a major mass transport complex originating from the Israeli shelf area developed underneath most of the present continental slope, containing approximately 1000 $km^3$ of sediments. Following the mass transport event, sedimentation in the shelf area increased, and thick prograding sigmoidal clinoforms were deposited (stage 4). This section constitutes ~60-70 % of the total Plio-Quaternary section in the shelf area whereas only 10 % in the deep basin. Thus, suggesting increasing sedimentation rate in the shelf area coeval with accumulation of a condense section in the deep basin. Channel system activity resumed and is evident within a high amplitude chaotic section representing the upper part of the Plio-Quaternary section (stage 5). Closely spaced channels flow to the NNE parallel to the base of the slope whereas decrease of channel's density is observed to the west.

## Site response of the vertical ground motion – Alternative proxies

**Peer, G. (1), Kamai, R. (2)**

1. Department of Geological and Environmental Science, Ben Gurion University of the Negev, Beer Sheva 84105, Israel
2. Department of Structural Engineering, Ben Gurion University of the Negev, Beer Sheva 84105, Israel

The vertical component of ground motions and specifically its site response is poorly understood. Traditionally, calculating the vertical component was performed by multiplying the horizontal ground motions by a constant V/H ratio of 2/3 for all spectral periods at all rupture distances. However, recent studies have shown that the vertical component can exceed that of the horizontal component, especially on soil sites at short rupture distances. Most vertical ground motion prediction equations (GMPEs) still use Vs30 – the time-averaged shear-wave velocity of the top 30m as a proxy for site characterization, although studies have shown that P-waves may contribute as much as the S-waves to the vertical ground motion and possibly even more. Because the vertical site-response is controlled by both S-wave and P-wave velocities (Vs and Vp respectively), and because P-wave velocities are highly sensitive to the presence of water, we believe that parameters other than Vs30 may be more effective for site-characterization in seismic-hazard evaluations of the vertical component of ground motions.

The purpose of this study is to identify a predictive proxy, to be used in seismic hazard studies of the vertical ground motion for describing the site-response component. To do so, we use data from the NGA-West2 ground-motion database in California and supplement it with Vp30 and the GWL at most of the stations in the database. The vertical amplification is calculated with respect to a baseline GMPE regressed on surface ground motion recordings in California. Vp30 is calculated from measured Vp profiles at the ground-motion station locations. Finally, measured ground-water levels from the USGS ground-water database are interpolated, to evaluate the GWL at the locations of the ground motion recording stations. Correlations between the site amplification and different profile proxies are explored in order to identify the most appropriate proxy. We find that while Vs30 alone cannot fully represent the vertical site-response, it still offers the best first-order approximation of the overall site-response. We also see very clear correlation between the amplification at short periods and the GWL. While the Vs30 scaling is sensitive to distance, the GWL scaling is mostly sensitive to magnitude. This is due to the relative contribution of S and P waves within the soil column. This topic will be further explored in future research.

## Characterizing the shear wave velocity profile of the seismic network stations in Israel

**Peleg, Y. (1, 2), Yagoda-Biran, G. (1), Kamai, R. (3)**

1. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501
2. Department of Geological and Environmental Science, Ben Gurion University of the Negev, Beer Sheva 84105, Israel
3. Department of Structural Engineering, Ben Gurion University of the Negev, Beer-Sheva 84105, Israel

Characterizing the shear-wave velocity (Vs) profile at the location of seismic network stations is essential for estimating their site response. The site-effect can then be removed from the measured ground motions at the station, for the development of local scaling relationships, such as ground-motion prediction equations and other seismological purposes. Currently in Israel, the seismic network stations are not characterized in terms of their geotechnical properties. In this study, we develop an indispensable database of Vs profiles in the locations of network stations in Israel, using the ReMi (Refraction Microtremor) method (Louie, 2001).

The ReMi method is a noninvasive passive geophysical method that uses the dispersive nature of Rayleigh surface waves. In the ReMi method, the shear-wave velocity profile is evaluated quickly and effectively, using a linear array of geophones measuring ambient noise (Heath & Louie, 2006). The data is then transformed from time-distance domain into slowness-frequency domain, so that phase-velocities of the dispersion curve can be recognized. After picking the minimum velocity envelope, the velocity-depth profile is modeled using the picks. This interpretation process is somewhat sensitive to user definitions and boundary conditions, and hence should be done very carefully.

Here, we will present two phases of our study: First, we conduct blind-tests at four borehole locations and compare the ReMi results with prior direct measurements, to gain confidence in our measurements and interpretations. Second, we present results obtained at a few example seismic stations and compare the obtained velocity profiles with other measurement techniques, for a discussion on the epistemic uncertainty associated with site characterization.

## Computation of realistic synthetic accelerograms for probable strong earthquakes in Israel for hazard assessment and early warning systems (first stage)

**Perelman, N.(1), Pinsky, V.(1)**

1. Seismology Division, Geophysical Institute of Israel, P.O. Box 182, Lod 7110101

Earthquake early warning systems have been expanding rapidly around the world. There are currently warning systems in Mexico, Japan, Taiwan, and Romania. Others are in the state of testing and investigation, such as Elarms in California, PRESTo in Italy, EEWS in Turkey, China etc. And also the government decision taken in June 2012 Israel is now building the Earthquake Early Warning System (EEWS).

The aim of this project is creation of a tool for testing future EEWS in Israel with synthetic accelerograms. Calculation of synthetic seismograms and accelerograms has recently become a useful tool in seismological research, and a wide variety of techniques have been developed. Forward modelling, which means in this case the generation of synthetic seismograms, represents an important part of many seismological studies, such as seismic tomography or the kinematic inversion of source parameters. For horizontally stratified Earth models the complete wave field computation can be performed by using the theory of normal mode or the discrete wave number method

The objective of this project is to develop software for simulation of the strong earthquakes ground motion felt in Israel, based on the new Graphic User Interface (GUI). This full-waveform synthetic seismograms and accelerograms generator (SSAG) should be tuned to local conditions of the source, media propagation and sites in Israel. In general, calculation of synthetic seismograms has recently become a useful tool in seismological research, and a wide variety of techniques have been developed.

In this study, we shall use the discrete wavenumber decomposition method which provides accurate realistic waveforms (Green's functions) at a long distance range (> 60 km), whilst for close stations the simulation techniques of Boore, 2003 will be utilized. The first method is realized in widely-used AXITRA code using a layered velocity model and density and quality factors for P and S wave. AXITRA input comprises also hypocenter location as well as full moment tensor description. The Boore, 2003 method is realized by A_TS_DRVR program from the SMSIM package.

## Testing virtual Israel earthquake early warning system with synthetic catalog

**Pinsky, V.(1)**

1. Geophysical Institute of Israel, HabaalShemTov 6, P.O.B 1123, LOD 7019802

In June 2012 Israel government decided about building an Earthquake Early Warning System (EEWS) in the country. The network configuration suggested was to be a staggered line of ~120 stations along the regional main faults: the Dead Sea fault and the Carmel fault and additional ~30 stations spread more or less evenly over the country. For the EEWS alarm the system should have to utilize two approaches: the P-wave based system combined with the S-threshold method. The former utilizes first wave arrivals to the closest stations (4 - 6) for prompt location and the 3 initial seconds of the waveform data for magnitude estimation. The latter issues alarm when the surface shaking (velocity or acceleration) exceeds the relatively high threshold corresponding to a magnitude 5 earthquake at a short distance (5-10 km) at least for the two neighboring stations. For each of the approaches and for a reasonable combination of them we simulate the EEWS performance based on a synthetic catalog. The input seismicity parameters for the processing are extracted from the real instrumental catalog. Using a general ground-motion prediction equations for PGA, $\tau c$ , Pd we then evaluate how false and missed alarm rates depend on the corresponding thresholds. Practically, in turn, these dependencies approve choosing initial thresholds for the EEWS providing appropriate false and missed alarms rates.

## The morphology of gypsum precipitated under hyper-saline conditions. Results from Dead Sea – Red Sea mixtures

**Reiss, A.G. (1,2), Ganor, J. (1), Gavrieli, I (2)**

1. Department of Geological and Environmental Science, Ben Gurion University of the Negev, Beer Sheva 84105, Israel
2. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem 95501, Israel

Gypsum (CaSO4*2H2O) is an evaporitic mineral that is a common precipitate in both natural and industrial processes. Its abundance has led to wide research into the precipitation mechanism of the mineral and an extensive data base about the thermodynamics and kinetics of gypsum precipitation exists. The relation between the chemistry of the solution from which the mineral precipitated and the morphology of the formed mineral has also been studied but mostly in synthetic $Ca^{2+}/SO_4^{2-}$ solutions. It thus remains unclear how the chemical parameters of hyper-saline water, from which gypsum precipitates, affect the morphology of the mineral. This information is important since the morphology of a solid is a major determinant of its ability to stay afloat; hence, it is a major factor that will determine if there would be an increase in the turbidity of the Dead Sea (i.e., a "whitening" event) due to massive gypsum precipitation in case the Dead Sea – Red Sea conduit will be built.

In order to study the solution-morphology relationship in hyper-saline conditions, a set of batch experiments was conducted. Each experiment was done by mixing different ratios of Dead Sea and Red Sea brines. Experimental solutions were enriched in $Ca^{2+}$ and $SO_4^{2-}$ so that different mixing ratios would have identical degrees of oversaturation with respect to gypsum (Ωgypsum) and that solutions with similar initial Ωgypsum would have varying $Ca^{2+}/SO_4^{2-}$ ratios. The experimental solution was then separated into aliquots. At designated times one of the aliquots was sampled for chemistry and the crystals were separated from the solution by filtration, and the crystals were then photographed in a binocular and analyzed using the ImageJ software for the processing of microscopy images.

The results of the experiments indicate that the morphology of gypsum is highly dependent on both the distance from equilibrium and the ratio of Dead Sea to Red Sea in the precipitating solution. Far from equilibrium (initial Ωgypsum ≥ 4) the crystals take the form of a radial center from which needles spread out in all directions. This morphology is observed regardless of Dead Sea/Red Sea ratios. Closer to equilibrium (initial Ωgypsum ≤ 2.8) the crystals are idiomorphic and planar and the closer to equilibrium the solution is, the less elongated the crystals become. In this close to equilibrium morphological region, as the relative amount of the $Ca^{2+}$ enriched and $SO_4^{2-}$ depletaed Dead Sea brine in the solution increases, the crystals become less elongated. This is opposed to the observed increase in crystal length/width observed when the $Ca^{2+}/SO_4^{2-}$ ratio is increased in synthetic solutions. In addition, it appears that the crystal population grows linearly with time.

## Intra-basin hydrological processes during large and extreme flash floods under various hydrometeorological conditions

**Rinat, Y. (1), Marra, F. (1), Morin, E. (1)**

1. Institute of Earth Sciences, The Hebrew University, Jerusalem 91904, Israel

Hydrological response is a result of the complex dynamic interactions between spatiotemporal rain and heterogeneous basin properties. This response is maximized under rare hydrometeorological conditions in which short, quazi-stationary, and intense rainstorms interact with catchments, resulting in extreme flash floods. These extreme flash floods provide a unique scenario in which hydrological behaviors that were concealed or not highlighted during less severe events are revealed. This study aims to gain a better understanding of different intra-basin processes and patterns during large stream flow events with a special focus on the extremes.

To achieve this, we developed a fully distributed hydrological model with high spatiotemporal resolution. The model was applied to five small to medium sized catchments (18-70 $km^2$) at the Ramot Menashe region in northern Israel (Mediterranean climate). High resolution (1 $km^2$, 5-min) rain fields measured by the Shacham meteorological radar were calibrated, corrected and used as inputs to the model. Detailed spatial DTM data and maps of landuse and soil were applied to obtain different model parameters. Infiltration, re-infiltration, evaporation, and surface routing were calculated at each model cell.

To account, quantify, and study the comprehensive hydrological basin response we identified runoff contributing areas, i.e. hillslope cells with surface runoff that reaches the stream network. The spatiotemporal evolution of these areas allows the study of the integrated effect of rainfall patterns with basin characteristics. In particular, it allows the identification of conditions in terms of basin characteristics and storm dynamics under which extreme flash floods are generated.

Results show that storm peak discharge is highly dependent on a combination of rain rate and contributing area, point to a strong connection between the landuse and the formation of contributing areas, and provide important insights regarding the occurrence of extreme flash floods.

## 3D structure of a complex of transform basins from gravity data, a case study from the central Dead Sea fault

**Rosenthal, M. (1,2), Schattner U. (2), Ben-Avraham Z. (1,2)**

1. Department of Geosciences, Tel Aviv University, Tel Aviv 69978, Israel
2. Dr. Mosses Straus Dept. of Marine Geosciences, Leon H. Charney School of marine sciences, Haifa University, Mt. Carmel, Haifa 31905, Israel

The Kinneret-Bet She'an (KBS) basin complex comprises the Sea of Galilee, Kinarot, and Bet She'an sub-basins. The complex developed at the intersection between two major tectonic boundaries: the Oligo-Miocene Azraq-Sirhan failed rift, that later developed into the southern Galilee basins and Carmel-Gilboa fault system; and the Dead Sea fault (DSF) plate boundary that developed since the Miocene. Despite numerous studies, KBS still remains one of the enigmatic basin complexes. Its structure, stratigraphy and development are vaguely understood – both inside the basin and in correlation with its surroundings. Our study presents a new and comprehensive 3D model for the structure of KBS complex. It is based on all available gravity measurements, adopted from the national gravity database, and new gravity measurements, collected in cooperation with the Geological Survey of Israel and funded by the Ministry of National Infrastructure, Energy and Water Resources. The gravity data were integrated with constraints from boreholes, surface geology, seismic surveys, potential field studies and teleseismic tomography. The dense distribution of gravity data [1] provides suitable coverage for modeling the deep structure in three dimensions. The model details the spatial distribution, depth, thickness and density of the following regional units within the KBS complex and across its surroundings: upper crust, pre-Senonian sediments, Senonian and Cenozoic sediments, Miocene volcanics, Pliocene and Quaternary volcanics. Additional local units include salt, gabbro and pyroclasts. Results indicate that the KBS complex comprises two sub-basins separated by a structural saddle: Kinneret-Kinarot (~6-7 km deep, ~45 km long) and Bet She'an (~4 km deep, ~10 km long) sub-basin. A 500 m thick layer of Miocene volcanics appears across the Bet She'an sub-basin, yet missing from the Kinneret-Kinarot sub-basin. Between the basins Zemah-1 borehole penetrated a salt unit. The model indicates that this unit is a part of a thick (1250 m) dome-shaped, perhaps diapiric, structure. A relatively thin (350 m) salt unit fills the Kinneret-Kinarot sub-basin. Above, a 700 m thick layer of Pliocene volcanics fills the entire KBS complex. These volcanics are uplifted in the Zemah area by ~200 m. The Pliocene volcanics dip northward from Zemah towards the center of the Sea of Galilee, and further north the Pliocene volcanics dip southward from Korazim towards the center of the Sea of Galilee. The depth differences exceed 3 km across a distance of ~15 km, forming a ~11° slope below the younger Quaternary fill of the basin. A low-density, probably pyroclastic, lens is calculated within the uppermost 2 km of the Sea of Galilee fill. Scenarios for the development of the basin are discussed.

[1] Rosenthal, M., Segev, A., Rybakov, M., Lyakhovsky, V. and Ben-Avraham, Z. (2015) The deep structure and density distribution of northern Israel and its surroundings. GSI Report No. GSI/12/2015, 33 pages, Jerusalem.

## Testing portable luminescence reader signals against late Pleistocene to modern OSL ages of coastal and desert dunefield sand in Israel

**Roskin, J. (1, 2, 3), Sivan, D. (1), Bookman, R. (2), Porat, N. (4), López, G.I. (5)**

1. Department of Maritime Civilizations, Charney School of Marine Studies and the Leon Recanati Institute for Maritime Studies (RIMS), University of Haifa, Israel
2. Department of Marine Geosciences, Charney School of Marine Studies, University of Haifa, Israel
3. School of Sciences, Achva Academic College, Israel
4. Geological Survey of Israel, Jerusalem, Israel
5. Luminescence Dating Laboratory, CENIEH, Burgos, Spain

Rapid assessment of luminescence signals of poly-mineral samples by a pulsed-photon portable OSL reader (PPSL) is useful for interpreting sedimentary sections during fieldwork, and can assist with targeted field sampling for later full OSL dating and prioritize laboratory work. This study investigates PPSL signal intensities in order to assess its usefulness in obtaining relative OSL ages from linear regressions created by interpolating newly generated PPSL values of samples with existing OSL ages from two extensive Nilotic-sourced dunefields.

Eighteen OSL-dated sand samples from two quartz-dominated sand systems in Israel were studied: (1) the Mediterranean littoral-sourced coastal dunefields that formed since the middle Holocene; and (2) the inland north-western Negev desert dunefield that rapidly formed between the Last Glacial Maximum and the Holocene. Samples from three coastal dune profiles were also measured.
Results show that the PPSL signals differ by several orders of magnitude between modern and late Pleistocene sediments. The coastal and desert sand have different OSL age - PPSL signal ratios. Coastal sand show better correlations between PPSL values and OSL ages. However, using regression curves for each dunefield to interpolate ages is less useful than expected as samples with different ages exhibit similar PPSL signals. The coastal dune profiles yielded low luminescence signal values depicting a modern profile chronology. This study demonstrates that a rapid assessment of the relative OSL ages across different and extensive dunefields is useful and may be achieved. However, the OSL ages obtained by linear regression are only a very rough age estimate. The reasons for not obtaining more reliable ages need to be better understood, as several variables can affect the PPSL signal such as mineral provenance, intrinsic grain properties, micro-dosimetry and moisture content.

## A Late Pleistocene linear dune dam record of aeolian-fluvial dynamics at the fringes of the northwestern Negev dunefield

**Roskin, J. (1,2,3), Bookman, R. (3), Friesem, D.E. (4), Porat, N. (5) Vardi, J. (6)**

1. Dept. of Maritime Civilizations, Charney School of Marine Studies and the Leon Recanati Institute for Maritime Studies (RIMS), University of Haifa, Mt. Carmel Haifa, 31905 Israel
2. School of Sciences, Achva Academic College, Israel
3. Dept. of Marine Geosciences, Charney School of Marine Studies, University of Haifa, Mt. Carmel Haifa, 31905 Israel
4. McDonald Institute for Archaeological Research, University of Cambridge Downing Street, CB2 3ER, Cambridge, UK
5. Geological Survey of Israel, 30 Malkhei Israel St., Jerusalem 95501, Israel
6. Prehistory Branch, Excavations, Surveys & Research Department, Israel Antiquities Authority, Jerusalem, Israel

A late Pleistocene aeolian-fluvial record within a rare vegetated linear dune-like structure at the fringe of the northwestern Negev dunefield provides direct evidence of dune-damming dynamics within the structure and its environs. Study methods included high resolution morphology and stratigraphy, micromorphology and sedimentological analyses. Chronology was based on OSL ages, six archaeological sites upon the structure and the INQUA Dune Atlas database.

Low-energy fine-grained fluvial deposits (LFFDs) underlying the structure and extending from its flanks indicate deposition in low energy hyper-concentrated flows upon floodplains and later in water bodies that formed by dune-damming. Interbedded sand with LFFDs within the linear structure indicates interchanging dominances between aeolian sand incursion and seasonal floods. Sand deposition during dune elongation led to structure growth and dune-damming of its mid-sized drainage system that in turn formed water bodies and upstream LFFD deposition following floods.

LFFD accumulation persisted by dune-dam maintenance of smaller sand mobilization events. Wet winters increased flood events boosting LFFD buildup rates as thus shortened dune-dam longevity. Extrapolation of sediment yields indicate that LFFD accretion up to the structure's brim could possibly have occurred over an accumulated timespan of decades. Geometric Kebaran (~17.5-12.9 cal. BP±1σ) to Harifian (12.9-11.2 cal. BP±1σ) artifacts within the structure's surface indicates intermittent, repetitive, and short-term camping utilizing adjacent water bodies over a time period of 4-5 kyr. The combination of the floodplain LFFDs and overlying and similar dune dammed LFFDs formed amplified LFFD exposures.

Fluctuating high wind power and precipitation combined with a time window of high availability of fine-grained fluvial sediment yield from eroded upstream highlands loess mantles supplied ample sediment for LFFD deposition. Dune incursion around 16 ka, combined to create a trio of aeolian-fluvial forcing factors supporting short-term dune-dammed depositional conditions that are restricted to the Terminal Pleistocene. The abundance and recurrence of dammed water bodies deteriorated when reduced wind power during the post-Younger Dryas constrained dune-dam maintenance. After water

body accommodation space dissipated due to LFFD accretion, overland flow led to dune-dam destruction and partial fluvial erosion of LFFD surfaces until today.

## Beach buildup and coastal aeolian sand incursions off the Nile littoral cell during the Holocene

**Roskin, J. (1,2,3), Sivan, D. (1), Shtienberg, G.(1), Porat, N. (4), Bookman, R. (2)**

1. Department of Maritime Civilizations, Charney School of Marine Studies and the Leon Recanati Institute for Maritime Studies (RIMS), University of Haifa, Mt. Carmel Haifa, 31905 Israel
2. Department of Marine GeoSciences, Charney School of Marine Studies, University of Haifa, Mt. Carmel Haifa, 31905 Israel
3. School of Sciences, Achva Academic College, Israel
4. Geologic Survey of Israel, 30 Malkhe Israel St., Jerusalem 95501, Israel

This study reviews the architecture and history of the Israeli coastal sand and dunefields during the Holocene aiming to: (a) Date the timings of beach accretion, and sand and dune incursions. (b) Discriminate between natural and human-induced forcing factors of sand mobilization and stabilization in time and space. (c) Present in detail and conceptually model the dunefield evolution. (d) Assess scenarios of sand transport in the future characterized by intense human impact and climate change.
Luminescence ages, radiocarbon dates and relative ages from previously published geological and archaeological reports, historical texts, together with new OSL ages (of ~100 samples) and stratigraphic/sedimentological data were used.
Dunefield sand sedimentology is similar from south to north. Sand sheet and dune sedimentology partly mimics its beach source and has not differentially influenced sand mobilization and stabilization. No distinct fining and heavy mineral assemblage trend has been identified.
The chronological database reveals time gaps and age clusters that are supported by the stratigraphic finds. The dunefields, initially induced by littoral sand build up following the decline in sea level rise at 6-4 ka, were later controlled by historic land-use intensity and modern land-use/negligence practices. At ~7-5 ka, beach sand buildup occured followed by inland transport of sand forming sand sheet and low dunes that partly pedogenized. Upon ridges near the coastline the sand was cemented by biogenic calcium carbonate. A gap in sand deposition exists for 4-2 ka. The water retention capacities of the sand sheets enabled the establishment of a sand-stabilizing vegetation cover that probably constrained further saltation. Eventually the cover became an attractive environment for fuel and grazing for the growing Hellenistic-Roman-Byzantine (~2.4-1.3 ka) coastal populations. This consumption and massive destruction of sand stabilizing vegetation, enabled sand erodibility and mobilization during winter storms. The sand gradually expanded to the current limits of today's dunefields. A gradual but unsteady post-Byzantine demographic drop occurred differentially along the coast due to governance and land-use practice is suggested to have led to sand stabilization.
Dune construction mainly evolved around the 19th century when the rapidly growing human presence destroyed vegetation, made the accumulated sand erodible. Increased storminess and large waves may have destroyed foredunes and are speculated to have

better enabled inland sand transport. New OSL ages support remote sensing studies that dunes began to stabilize ~50-60 years ago throughout the coast until today.

## Characterizing ocean floor abyssal hill morphology to infer seafloor spreading evolution

**Roth, S. (1), Granot, R. (1)**

1. Department of Geological and Environmental Sciences, Ben Gurion University of the Negev, Beer Sheva 84105, Israel

Abyssal hills (AHs), formed along mid-ocean ridges by normal faults and volcanic activity, can potentially provide constraints on past seafloor spreading rates, directions and the geometry of spreading ridges. However, the morphology of AHs still remains mostly unexplored. Previous studies have examined AH morphology and showed that the shape of AHs is related to spreading rate. However, these studies have simultaneously examined wide regions therefore averaged out temporal changes in the tectonic processes that shaped them. We have developed a new automated approach for studying the shape of AHs that allows detailed temporal investigation of the tectonic processes acting along the ridges. We verified our approach along the sediment-free Mid Atlantic Ridge, the South East Indian Ridge and the East Pacific Rise by examination of high-resolution multibeam data. Our preliminary results indicate that the shape of AHs could potentially be utilized to constrain the seafloor spreading evolution of regions devoid of magnetic anomalies and sediments (e.g., the North Pacific Cretaceous quiet zone).

## $^{87}Sr/^{86}Sr$ sources of late Miocene-early Pliocene water bodies in northern Israel

**Rozenbaum, A.G. (1, 2), Stein, M. (1,2), Starinsky, A., (2), Sandler, A. (1), Zilberman, E. (1)**

1. Geological Survey of Israel, 30 Malkhe Israel St., Jerusalem, 95501.
2. Institute of Earth Science, Hebrew University of Jerusalem, Givat Ram, Jerusalem, 91904.

During the late Miocene to the early Pliocene periods a thick sequence of sedimentary rocks accumulated in the Lower Galilee (LG) and the Jordan Valley (JV) basins in northern Israel. The sequence lies between the Lower Basalt/Hordos Fm. and the Cover Basalt and comprises: the Umm Sabune Fm., the Clay Series Unit, the Bira Fm., the Gesher Fm., the Fejjas Tuff and a unit of conglomerates paleosols and pyroclastic rocks. Here we focus on the Bira and Gesher Formations of Tortonian (~10 – 7 Ma) and Messinian-Zanclean (~7-5 Ma) ages, respectively. The Bira Fm. consists mainly of limestones, dolostones and marls in the LG and also of evaporites (gypsum and halite) in the JV. The Gesher Fm. comprises limestones, dolostones and marls in both the LG and JV basins. The depositional environments of these formations were lacustrine and palustrine, but the proximity of their western margins to the Mediterranean Sea enabled limited marine influence during sporadic ingressions.

$^{87}Sr/^{86}Sr$ ratios of soluble (carbonate-evaporite) and insoluble (non-carbonate) fractions of the Bira and Gesher carbonate samples were used to constrain the sources of both lakes' waters and fine-detritus and reconstruct the paleohydrological conditions in the watershed. The $^{87}Sr/^{86}Sr$ ratios of ~ 0.7075 of the soluble fraction of most Bira Fm. carbonates reflect the contribution of different types of continental water sources and minor contribution of marine waters. The higher $^{87}Sr/^{86}Sr$ ratio (~0.7085) in the upper part of the formation (~8-7 Ma) ratios reflects higher contribution of sea-water. The soluble fractions of the Gesher Fm. carbonates have higher $^{87}Sr/^{86}Sr$ ratios (up to 0.7085-0.7087) that cannot be attributed to seawater contribution since the Mediterranean Sea retreated to the west. These ratios are explained by contribution of Sr from waters draining mountain soils. The latter are evolved by pedogenesis of settled desert dust that was blown from the Sahara-desert.

The $^{87}Sr/^{86}Sr$ ratios of the insoluble fraction show an overall increase from basaltic values of ~ 0.704 at the lower part of the Bira Fm. to "granitic-crustal" values of ~ 0.711 at the upper part of the Bira Fm. and throughout Gesher Fm.. Between ~ 10 and 7 Ma most of the detritus was derived from local, mainly basaltic sources, while at ~7.5 -5.33 Ma, fine detritus was mobilized from the evolving Sahara-desert to the lakes watershed. The contribution of the Sahara dusts was enhanced during the Messinian Salinity Crisis (~5.97-5.33 Ma.).

## Makhteshim worldwide - different processes forming familiar morphologies

**Ryvkin, I. (1), Finzi, Y. (1)**

1. The Dead-Sea and Arava Science Center Tamar regional council, Dead-Sea mobile post 86910, Israel

The erosional crater (makhtesh) is a unique natural phenomenon in which a valley surrounded by cliffs forms at the crest of an anticline. The term makhtesh was introduced in the mid-20th century and was developed since then primarily based on the characteristics of the three largest erosional craters of the Negev desert in Israel. A review of 15 makhteshim from around the world shows that their diversity and richness of the characteristics extend far beyond those observed in the Negev. In particular, we present details of Sinbad Valley, Colorado, which was formed by dissolution of a salt diapir and collapse of the top layers of a salt-anticline. Following the collapse, erosion formed a gap in the surrounding cliffs and enabled drainage of the crater and transport of sediments from within it. The resulting morphology is very similar to that of the Negev makhteshim and therefore it serves as a key example of an alternative formation process and alternative lithology of a makhtesh. Our findings indicate that a makhtesh may form in various ways, in various structures and in a large range of environmental conditions. We therefore propose that the definition of the term 'makhtesh' should be revised and updated, and we propose the main improvements to the definition that if accepted will make it more relevant and comprehensive for describing all makhteshim.

## Kinetic isotope effects in the carbonate system

**Sade, Z. (1), Halevy, I. (1)**

1. Department of Earth and Planetary Sciences, Weizmann Institute of Science, Rehovot 7610001, Israel

Recent studies indicate the difficulty, and even infeasibility, of precipitating carbonate minerals in oxygen isotopic equilibrium under laboratory conditions [1]. Non-equilibrium compositions are also widely observed in natural carbonate minerals, such as speleothems, cryogenic cave calcite, travertines, lacustrine carbonates, carbonates precipitated from alkaline solutions, some marine calcareous species and microbially-mediated carbonates [e.g., 2-5]. Clearly, isotopic equilibrium is a specific and unique state among the multiple alternatives of non-equilibrium states.

The reactions of $CO_2$(aq) (de)hydration and (de)hydroxylation play a key role in all of the environments mentioned above. However, to date, the magnitudes of the kinetic isotopic fractionations during these reactions are highly uncertain. In addition, the literature is lacking the basic theoretical framework required for any quantitative treatment of these kinetic fractionations.

Here we bridge these fundamental gaps in theory, and revisit theoretical and experimental data, in order to better constrain the kinetic isotope effects during $CO_2$(aq) (de)hydration and (de)hydroxylation. This research advances the understanding of the complex carbonate system, and is an essential step towards environmental interpretations of non-equilibrium isotopic compositions in carbonate minerals.

[1] Watkins et al. (2013) EPSL 375, 349-360. [2] Hendy (1971) GCA 35, 801-824. [3] Wefer & Berger (1991) Mar Geol 100, 207-248. [4] Clark & Lauriol (1992) Chem Geol 102, 217-228. [5] Clark et al. (1992) GCA 56, 2041-2050.

## Novel (U-Th)/He geochronology of speleothems: cold-climate full retentivity across geologic timescales (104-107 yr)

**Sadeh, M. (1) Haviv, I. (1), Vaks, A. (2), Mason, A. (3), Bar-Matthews, M. (2), Frumkin, A. (4), Ayalon, A. (2)**

1. Department of Geology and Environmental Sciences, Ben Gurion University of the Negev, Israel
2. Geological Survey of Israel, Israel
3. Department of Earth Sciences, University of Oxford, England
4. Institute of Earth Sciences, The Hebrew University of Jerusalem, Israel

Radiogenic helium is the product of alpha decay in the U and Th series and could potentially accumulate to measurable quantities in many speleothems with common U content. However, it is well established that helium could be partially lost due to thermally-activated diffusion. In this study the retentivity of speleothem-derived carbonates to helium is quantified by comparing (U-Th)/He ages to U/Th and U-Pb ages and by step-heating diffusion experiments. Once helium diffusion kinetics in carbonates is well understood, the (U-Th)/He method can complement and improve our ability to constrain the age of speleothems and other carbonates.

Analyzed samples include speleothems layers from five caves with average annual temperatures which vary from 0C to >20C, stretching from Siberia at the north, to the northern margin of the Saharo-Arabian desert at the south. (U-Th)/He ages of samples collected from caves with annual temperatures of 0-7C range between 10-2200 ka and are statistically identical to independent U/Th and U-Pb ages. This implies that 100% of the helium is retained in speleothems at those temperatures. Ages of samples taken from caves with annual temperatures of 18-20°C range between 70-700 ka and are younger than U/Th and U-Pb ages, implying that 60-80% of the helium is lost at those temperatures.

Step-heating experiments conducted for calcite and aragonite samples yield similar activation energies of 27.2-31.7 kcal/mol, yet the diffusivity of helium in aragonite is about two orders of magnitude higher than in calcite. Calcite samples display multiple diffusion domain (MDD) behavior with differences of up to two orders of magnitude between the smallest and largest domains. Interestingly, aragonite samples seem to display a single diffusion domain behavior below 250-280°C.

This study provides the first consistent (U-Th)/He age determinations in carbonates, demonstrating its cold climate applicability. In addition, we are cautiously optimistic concerning the option to invert the fraction of helium lost in hotter climate to long-term, near surface paleo-temperatures.

## Folding evolution in the Levant basin; a new perspective on the Syrian Arc Fold Belt

**Sagy, Y.(1), Gvirtzman, Z. (2,4), Reshef, M. (3)**

1. The Geophysical Institute of Israel, P.O. Box 182, Lod 71100
2. Geological Survey of Israel, 30 Malkhei Israel, Jerusalem 95501
3. The Department of Geosciences, Tel Aviv University, Tel-Aviv 69978
4. The Institute of Earth Sciences, Hebrew University, Jerusalem 91904

A series of elongated folds developed since the Late Cretaceous throughout the Levant region extending from the Palmyra Mountains in Syria, through the mountain backbone of Israel, to the northern Sinai ridges, known as the Syrian Arc Fold Belt. Observation from onshore and shallow marine subsurface, which have partly experienced erosion or non-deposition, provided important but partial information regarding the origin, timing of activity and spatial evolution of the Syrian Arc. Trying to fill up missing information, we take advantage of the continuous stratigraphic record offshore in order to document folding evolution in time and space. Using >27,000 km of 2D seismic lines we interpreted axial plain of 72 folds. A detailed analysis of thickness variation across each fold was carried out, distinguishing between onlapping patterns, syn-tectonic depositional pattern, and post deposition truncation patterns. Altogether our study maps orientations, amplitudes and lengths of folds and determines the history of folding in the basin, distinguishing between episodes of activity and quiescence, and evaluates deformation rates.
Our results demonstrate that the Syrian Arc fold belt extend north-westward to more than 200 km offshore Israel, folding begun during the Late Cretaceous (Santonian) and continued for more than 80 m.y. till the Early Pliocene. The various folding episodes included reactivation of folds and generation of new ones. Interestingly, fold's axes orientation remained relatively constant (NE to NNE) for more than 80 m.y., regardless of the ~ 150 anticlockwise rotation of Africa with respect to Eurasia since the Late Cretaceous and the development of new active plate-boundaries along the Levant borders since the Oligocene. Larger scale observations suggest the Levant folds are a part of a wider compressional belt, extending from Morocco to Syria, along the northern margins of the African-Arabian plate. Based on this observation and on our detailed analysis, we suggest that folds orientation is primarily determined by the shape and preexisting deformation along the continental margin. That is, folding orientation over 80 m.y. of Late Cretaceous and Tertiary shortening was dictated by deformation that had shaped the African-Arabian margin in the Late Paleozoic and Early Mesozoic.

## Recommended policy of early warning principles for tsunami hazards in Israel

**Salamon, A. (1), Rosen, S. D. (2), Gitterman, Y. (3), Yahav, A. (4), Ben-Arieh, S. (5), Debutton, Y. (4), Dover, D. (6), Vatenmacher, M. (6), Miloh, T. (7)**

1. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501, Israel
2. Israel Oceanographic & Limnological Research Ltd., Tel-Shikmona, P.O.Box 8030, Haifa 31080, Israel
3. Seismology Department, Geophysical Institute of Israel, P.O.Box 182, Lod 71100, Israel
4. National Doctrine, Training and Exercises Division, National Emergency Management Authority (NEMA), Ministry of Defense, Israel
5. National Steering Committee for Earthquake Preparedness, Israel
6. Engineering and Protection Branch, The Home Front Command, Israel
7. Faculty of Engineering, Tel-Aviv University, Tel-Aviv 69978, Israel

The policy on of early warning principles for tsunami hazard in Israel was formulated by a scientific committee in light of the Governmental decision No. 4738, in order to construct a framework for a tsunami early warning system ("Mayim Adirim") along the Mediterranean coast of Israel. The committee included members from governmental research institutes, academia, the National Emergency Management Authority of the Ministry of Defense (NEMA, MOD) and the Home Front Command (HFC). The committee focused on evaluating the tsunami hazard to Israel from distant earthquakes (near offshore landslide tsunamis will be dealt elsewhere), the probability of occurrence and the potential damage, and consequently recommended on the required policy, warning principles and frame of preparedness.

The resulting report provides specific guidelines and detailed suggestions for the policy makers for the establishment of efficient 'end-to-end' Tsunami Early Warning procedures in order to improve public awareness and preparedness. The main suggestion was to form two new centers, one 'scientific' ("Nachshol Nitzpeh") and the other 'operational' ("Migdalor") that are responsible for monitoring and handling real tsunami events, both functioning 24/7. The scientific center (consisting of seismologists, oceanographers and geologists), is based on real-time scientific data obtained from 'in-state' monitoring systems as well as on 'out-of-state' early warning messages received from the Tsunami Service Providers (TSP) that operate within the framework of the Intergovernmental Coordination Group of the North-Eastern Atlantic, the Mediterranean and Connected Seas (ICG/NEAMTWS).

The 'scientific' center will inform the 'operational' center in real time as to the probability of tsunami occurrence and issue the proper alert messages. The 'operational' center (consisting of civil protection representatives) will in turn decide whether or not to issue a tsunami warning messages to the proper authorities and the public. It is of utmost importance to decide on a common language and terminology of the exchanged messages between the two centers and the international Tsunami Service Providers. The 'scientific' center should be implemented immediately at the Seismology Department of the Geophysical Institute of Israel, and so is the 'operational' center under the responsibility of the National Emergency Management Authority (NEMA, MOD).

The report suggests ways of how to increase public awareness to the possible risk of tsunamis and at the same time also promote their safe behavior through education and training.

## Non-steady evolution of longitudinal profiles of gravel-bed channels in response to changes in flood regieme and base level lowering

**Salomon, R. (1), Morin, E. (1), Enzel, Y. (1), Haviv I. (2)**

1. Institute of Earth Sciences, The Hebrew University, Jerusalem 91904, Israel
2. Department of Geological and Environmental Science, Ben Gurion University of the Negev, Beer Sheva 84105, Israel

Longitudinal profiles of alluvial channels may be altered rapidly in response to base level lowering or changes in flow regime. Previous models simulating the response to such changes assumed steady and uniform discharge, or used a calibrated diffusion coefficient as a proxy for discharge. Such models do not account for event-specific morphological changes and the intra and inter annual variance of flash flood volume and peak discharge, which is typically high in channels of dry environments. We adopt a different approach: (a) A new model for gravel-bed channels combining kinematic wave flood routing with sediment transport based on the Meyer-Peter-Muller equation. This model predicts changes in channel longitudinal profile in response to changing flow regimes and base-level lowering rates; (b) A stochastic approach which produces a synthetic data series of floods based on the probability distribution of peak discharge and hydrograph properties in a specific basin. The properties of this "flood generator" can be altered to stimulate flood characteristics (hydrograph shape, flood frequency, magnitude) and thus mimic potential climate variability or climate change. The model was applied to the lower reach of Nahal Darga gravel-bed channel, which drains into the Dead Sea lake. During the last 40 years, the initial uniform gradient (linear) profile of this reach has become convex due to a drastic drop of the Dead Sea base level at a rate of 1 m/y. Initially, a set of measured time-dependent channel profiles were used for the model evaluation and subsequently the effect of different theoretical scenarios of lake level drop and flash flood regime has been examined. The model delineates a wide range of potential channel profiles strictly due to the natural flow variance under a given flow regime and emphasizes the key role of stochasticity in channel morphology. Although extreme floods can have a prominent influence on channel evolution, the most effective discharge at the Darga channel consisted of floods with medium peak discharge and a more frequent occurrence (recurrence interval of ~10 years). Similar novel approaches, which combine flood generators and process-based modeling, could help decipher morphological signature of past and future climate scenarios.

## Reddening (rubification) processes in Mediterranean soils: relations between iron minerals and clay minerals

**Sandler, A. (1), Goldman, N. (2)**

1. Geological Survey of Israel, Jerusalem
2. The Open University, Ra'anana

Reddening is one of the characteristics typical of Mediterranean soils. The ultimate red soil types are Terra Rossa, developed on hard carbonates, and Hamra, on sand or sandstone. Goethite (α-FeOOH) and hematite (α-$Fe_2O_3$) are the most abundant minerals in well-drained soils, along with short-range-ordered crystalline minerals (ferrihydrite and ferroxite) or non-crystalline phases. In soils with dry water regime incipient ferrihydrite transforms into hematite, whereas in wetter regimes it transforms into goethite. Higher hematite content causes deeper red color of soils.

The aims of the current study are: 1. to identify the sources of iron to soil minerals: heavy versus clay minerals; 2. to define the types of iron minerals and their distribution in soil microenvironments with evolving reddening. The methods used were chemical analysis, XRD and HRTEM+SAED, and the soils analysed were mainly Terra Rossa and Hamra, along with sand and dust.

In a section of four sites, samples from beach sand to mature brown Hamra (Ashdod vicinity) and two dust samples, exhibited a similar occurrence of iron in the fine fraction: crystals of < 0.05 μm size, embedded in "clouds" of clay minerals. The point chemical analysis indicated iron with nil to variable amounts of titanium that were identified by SAED as goethite and hematite. Some crystals enriched by titanium were identified as anatase, rutile and ilmenite. Abundant opaque minerals in the fine sand and coarse silt fractions were also made of iron with variable titanium contents. HRTEM observations showed microcrystals pf hematite precipitating on their surfaces. Yet, the bulk chemical and mineralogical analyses indicated that the mass of iron and titanium minerals is ~3 fold lower than feldspars in sand. In the mature Hamra iron and titanium are enriched five folds more than in the sand and more than aluminium. This indicates that the dark heavy minerals in sands contribute only a small fraction of the soil iron and titanium minerals whereas the continuously accumulating dust is the main source. Well-leached reddish Hamra and Terra Rossa soils from central and northern Israel, respectively, have the same microenvironments of tiny crystals embedded in clay, despite a dramatic change in their clay minerals' composition. This could indicate that the iron-titanium crystals are detrital dust particles that are continuously added and accumulated in soils with no involvement in the transformation of clays. However, the occurrence of ferrihydrite crystals in the well-leached reddish soils, along with a decrease in Ti/Fe ratio suggests dissolution and precipitation of iron minerals, at least in part. Further study will attempt at better identification and quantification of this process.

## Miniposters for improving dissemination of scientific knowledge in the field – an evaluation of effectivity for teaching about flash-floods

**Sapir, K.(1), Ginat, H.(1), Yarkoni, M.(2), and Finzi, Y.(1)**

1. Dead Sea and Arava Science Center, Israel.
2. Ma'ale Shaharut High School, Yotvata, Israel

Miniposters are part of a venture to disseminate professional-scientific knowledge on natural phenomena, archaeology, and geological processes that sculpt the landscape or are touristic hotspots. Most miniposters are graphically designed so that the front is suitable to present to a group, and the back side includes supplementary explanations to benefit the guide/teacher. The Miniposter Project, which also includes workshops for guides and an explanatory booklet, intends to support and enhance scientific dissemination by tour guides and teachers by providing access to professional, aesthetic and clear information.
The Miniposter Project in Arava, Eilat and Timna was led by Keren Sapir of the Dead Sea and Arava Science Center in conjunction with guides from the Society for the Protection of Nature, Nature and Parks Authority, El Artzi, and the Eilat Field School. The graphic design was done in collaboration with Studio Yotvata and was inspired by the drawings of guides, articles, Ben Shalmon's book "Nature of the Desert" etc.
Twelfth grader Matan Yarkoni from Ma'ale Shaharut High School is completing his final project, which examines the level of effectiveness of using miniposters for field trips and for explaining flash-floods. During his research, he developed a series of miniposters showing the different stages of the formation of flash-floods, and pictures of flowing rivers in the Arava. These illustrate the phenomenon and enable travelers to understand flash-flood mechanisms and views any time of the year. These miniposters were used for several tours, and feedback was collected from the tour-guides/teachers as well as from the tourists/students. Feedback questionnaires and interviews with travelers and travel guides have shown that the miniposters are indeed effective and user-friendly, simplify complex issues and make it easier to explain natural phenomena in the field. However, there have also been concerns about overuse and misuse of miniposters. These shortcomings can be minimized or prevented by offering courses and describing teaching methods for guides that use miniposters. Our conclusion is that the miniposters are efficient and effective teaching aids as long as they are used correctly. This assertion in specifically true for explaining flash-floods in the Negev.

## Spatial and temporal variations in anoxic conditions in the Red Sea from redox-sensitive elements and organic carbon abundances in deep-sea sediments during the last 150,000 years

**Sava, O. (1), Torfstein, A. (1,2), Almogi-Labin, A. (3)**

1. Institute of Earth Sciences, Hebrew University of Jerusalem. Jerusalem, Israel
2. The Interuniversity Institute for Marine Sciences, Eilat. Israel
3. Geological Survey of Israel, 30 Malkhe Israel st. Jerusalem, Israel

The Red Sea is a deep and elongated water body that is connected to the oceans across the narrow and shallow Bab-el-Mandeb (BeM) sill. Due to the limited connection to the ocean and its location within the Saharo-Arabian desert belt, the Red Sea water composition and physical configuration is strongly modulated by the water exchange across the BeM, it self controlled by global sea level changes. Regional precipitation in the Red Sea watershed is extremely scarce and can originate from the tropical rain belt or potentially from southward penetration of East Mediterranean systems. The combined effect of the above controls the mixing or stratification of the Red Sea water column, which in turn is associated with the development of anoxic conditions.

Here, we explore the spatial and temporal development of anoxic conditions in the Red Sea and the Gulf of Aden, and evaluate it in the context of the accumulation and composition of organic matter in the sediments. We report new records of redox-sensitive element abundances, total organic carbon (TOC) and organic $\delta^{13}C$ in three marine cores located in the north and south Red Sea (KL23 and KL11, respectively), and the Gulf of Aden (KL15). We find a major event of organic matter accumulation in the Red Sea during the last deglacial (≥3%), which is coupled with peaks in the abundances of various redox-sensitive elements and micronutrients (Mn, Fe, Co, Ba, V, Cd, Ni, Cu, Cr, Mo, U). This event is limited to the Red Sea and is not observed in the open waters of the Gulf of Aden, marking the sharp deglacial sealevel rise and influx of fresh seawater through the BeM straits, which triggered density stratification in the Red Sea and development of anoxia in the bottom waters. Similar, albeit smaller, peaks of some inorganic elements, were identified ca. 4 ka and 100 ka. These events cannot be attributed directly to a sealevel – driven change in water circulation, but rather, reflect diagenetic redistribution processes in the sediments.

## Verifying the efficacy of national earthquake education programs in the southern Israeli periphery

**Schmidt, J.(1) Ginat, H. (1), Morris, A.(1), Finzi, Y.(1) Ish Shalom, C.(1) Alon, P.(1) Rifkin, I.(1)**

1. Dead Sea and Arava Science Center. Tamar regional council, Dead-Sea Mobile Post, 86910, Israel

A recent research project conducted by anthropologists, geologists and educators from the Dead Sea and Arava Science Center measured the efficacy of earthquake education classes taught within the context of a "multi-age" national emergency preparation program jointly operated by the Israeli Homefront Command and the Israeli Ministry of Education. The national program aims to educate students on the risks of earthquakes and offer ways for them to appropriately prepare for and behave during and after a major seismic event. The program intends that the students act as 'agents of preparation' and relay the knowledge they gain to their familial-community settings.

Conducted between 2013-2016 at elementary and junior high-schools throughout the Israeli southern periphery (the Dead Sea and Arava, Mitzpe Ramon and Eilat), the study combined qualitative (ethnographic interviews and participant observation at the schools) and quantitative (serial questionnaires) research methodologies. The study focused on the lessons taught to 5th graders and verified what the students retained from the lessons and to what degree the information they received reached their families.

The researchers also coordinated with supervisors in the Ministry of Education to devise a series of supplementary earthquake education lessons to fit within the 8th grade Earth Science/Geography curriculum. The team similarly monitored the lessons taught to the 8th graders by fusing ethnographic fieldwork techniques with a quantitative assessment of data retention rates among students. Overall, twenty-two classrooms of 5th and 8th graders were observed and more than 2000 questionnaires collected.

The presentation mentions a number of obstacles encountered in the field and surveys the major findings. It then presents the conclusions and offers suggestions for updating and improving both the operational and pedagogical segments of the earthquake education unit in the national program.

The presentation concludes with a brief preview of an evolving interrelated study intent on advancing organizational resilience to earthquakes within the Israeli tourism industry in general and its hospitality sector in particular. The study is being conducted by an interdisciplinary research team from the Dead Sea and Arava Science Center, Ben-Gurion University and the private sector and is already underway in Eilat and the Dead Sea. The team aims to apply current theoretical knowledge and ethnographic field experience to consider a large – and largely unaccounted for – demographic that remains on the sidelines of nationwide earthquake mitigation efforts. Addressing a number of systematic shortcomings, the researchers are exploring potential avenues for motivating the hospitality industry to reduce the impact of a catastrophic earthquake by preparing itself to conduct an effective recovery.

## Global C-cycle perturbations, climate change and local dysoxic developments in Cyanobacteria sea; Mid-Triassic marginal marine, multi isotope systematics

**Schneider-Mor, A. (1), Zilberman, T. (1), Korngreen, D. (1)**

1. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501

In poor nitrate marine environment, productivity is supported by fixation and shuttling of N from the atmosphere by cyanobacteria1. Although many dominant stromatolite horizons are well known from the upper- Middle to the Late Triassic outcrops in Israel, the early-Middle Triassic Ra'af Fm. is considered mainly as borrowed succession with some poor variety skeletal transported horizons, but stromatolites were not identified. In the worldwide, the early -Middle Triassic period (Anisian, Pelsonian), was characterized by a distinctive recovery of the carbonate factory after the P–T crisis. However, this global recovery seems to skip the regional Pelsonian Ra'af Fm.in Israel. The four studied sites (Ramon1, Hamieshar 1, Nafha 1 and David 1) were located in small proximal basins in Gondwana north margins facing the tropical Tethys. Our research is a multi-proxies study, including carbonate /siliciclastic ratio, carbon (inorganic and organic) and oxygen isotopes combined with nitrogen isotopic composition, total organic matter content (TOC) and C/N ratio, to shed light on the regional geochemical conditions in a mixed siliciclastic/carbonate sedimentary system. This work shows that the studied interval was interspersed by five global C-cycle perturbation events recognized in all sites (regional and global correlation proxy). The oxygen isotope excursions reveal oscillation between warming and cooling periods. The nitrogen isotopes values range between 2‰ and 0‰ in all study sites, indicating the attendance of cyanobacteria. The nitrogen isotope profiles are punctuated by negative shifts of -2‰ to -4‰, that could result from N fixation under low oxygen levels 2 or very low N availability 3 in sea water. The C/N ratios and the TOC trends are coupled, suggesting events with high terrestrial OM influxes. Dysoxic events are tied to the terrestrial OM influxes, but also with climate change (warming/cooling). The flourishing of cyanobacteria, indicating poor nitrate environment, could suggest oligotrophic conditions or high productivity that consumed the nitrates. These raise questions about the character of the original productivity during the early- Middle Triassic and which diagenetic processes the OM went through.

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2 Kidder, D. L. & Worsley, T. R. Phanerozoic large igneous provinces (LIPs), HEATT (haline euxinic acidic thermal transgression) episodes, and mass extinctions. Palaeogeography, Palaeoclimatology, Palaeoecology 295, 162-191 (2010).

3 Grasby, S. E., Beauchamp, B. & Knies, J. Early Triassic productivity crises delayed recovery from world's worst mass extinction. Geology 44, 779-782 (2016).

## The formation of lacustrine dolomites: an example from the Tortonian-Messinian sequence at the East Mediterranean margins (northern Israel)

**Shaked Gelband, D. (1,2), Starinsky, A. (1), Stein, M. (1,2)**

1. Institute of Earth Science, The Hebrew University of Jerusalem, Givat Ram campus 91904
2. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501

Lacustrine water bodies that filled the tectonic depressions in the Lower Galilee area of Israel during the Tortonian-Messinian periods deposited Bira and Gesher formations, which comprise marly limestones and dolomites, basalts, and varying amounts of mollusc fossils. Most fossils are gastropods of fresh to brackish water origin, while marine representation is minor and comprise monospecific assemblages of euryhaline bivalves. During the deposition of the Tortonian Bira formation the lakes were mostly influenced by meteoric waters while during the deposition of the Messinian Gesher formation they became more swampy. Here, we set to establish the deposition conditions of the dolomites in the lacustrine formations. The following petrographic characteristics indicate dolomitization of precursor carbonate sediment during early diagenesis stage: (1) Dolomitized fossils with similar texture as the surrounding dolomite matrix; (2) Common euhedral inner zone crystals, representing original growth in solution or plastic environment; (3) Subhedral outer shape derived from neighboring crystals collisions. More information is given by the $\delta^{18}O$ and δ+C values of the dolomites. The $\delta^{18}O$ of the inter-layered limestones and dolomites fluctuates between -3‰ to -4‰ (VPDB) in the limestones and +5‰ to -1.5‰ (VPDB) in the adjacent dolomites. These fluctuations are prominent in the Bira formation and become smaller along the sequence with the decrease in the dolomite values. δ13C values of both limestones and dolomites gradually decrease along the stratigraphic section, from -3.5‰ to -10‰ (VPDB) in the limestones, and from 0‰ to -8‰ (VPDB) in the dolomites. The data suggest a dolomitization process controlled by the following events: 1. Evaporation of fresh lake waters originated from the surrounding environment as runoff. It should be emphasized that significant evaporation could take place only in terminal lakes, during periods of relatively dry climate with low precipitations. 2. Calcite minerals precipitated due to evaporation, forming carbonate sediment at the bottom of the lake. 3. Precipitation of calcite raised the Mg/Ca ratio in the lake's waters. 4. High Mg/Ca ratio initiated dolomitization. The process terminated when replacement of the original carbonate sediments was complete. Thus, dolomites of the studied sequence are climate indicators. The alternate appearance of limestones and dolomites indicates climate changes through time. An additional dolomitization mechanism is suggested for the upper part of the sequence. This part is synchronous to the Messinian Salinity Crisis (MSC), in which evaporate sediments were deposited in the Mediterranean basin as a result of the sea desiccation. As mentioned above, there is a decrease of $\delta^{13}C$ in both dolomites and limestones, explained by organic activity in a swampy environment (Bacterial Sulfate Reduction (BSR): $2CH_2O + SO_4 \rightarrow 2HCO_3^- + H_2S$). During BSR, biogenic $HCO^{3-}$ ions are supplied and SO42- ions, which considered as inhibitores for dolomite growth, are consumes, enabling dolomite precipitatation.

## MESSILLA - Earthquake Early Warning System for Israel Railways

**Shapira, A.(1)**

1. University of Haifa Dept. for Geography and Environmental studies and Institute for Regulation of Emergency and Disaster College of Law and Business, Ramat Gan

"Messsilla" is a code name of an early warning system, designed and constructed by the RESHEF company to serve the Israel Railways . The main objective of Messilla is to alert the Israel Railways that strong ground motions, generated by an earthquake were detected in Israel. Consequently, manned and automated instructions will be issued to slow or stop the running trains and evacuate passengers from the terminals. The Messilla system is based on 120 recording sites equipped with EQI accelerometers. About a third of the accelerometers are installed in the railway terminals and the rest are installed along the Dead Sea fault and the Yagur fault. The accelerometers along these active faults are 10 km apart from each other. IP-VPN physical communication lines connect the accelerometer to a hup in the operation room of Israel Railways. The communication reliability is aimed to be of the level of 98% of the time for each communication line / recording site. Messilla is designed to issue an alarm within 4 sec from the time that the first accelerometer has detected a pre-defined acceleration level. Currently, there are 8 specified threshold levels: 0.01g, 0.025g, 0.05g, 0.075g, 0.1g, 0.2g, 0.5g and 1g.

Through the testing period (2017), an alarm is issued when at least two accelerometers, located within 30 km from each other, will detect ground motions of either 0.075g, 0.2g or 0.5g, within a time window of 10 sec, corresponding to a moderate, strong and very strong event , respectively. When a moderate event is detected, all train within 200 km from the first accelerometer that detected the event, are instructed to slow down. When a strong event is detected, all trains within 50 km from the first accelerometer to detect the event, are instructed to stop. If the event is very strong, all trains within 150 km are instructed to stop. In any event when an earthquake is detected by Messilla, the train stations are alerted and if the local accelerometer detects an acceleration level of 0.025g or more, all passengers in the terminal are instructed to move to open space. These instructions are also given to passengers in all trains stations in cases of detecting a strong or very strong event.

The acceleration levels that define the alarming criteria are based partially on the limited acceleration data recorded in Israel.

## Updated analysis of seismogenic zones in Israel and adjacent areas: Main approach and preliminary results

**Sharon, M. (1, 2), Kurzon, I. (1), Sagy, A. (1), Marco, S. (2), Ben-Avraham, Z. (2), Rosensaft, M. (1)**

1. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem 95501, Israel
2. Department of Geophysics, Tel-Aviv University, Tel-Aviv 69978, Israel

The identification and characterization of seismogenic zones are significant for seismic hazard estimation. Since the last zonation in Israel, more seismic data has been recorded and the resolution of fault mapping has improved. Therefore, in order to reassess the seismic hazard in the region, an updated analysis of seismic zones is required. Most of the seismic hazard in the region is considered to be due to earthquake activity along the Dead Sea transform fault system, which is the most dominant tectonic feature in the region. In this study, we use seismic data that contains earthquakes recorded by the Geophysical Institute of Israel during the period of 1985-2015, and were recently relocated. Based on that data, we calculate the density of earthquakes, the density of the seismic moment, and the a and b parameters of the frequency-magnitude relation, in a rectangular area between the latitudes 28N-34N and the longitudes 33E-37E. We present our preliminary results, that on the one hand we consider as premature for identifying and characterizing seismic zones, but on the other hand, depict a method and a path of how to capture the main active tectonic features and translate them to seismic zones. We plan to further process the data, considering additional seismicity characteristics, and geological data as well. The implementation of this proposed method should be for seismic hazard estimation.

## Sediment budget along cliff dominated coasts in the eastern Mediterranean during single storm to seasonal time scales

**Shemesh, R. (1,2), Crouvi, O.(1), Mushkin, A. (1), Katz, O. (1), Enzel, Y. (2), Lensky, N. (2)**

1. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem 95501, Israel
2. Institute of Earth Sciences, The Hebrew University, Jerusalem 91904, Israel

Understanding the evolution of rocky coasts remains a fundamental knowledge gap in coastal research. In this context, the contribution of sea-cliff sediments to the coastal sediment budget and to the evolution of rocky coasts is rarely quantified. Here, we quantified the volumetric changes that occurred during 3 years (2013-2016) along a 190 m section of a rocky coast along Israel's Mediterranean coastline. We used high resolution (~1 cm) ground based LiDAR to scan both the beach and the sea-cliff at weekly to seasonal time intervals. Our measurements show the expected seasonal pattern of beach evolution: erosion during fall and winter and accumulation during spring and summer. We found that the beach can temporary accumulate large volume of sediments during a single winter storm, but this does not change the overall erosional regime during the winter. The sea cliff and taluses erode all year round. The flux of sediments eroded from these features depends on both the talus properties and storms frequency and characteristics. These sediments accumulate on the beach during spring-summer and can explain up to 60% of the total sediments accumulated on the beach during these seasons. On the other hand, during fall-winter the erosional products of the cliff and taluses do not accumulate on the beach. Our findings suggest that the collapse and erosion of sea cliffs have an important role in the evolution of rocky coasts and significant implications to mitigation efforts of sea cliff retreat.

## Obtaining the elastic constants of a transversely isotropic rock from a single triaxial test

**Shitrit, O. (1), Hatzor, Y.H.(1), Feinstein, S.(1), Palchik, V.(1), and Vinegar, H.J.(1,2)**

1. Department of Geological Environmental Sciences, Ben-Gurion University of the Negev, Beer-Sheva 84105, Israel
2. Israel Energy Initiatives Ltd., 5 Shlomo HaLevi Street, Jerusalem 91450, Israel

Transversely isotropic rocks such as shales and chalks are typically tested using two specimens: vertically-oriented (sample axis is normal to the bedding direction) and horizontally-oriented (sample axis is parallel to the bedding direction). In many cases test results are available only for vertically-oriented samples (e.g. cores from a vertical well, limited rock material, mistaken approach while assuming isotropy). We present here a new method for analyzing results from a single triaxial test of a vertically-oriented sample. Using this method, we derive the vertical Young's modulus, vertical Poisson's ratio, bulk modulus, two of the five elastic stiffness constants C13 and C33, and obtain good constraints on C11, C12 and C66. The method considers the stresses applied during the hydrostatic stage and triaxial stage of the triaxial compression experiment, and introduces them into the generalized Hooke's law of elastic stress-strain relationships. The relationships are then modified to allow for a theory-based graphical interpretation of the test results. A new parameter is defined here for the first time: the ratio between horizontal and vertical strains during the hydrostatic compression stage, designated by $\chi$. The $\chi$ parameter should equal one when the rock is isotropic, and decrease towards zero with increasing degree of anisotropy. It can be evaluated also from acoustic velocity measurements using the relationships established here. The analytical methodology is applied here on existing triaxial test results of air-dried, organic-rich chalk core samples from the Zoharim and Aderet wells in the Shefela basin. We observe a strong dependence of all elastic stiffness constants on porosity and kerogen content. The $\chi$ values indicate stronger anisotropy with increasing porosity and kerogen contents. Vertical Poisson's tends to increase with increasing $\chi$ values (i.e. smaller anisotropy). Comparisons of the static bulk modulus with the corresponding dynamic values show good correlation and the dynamic/static bulk modulus ratio of ~2.65-3.5.

## Anthropogenic overprints on natural coastal aeolian sediments, a case study from the periphery of ancient Caesarea, Israel

**Shtienberg, G. (1), Dix, J.K. (2), Shahack-Gross, R. (1,3), Yasur-Landau, A. (1,3), Roskin, J. (3,4,5), Bookman, R. (5), Waldmann, N. (5), Shalev, S. (1,6), Sivan, D. (1,3)**

1. Department of Maritime Civilizations, L.H. Charney School of Marine Sciences, University of Haifa, Haifa 3498838, Israel
2. The School of Ocean and Earth, University of Southampton, Southampton SO14 3ZH, UK
3. The Recanati Institute for Maritime Studies (RIMS), University of Haifa, Haifa 3498838, Israel
4. The School of Sciences, Achva Academic College, Israel
5. Dr. Moses Strauss Department of Marine Geosciences, L.H. Charney School of Marine Sciences University of Haifa, Haifa 3498838, Israel
6. Department of Archaeology, University of Haifa, Haifa 3498838, Israel

Since the rise to dominance of humans, mainly following the agricultural revolution, the earth's soils and sediments have been affected by anthropogenic activities. A complex history of human impact on the environment can potentially be revealed in sediments and soils that are currently buried. In the current study the effect of human settlement on their proximate environment is explored, outside the settlement of ancient Caesarea, a well-known Roman to Early Islam period urban centre in the central coastal plain of Israel. This investigation is conducted by analysis of human induced macroscopic artefacts as well as microscopic remains found in buried sediments. These anthropogenic markers are retrieved through boreholes and assessed by sedimentological analyses coupled with radiometric dating techniques, microarchaeology and integrated with archaeological and historical records. Two units were identified in the study area south of ancient Caesarea based on their petro-sedimentological properties. The lowermost unit is a red-brown silty clayey sand loams locally know and hamra, while the uppermost covering unit is inferred as loose sand. The sand unit, reaching thicknesses of up to 9 metres, is chronologically constrained between 6 ka and the present consisting of four facies. Out of these four facies the uppermost and lowermost lithologies were interpreted as natural beach and aeolian deposits that are interbedded with two grey coloured, artefact-containing, anthropogenic sand facies. One anthropogenic facies represents an urban garbage mound and the other is an agricultural pedo-sediment, both dated to the Roman- Early Islamic periods. The pedo-sediment appears to be improved, in terms of soil fertility, and we therefore propose that it is the outcome of manuring enrichment for agricultural purposes. Taking advantage of the high coastal freshwater aquifer in the study area that facilitates capillary rise, we propose that this pedo-sediment represents buried agricultural plots. The drilling and excavations conducted in the hinterland of Caesarea along with the holistic approach presented in the current study could be of relevance to other archaeological sites around the Mediterranean. Moreover, this study shows potential to further the knowledge and understanding regarding human societies, their connection to and impact on the environment.

## Tufa deposits sheltered by Inland notches as indicators of Quaternary denudation rates

**Shtober-Zisu, N. (1), Vaks, A. (2), Amasha, H. (3), Frumkin, A. (4)**

1. Department of Israel Studies, University of Haifa, Haifa
2. Geological Survey of Israel, Jerusalem
3. Department of Geography and Environmental Studies, University of Haifa, Haifa.
4. Institute of Earth Sciences, Hebrew University, Jerusalem.

Denudation is the long-term sum of processes that cause the wearing away of the Earth's surface, engaging weathering and erosion. As denudation of carbonate terrains involves mainly karstic dissolution, Israel is a natural laboratory for the study of denudation rates because of its carbonate terrain and steep precipitation gradient, ranging from >1000 mm in the north to less than 100 mm in the south.

Several studies on denudation rates in Israel provide contradictory evidences. Ryb et al [1] found that denudation rates in the Mediterranean climate zone are 21±7 mm per ky, whereas Bar et al [2] showed much lower rates on the long-term scale (Oligocene-present). In this study we determined minimal ages of formation of Inland notches [3] using U-Th dating of tufa deposits developed under the notches' visors or covering notches' cavity beds. The ages of tufa were used to determine the relative slope denudation rates on Mt. Carmel (Israel) that receives annual precipitation rates of 700 mm.

Inland notches are elongated concave-shape indentations that develop on the carbonate rocky cliffs of mountainous zones. These unique features formed as a result of the interaction between specific lithological and weathering factors, emphasizing the importance of climate upon denudation. Inland notches form because the most porous cavity bed retreats at a faster rate compared to the slower subaerial dissolution of the visor bed, until a critical point is reached where the visor collapses. Notches are most common in semi-arid and in Mediterranean climates, mainly in areas with annual rainfall of between 400 mm and 850 mm. Occasionally, tufa stalactites and stalagmites grow within the cavity of the notch.

The Carmel tufa deposits that grew under the notches visors and on the cavity back-wall were dated by U-Th at the Geological Survey of Israel using ion exchange column chemistry and MC-ICP-MS techniques modified after Vaks et al [4]. In each notch the oldest tufa layer was dated giving the minimum age of the surface formation. Six layers from four tufa samples were dated giving ages spanning from 13,636 ± 834 ky to 37,562 ± 2,397 ky, implying that the minimal age of these notches is last glacial period, or last deglaciation.

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2. Bar, O., et al., The uplift history of the Arabian Plateau as inferred from geomorphologic analysis of its northwestern edge. Tectonophysics, 2016. 671: 9-23.
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Geomorphology, 2015. 229: 85-99.
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## The role of major forest fires on rock disintegration in a Mediterranean environment

**Shtober-Zisu, N.(1), Tessler, N.(2), Tsatskin, A. (3), Greenbaum, N. (4)**

1. Department of Israel Studies, University of Haifa, Haifa, Israel.
2. Department of Biology and Environment, University of Haifa, Haifa, Israel.
3. Department of Archaeology, University of Haifa, Haifa, Israel.
4. Department of Geography & Environmental Studies, University of Haifa, Haifa, Israel.

Massive destruction of carbonate rocks occurred on the slopes of Mt. Carmel (Israel), during a severe forest fire in 2010 (Fig. 1). The bedrock surfaces exhibited extensive exfoliation into flakes and spalls covering up to 80%–100% of the exposed rocks; detached boulders were totally fractured or disintegrated. The fire affected six carbonate units—various types of chalk, limestone, and dolomite. The burned flakes show a consistent tendency towards flatness, in all lithologies, as 85%–95% of the flakes were detached in the form of blades, plates, and slabs.

The extent of the physical disruption depends on rock composition: the most severe response was found in the chalk formations which are covered by calcrete (Nari crusts). These rocks reacted by extreme exfoliation, at an average depth of 7.7 to 9.6 cm and a maximum depth of 20 cm. Scorched and blackened faces under the upper layer of spalls provide strong evidence that chalk breakdown took place at an early stage of the fire.

The extreme response of the chalks can be explained by the laminar structure of the Nari, which served as planes of weakness for the rock destruction. Three years after the fire, the rocks continue to exfoliate and break down internally. As the harder surface of the Nari was removed, the more brittle underlying chalk is exposed to erosion. These flakes seem to play an important role in reforming the soil after the fire, especially by increasing the coarse particles percentage. These, in spite of the absence of vegetation cover, improve soil infiltration and percolation rates and cause long-term changes to the hydrological regime.

It is difficult to estimate the frequency of high-intensity fires in the Carmel region over the past 2-3 million years, as well as the extension and density of the vegetation. It is even harder to assess the frequency of fires (and the destruction) of a single rock outcrop. Our findings show that rock outcrop may lose even 20 cm of its thickness in a single fire. This value, if accounted to the long run, can be responsible for a high percentage of the total denudation rate and therefore, in the mountainous carbonate slopes of the Mediterranean region, wildland fires may serve as extremely important factors in landscape evolution (Shtober-Zisu et al., 2015).

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## Dynamics of methane bubble ascent within shallow muddy aquatic sediments

**Sirhan, S.(1), Katsman, R.(1), ten Brink U.(1)**

1. The Dr. Moses Strauss Department of Marin Geosciences, Leon H. Chamey School of Marine Sciences, University of Haifa, Mt. Camel, Haifa 3498838, Israel.

Mature methane gas bubbles in the fine-grained, clay-bearing (cohesive) aquatic sediments, found at many locations throughout the world, are much larger than the characteristic pore size. When gas pressure within the bubble is high enough to overcome compression, friction, and cohesion at grain contacts, gas migrates upward driven by buoyancy, by pushing the grains apart and fracturing the fine-grained sediments. Fracturing of the fine-grained cohesive sediments by the migrating bubbles destabilizes sediment and might result in slope failure. Migrating methane bubbles may bypass processes of oxidation in the upper sediment layers due to their fast rise velocity, and release to the water column and eventually to the atmosphere. In this study we use coupled macroscopic single-bubble mechanical/reaction-transport numerical model to explore bubble ascent under various ambient concentration profiles, associated with bio-chemical processes of methane production and consumption below sediment-water interface, as it occurs in nature. Modeling results show that changes in the ambient dissolved-methane concentrations strongly affect bubble ascent velocity. It is demonstrated that bubble migration scenario within fine-grained muddy sediments is controlled dominantly by the internal bubble pressure that manages solute exchange with adjacent porewater, and which is significantly affected by the ambient stress. For shallow water depths two sequential bubble propagation patterns were observed: (1) Stable (saw-tooth) fracturing, followed by (2) Dynamic (unstable, rising line) fracturing, leading to an ultimate release of the bubble to the water column. However, for a higher water depth, bubble propagation pattern is characterized by stable fracturing only. In this pattern the bubble becomes more sensitive to the ambient field of methane concentrations and may stop below sediment-water interface due solute release caused by the local methanotrophy.

## Annual dynamics of halite precipitation in the Dead Sea: In situ observations and their geological implications

**Sirota, I. (1, 2), Enzel, Y. (2), Lensky, N. G. (1)**

1. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem 95501, Israel
2. Institute of Earth Sciences, The Hebrew University, Jerusalem 91904, Israel

Layered halite sequences deposited in deep basins throughout the geological record. However, analogues of such sequences are commonly studied in sallow environments. Here we study active precipitation of halite layers from the only modern analog for deep, halite-precipitating basin, the hypersaline Dead Sea. In situ observations in the Dead Sea link seasonal thermohaline stratification, halite saturation, and the characteristics of the actively forming halite layers. The spatiotemporal evolution of halite precipitation in the Dead Sea was characterized by means of monthly observations of the i) lake thermohaline stratification (temperature, salinity, and density), ii) degree of halite saturation, and iii) textural evolution of the active halite deposits. We present the observed relationships between textural characteristics of layered halite deposits (i.e. grain size, consolidation, and roughness) and the degree of saturation, which in turn reflected the limnology and hydro-climatology. The lakefloor is divided into two principle environments: A deep, hypolimnetic and a shallow, epilimnetic lakefloor. In the deeper hypolimnetic lakefloor halite continuously precipitates with seasonal variations: (a) during summer, consolidated coarse halite crystals form rough surfaces under slight super-saturation. (b) During winter, unconsolidated, fine halite crystals form smooth seafloor deposits under high supersaturation. The observations also emphasize the thought regarding seasonal alternation of halite crystallization mechanism. The shallow epilimnetic lake floor is highly influenced by the seasonal temperature variations, and by intensive summer dissolution of part of the previous year's halite deposit which results in thin sequences with annual unconformities. This emphasizes the control of temperature seasonality on the precipitated halite layers characteristics. In addition, precipitation of halite in the hypolimnetic floor, on the expense of the dissolution of the epilimnetic floor, results in lateral focusing and thickening of halite deposit in the deeper part of the basin and thinning of the deposits in shallow marginal basins.

## Distribution of sinkholes along the Dead Sea coast

**Sneh, A. (1)**

1. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501

Sinkholes along the coast of the Dead Sea, formed by dissolution of a salt bed embedded in a mud – sand – gravel Holocene sequence (the Ze'elim Formation), are aligned parallel to regressive shorelines of the Dead Sea.
With the lowering of the lake level and hence of the fresh/saline water interface, the salt bed gets gradually immersed in freshwater, resulting in dissolution whose front follows the retreating interface that runs obviously parallel to the shorelines.
In exceptional cases sinkholes formation is also enhanced parallel to ephemeral stream courses and along tectonic lineaments.

## Curvature and morphological development of initially complex subduction zones using 3D modeling: the case of the Cyprian Convergent Zone

**Suchoy, L. (1), Gerya, T. (2), Lazar, M. (1)**

1. The Dr. Moses Strauss Department of Marine Geosciences, Leon H.Charney School of marine sciences. University of Haifa, Mt. Carmel, Haifa 31905, Israel
2. Institute of Geophysics, Department of Earth Sciences, ETH, Zurich, Zurich, Switzerland

Curvature of subduction zone is a surface phenomenon of subducting plates deep below the surface. It is normally modeled by using simple rectangular initial conditions which are unlikely to exist in nature. A more realistic oblique to curved subduction initiation is yet to be fully examined. We apply advance high-resolution 3D thermo-mechanical numerical modeling, I3ELVIS, to simulate subduction initiation and development in a complex geometric environment. These include bonded straight and oblique subduction with overriding and subducting continental blocks in both fast and slow subduction velocity. Results of the experiments show curvature developments of the overriding plate to be stable feature as well as retreat and rollback of the subducting plate. Deep morphological features show delay subduction around the transition from straight to oblique subduction resulting in gap at the edge of the slab. Some similarities to the Cyprian Convergent Zone include lack of volcanism and STEP faulting allow for future prediction of future high retreat rate in the Western Cyprian Arc.

## $CO_2$ storage capacity assessment of the Paleozoic-Triassic deep saline aquifer in southern Israel: Implementation of a geostatistical approach in data-poor regions

**Taragan, R. (1,2), Calvo, R. (2), Feinstein, S. (1)**

1. Department of Geological and Environmental Science, Ben Gurion University of the Negev, Beer Sheva 84105, Israel
2. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem 95501, Israel

$CO_2$ emission to the atmosphere is considered as one of the major reasons for global warming. One of the more feasible options for reducing $CO_2$ emission from fossil fuels combustion is its capture and storage in porous rocks in the deep subsurface. Deep saline aquifers are considered to have the best potential for $CO_2$ storage, for long periods of time. The most effective phase for $CO_2$ to be stored in the subsurface is in its supercritical phase, when it has a density of liquid and viscosity of gas properties, and thus will allow better usage of the pore space, while keeping the easy injectivity of a gas. As part of the effort being made to evaluate the $CO_2$ storage potential of deep saline aquifers in Israel, the objective of this study is to evaluate the storage potential of the Lower aquifer in the Negev, which comprises Paleozoic – Triassic rocks of the Negev and Ramon groups. The thermophysical conditions prevails in this aquifer are suitable for $CO_2$ storage throughout most of the study area, however, the large depth of this aquifer is one of the reasons for the scarcity of wellbores and seismic data in this section. Due to this lack of data, it's crucial to examine the variability in the calculated depth and thickness of the layers, caused by using different methods of spatial interpolations. In addition, a few sensitivity tests of several parameters controlling the temperature and pressure of the subsurface, and by that effecting the capacity assessments has been conducted, in order to determine the magnitude of error in the effective capacity calculation. Moreover, in order to have a better understanding of the petrophysical properties and the litho-facies of the studied section, an in depth geological investigation of these layers is being carried, using petrophysical and petrographical data from boreholes.

## Preservation of production potential from natural groundwater sources by wells

**Tatarsky, B (1)., Gev, I.(2), Itzhak, Y.(1), Gilboa, Y.(1), Alamaro, Y.(1), Omer, E.(1), Avital, A.(1), Van-Steenwinkel, J.(1)**

1. TAHAL Consulting Engineers Ltd., 5 Arik Einstein St., Or Yehuda.
2. Israel Water Authority, 14 Hamasger st., Tel Aviv

Average groundwater production in Israel is ~1,000 million cubic meters (MCM) per year for all uses (domestic, irrigation and industry). Groundwater exploitation is taking place today by ~1,500 active production wells. Most of the current production is by old wells that were drilled more than 50 years ago, in the 1950s and 1960s. Over the past few decades there has been a steady decline in the production capacity of groundwater because of the shutdown of many wells for various reasons including: hydrogeological conditions (water level depletion, groundwater pollution), operational and economic considerations, regulation, and specific protective zone guidelines. Technical failure of the well structure is a dominant factor affecting the lifetime of a well and is in many cases the initial trigger for some of the other causes mentioned above.

The current project included an in-depth analysis of all pumping wells in Israel, with a detailed examination of a selected group of 200 representative wells. The main factors and characteristics involved in the corrosion and incrustation processes of boreholes are defined and described in detail.

Based on the above, a methodology was developed for estimating the lifetime of a well according to hydrogeological and technical characteristics. Based on the results, the average lifetime of a well is around 60 years. Accordingly, the loss of production capacity in future years due to well failure was estimated to be ~500 MCM by 2030 and an additional 300 MCM by 2050. A well drilling and rehabilitation plan to maintain current production potential is presented, along with an initial cost estimation. Finally the current drilling capacities and capabilities of existing drilling contractors in Israel are reviewed and the main gaps for executing the preservation plan evaluated.

The main conclusion from the study is that a fundamental change in state policy regarding the drilling of new wells and renewal of old wells is essential in order to maintain the production potential of groundwater, which is still a main source of water in the national water supply system. Execution of the necessary drilling plan requires an exceptional lineup of personnel and effort as well as substantial budgets, and should be directed by the Israel Water Authority.

## Foraminifera as a novel proxy for industrial pollution: a case study from the Mediterranean coast of Israel

**Titelboim, D.(1), Sadekov, A. (2), Almogi-Labin, A.(3), Herut, B.(4), Kucera, M.(5), Hyams-Kaphzan, O.(3), and Abramovich, S.(1)**

1. Ben-Gurion University of the Negev, Beer Sheva, Israel
2. University of Cambridge, Cambridge, UK
3. Geological Survey of Israel, Jerusalem, Israel
4. Israel Oceanographic and Limnological Research, Haifa, Israel
5. MARUM – Center for Marine Environmental Sciences, University of Bremen, Bremen, Germany

In recent years we have been witnessing a considerable growth of industrial facilities along coastal areas. Some of these have major economical and national importance yet their operation can introduce a wide range of chemicals that might contaminate the coastal area and impact local ecosystems and our health. Among some of these harmful chemicals are metals that are introduced to the coastal environment by some of these facilities. Here we present a novel approach for monitoring low-level industrial pollution in coastal environments based on anomalies in metal concentration within foraminiferal shells. In recent years we have been witnessing a considerable growth of industrial facilities along coastal areas. Some of these have major economical and national importance yet their operation can introduce a wide range of chemicals that might contaminate the coastal area and impact local ecosystems and our health. Among some of these harmful chemicals are metals that are introduced to the coastal environment by some of these facilities. Here we present a novel approach for monitoring low-level industrial pollution in coastal environments based on anomalies in metal concentration within foraminiferal shells. Material for this study was obtained during the monthly campaigns of a biomonitoring project (2012-2015) of a heat polluted area and of a nearby natural clean station off the northern Mediterranean coast of Israel. Essentially, monitoring of water chemistry in both habitats showed no indications of presence of heavy metal contamination. Yet, laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) analyses of two common local foraminifera the hyaline species Pararotalia calcariformata and the miliolid species Lachlanella sp. 1 that were collected alive from both areas, recorded presence of various metals (Mn, Cu, Zn, Ba, Pb) within their shells. Metal concentrations within the miliolid species were significantly higher than those of the hyaline species despite of the fact that both species were collected from the same environment. For example, the concentration of Cu in the ambient water was lower than 1μg/L, whereas the values recorded in P. calcariformata ranged between 2-12 μg/L in and between 11-157 μg/L in *Lachlanella sp.* 1. These results highlight the efficiency of using miliolid species that are extremely common in shallow coastal areas as recorders of extremely low concentrations of metals, thus potentially detecting pollution before harming the ecosystem.

## Calcification of heat tolerant benthic foraminifera under extreme temperatures - evidence from a heat-polluted shallow marine environment

**Titelboim, D.(1), Sadekov, A.(2), Almogi-Labin, A.(3), Herut, B.(4), Kucera, M.(5), Schmidt, C.(5), Hyams-Kaphzan, O.(3), and Abramovich, S.(1)**

1. Ben-Gurion University of the Negev, Beer Sheva, Israel
2. University of Cambridge, Cambridge, UK
3. Geological Survey of Israel, Jerusalem, Israel
4. Israel Oceanographic and Limnological Research, Haifa, Israel
5. MARUM – Center for Marine Environmental Sciences, University of Bremen, Bremen, Germany

Shallow marine calcifiers play an important role as marine ecosystem engineers and in the global carbon cycle. Understanding their response to warming is essential to evaluate the fate of marine ecosystems under global change scenarios. So far, most data on thermal tolerance of marine calcifiers have been obtained by manipulative laboratory experiments. Such experiments provide valuable physiological data, but it remains unclear to what degree these observations apply to natural ecosystems. A rare opportunity to test the effect of warming acting on ecosystem-relevant scales is by investigation of heat-polluted coastal areas. Here we study growth and calcification in benthic foraminifera that inhabit a thermally polluted coastal area in Israel, where they are exposed to temperature elevated by 6°C above the natural seasonal temperature range and reaching up to ~42°C in summer. Several species of benthic foraminifera have been previously shown to persist throughout the year in the heat-polluted area, allowing us to examine in natural conditions the thermal limits of growth and calcification under extreme temperatures as they are expected to prevail in the future. Live specimens of two known heat tolerant species *Lachlanella sp.* 1 and *Pararotalia calcariformata* were collected over a period of one year from two stations, representing thermally polluted and undisturbed (control) shallow hard bottom habitats. Single-chamber element ratios of these specimens were obtained using laser ablation and the Mg/Ca of the last chambers (grown closest to the time of collection) were used to calculate calcification temperatures. Our results provide the first direct field evidence that these foraminifera species not only persist extreme warm temperatures but continue to grow and calcify. Species-specific Mg/Ca thermometry indicates that P. calcariformata precipitate their shells at temperatures as high as 40°C and *Lachlanella sp.* 1 at least up to 36°C. Instead, both species showed a calcification threshold above the local winter temperatures. Calcification in *P. calcariformata* only occurred above 22°C and in *Lachlanella sp.* 1 above 15°C. Our observations from the heat-polluted area indicate that under future warming scenarios, growth and calcification in both benthic foraminifera species will not be inhibited during summer heat and the seasonal temperature window for their calcification will be expanded throughout much of the year. The observed inhibition of calcification at low temperatures indicates that the role of heat-tolerant foraminifera in carbonate production will most likely increase in future decades.

## Petrophysical properties of loess and unconsolidated sands units in the southern Shfela region

**Tkacz, I.(1) , Waldmann, N. (1)**

1. The Dr. Moses Strauss Department of Marine Geosciences, University of Haifa, 31905-Haifa, Israel

In the current study we show a new record of petrophysical properties of the shallow underground in the south Shfela region, southern Israel. A 34 meter long core was retrieved and consequently measured for petrophysical analyses utilizing a Multi Sensor Core Logger (MSCL) for sonic velocity, density and magnetic susceptibility. The down-core logging was complemented with down-hole measurements of the electrical properties using vertical borehole magnetic field measurement providing a comprehensive dataset of the uppermost ~35 m of sediments. Our results were further amalgamated with laboratory measurements of permittivity and conductivity using MC-100 dielectric test cell.
Our study shows that magnetic field attenuation and MSCL datasetshave major variations in the shallow sedimentary overburden indicating a non-homogenous record that can be divided into three major stratigraphical layers: U1, U2 and U3 (0-12, 12-22,and 22-34 m, respectively).The magnetic susceptibility, P-wave velocity and gamma-density values show great agreement with the magnetic field attenuation changes. One of the most obvious observations shows that while the magnetic susceptibility and the P-wave velocity values decrease with depth, the density increases. Initial interpretation of the dataset provides important clues as for better understanding the influence ofclimate and hydrological changes on the petrophysical properties of the sedimentary record.
A complementary work will be further carried out utilizing standard sedimentological analyses (e.g., granulometry, microscopy and mineralogy) to be complemented with chronology (e.g., OSL) in order to identify the different sedimentary components influencing the identified changes in the petrophysical values through time.

# Depth conversion of 2D seismic data in the Southern Golan Heights

**Trachtman, P. (1), Aizenshtat, E. (2), Bartov, Y. (2), Dror, O. (1)**

1. Geophysical Institute of Israel, P.O.Box 182, Lod 71100, Israel
2. Genie Enrergy LTD. 5 Shlomo Halevi Jerusalem, 9777019, ISRAEL

As part of an oil and gas exploration campaign led by Genie Energy LTD in the Golan Heights, 19 seismic lines comprising from both old and new datasets were used. The research area extends over the elevated Golan-Heights plateau bordered by the Palmyra fold-belt to the north-east and the Dead Sea Fault System to the west.
The goal of the workflow was to maintain the geological integrity of the subsurface and create a meaningful velocity model tying all the information into the depth domain. The first step was reprocessing all the lines in order to tie all the different data acquisitions to a systematic one and to be able to identify important reflectors.
Due to topographic height differences within the research area, varying some 1500 m (from 200 m BSL in the south up to 1300 m in the north), an initial correction to account for the topography was performed (static correction).In the early stages of the research, it was established that the results of a standard Pre-Stack-Depth Migration process (PSDM), which utilized an interval velocity model, were in poor correlation with borehole depths and measured stratigraphy.
It was observed, that in comparison with off-shore surveys with standard time processing, the land acquired data yields inferior results (low signal to noise ratio). We therefore suggested tailor made workflow that incorporates different acquisition parameters and signal to noise ratio, while using well data and geological information to create a meaningful velocity model. The workflow is constructed as an iterative process, in which the interpreter and the seismic processor update the velocity model. Using an initial interpretation, RMS velocities were extracted along horizon planes and RMS velocity maps were computed for each horizon. A Constrained Velocity Inversion (CVI) was preformed to create an interval velocity model in depth, by which the time migrated sections were converted to depth sections.
Results yielded high quality imaging that enabled interpretation in the depth domain. The workflow proved to be a viable tool to convert time migrated sections to depth domain, enabling a coherent and meaningful geological model.

## Heteroaggregation between intrinsic colloids and carrier colloids: Implications for Cerium(III) mobility through fractured carbonate rocks

**Tran, E. (1), Klein Ben-David, O. (2), Teutsch, N. (3), Weisbrod, N. (1)**

1. The Zuckerburg Institute for Water Research, The Jacob Blaustein Institute for Desert Studies, Ben Gurion University, Midreshet Ben Gurion, 84990
2. Nuclear Research Center of the Negev, Negev, PO box 9001, Beer Sheva, 84190
3. Geological survey of Israel, 30 Malkhe Israel St., Jerusalem, 95501

Colloid facilitated transport of radionuclides has been implicated as a major transport vector for leaked nuclear waste in the subsurface. In the Negev Desert, carbonate rocks compose the vast majority of local bedrock and thus are the most likely rocks to serve as a matrix for a geological nuclear waste repository. Previously, transport experiments using fractured chalk columns showed that the precipitation of Ce(III) with carbonate as intrinsic colloids increases the recovery and transport rate of Ce(III). However, it has also been well-documented that sorption of radionuclides onto mobile carrier colloids such as bentonite and humic acid often accelerates their transport through saturated rock fractures.

Here, we demonstrate how precipitated Ce(III) intrinsic colloids may aggregate with these mobile carrier colloids as "heteroaggregates" to further increase Ce(III) mobility. Colloid stability tests, batch sorption tests and SEM images were used to investigate the mechanism of Ce(III) association with bentonite and humic acid carrier colloids. On bentonite colloids, Ce(III) appears to be fractionated between chemical sorption to the bentonite colloid surfaces and heteroaggregation of bentonite colloids with intrinsic carbonate colloids, precipitated naturally in solution. However, SEM images and colloid stability experiments reveal that in the presence of humic acid, Ce(III) seems to only be associated with the humic acid colloids by heteroaggregation of intrinsic and carrier colloids. When both colloid types are present, it is likely that a humic acid coating is present on the bentonite colloids, to which Ce(III) is fractionated between chemical sorption and heteroaggregation.

The heteroaggregation of Ce(III) intrinsic colloids with carrier colloids in solution appears to increase the overall migration of Ce(III) through saturated fractures. In transport experiments, Ce(III) recovery from a fractured chalk core where either bentonite or humic colloids were added was 7.7-26.9%, in comparison to 0.1-11.2% recovery observed for all experiments conducted without any carrier colloids. The greatest Ce(III) recovery was observed when both types of carrier colloids were present (25.4-37.4%). Heteroaggregation of intrinsic and carrier colloids may be an important factor to consider when predicting potential mobility of leaked radionuclides from geological repositories for spent fuel located in carbonate rocks.

This study may have important implications for current research being conducted on transport of radionuclides including U, I, Cs and Cr in natural groundwater in the Negev. As high concentrations of bicarbonate (250-500 mg/L) found in Negev groundwater may lead to the precipitation of intrinsic colloids, greater transport and recovery may be expected through field-scale fracture networks in chalk.

## New perspective on neotectonic processes and sedimentary patterns at Ein Gedi area

**Tzarfati, G. (1,2), Agnon, A. (1), Levy, E. (2)**

1. Institute of Earth Sciences, The Hebrew University, Jerusalem 91904, Israel
2. Geophysical Institute of Israel, Lod 71100, Israel

Sediment cores recently drilled for studying the late Quaternary environmental history, can shed new light on the interpretation of seismic reflection profiles at the Dead Sea lake and its shores. During 2010-2011, ICDP's Dead Sea deep drilling project (DSDDP) collected >700 m of almost continuous cores from: a deep basin site (455 m long), and a nearshore site at 'Ein Gedi Spa (340 m long). The deep basin borehole was thoroughly sampled for dating, lithologic, petrographic, geochemical, hydrochemical, and geobiological analyses. The cored sections show sedimentary patterns resulting from lake level fluctuations attributed to climate change, punctuated by slumping and shaking events.

We plan to combine core and downlogging data with seismic sections, in order to provide new detailed high resolution interpretation of the nearshore subsurface with focus on Late Quaternary units. Three sections from 1975 (DS-0187A/8/9) and a more recent one (DS-2281) from 1996, bound an approximate rectangle 2.7X4.5 km in size around 'Ein Gedi Spa. South of these, new sections (ZE-5120/1) from 2013 bound an overlapping rectangle 1.7X2 km in size. The profiles reach 4-6 seconds (TWT) and show clear seismic reflectors at the upper two seconds. Reflectors with acute amplitude differences can indicate sharp lithologic transitions between massive and fine grain loose sedimentary units within the Lisan and Ze'elim Formations. 'Ein Gedi Spa borehole is a control point for the shallow seismic data that stretch along the lake and its shores. The 'Ein Gedi 2 borehole (2500 m), is a tying point for the seismic sections and provides calibration for deeper horizons. The results of this new interpretation will shed light on nearshore neotectonic and depositional processes and their relation to sedimentary patterns at the deeper part of the Dead sea lake.

## Provenance of the Southern Kalahari: A wetland that became dry

**Vainer, S.(1), Erel, Y.(1), Matmon, A.(1)**

1. The Fredy & Nadine Herrmann Institute of Earth Sciences, The Hebrew University of Jerusalem, Edmond J. Safra Campus Givat Ram, Jerusalem 91904, Israel

The ca. 140 Ma vast Kalahari Basin is characterized by uplifted margins, terrestrial sedimentation within semi endorheic sub-basins, subdued morphology and tectonic quiescence. This intracratonic basin has been subjected to a prolonged period of subsidence affecting its sedimentary fill by plate motion and climatic cycles. Provenance studies of Kalahari Group sediments mainly focused on the easily accessible uppermost part that represents only the last phase of sedimentation, leaving unresolved questions for the rest of the strata.

The southern Kalahari Group succession exposed along the walls of the Mamatwan Mine, Northern Cape, South Africa, reveals three main depositional environments; a bottom pluvial, low-energy water body, a middle fluvial, high-energy environment and an upper aeolian sandy unit. The entire section, which was deposited within the Quaternary, records significant environmental and depositional changes suggesting a highly dynamic landscape. The fully exposed section (55 m) of the Kalahari Group at Mamatwan Mine was analysed for its mineralogy, elemental composition, Sr, Nd and Pb isotopic ratios and iron species. Mineralogical assemblage implies that a brackish and alkaline shallow water-body existed during the early-middle Pleistocene contemporaneous with relative dense hominine occupation of the area.

Isotopic ratios were used to determine the source of the sediments, which was found to be mainly of recycled Archean volcano-sedimentary rock, outcropping today to the east of Mamatwan. Weathering sensitive indices show that sediments carried to the basin underwent considerable weathering indicative of greater surface water availability than the present.

The lacustrine environment was rapidly filled with clasts that were derived mainly from the surrounding hills and experienced limited degree of source rock chemical weathering, but underwent subsequent groundwater alteration by iron-rich solution and precipitation of celcrete and silcrete duricrusts. The changes in depositional environments ultimately resulted in a shift to a mostly aeolian regime in the region supplying pre-eroded sediments from Protorozoic western and north-western source areas following the establishment of the modern wind regime. The filling of the basin occurred during the middle-Pleistocene transition and was accompanied by reduced surface water availability.

## 3D Modeling of wave propagation in the continental shelf of Israel: Soft Sediments, Sub-surface Canyons and Ground Motions

**Volk, O. (1,2), Shani-Kadmie, S. (l1,2) , Gvirtzman, Z. (2), Tsesarsky, M. (1,2)**

1. Geological and Environmental Sciences, Ben Gurion University, Beer-Sheva, 84105
2. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem, 95501

We study the propagation of seismic waves, ensuing ground motions and their amplification atop sedimentary structures underlying continental passive margins. We employ a set of generic models with increasing complexity within a framework of a 3-D numerical scheme. The basic geological structure and velocity model were derived from the sub-surface of the Israeli coastal plain where soft sediments form a wedge over the stiffer bedrock and fill sub-surface canyons that incise deep into the bedrock. Ground motions were modeled for both sea-side and land-side seismic sources. We show that for a land-side source peak ground velocities (PGV) atop a sedimentary wedge are amplified by a factor of two, relative to a reference model. This amplification is mainly due to ellipticity of Rayleigh waves in the soft sediment layer. Spatial distribution of amplification factors shows that sedimentary wedges does not exhibit a prominent edge effect. Atop deep, sediment-filled canyons ground motions are amplified along their axis, with an amplification factor of up to 2.4 relative to adjacent rock site in the model. This amplification is mainly due to the geometrical focusing of SH waves.

## Late Paleocene changes in nutrient patterns prior to the Paleocene-Eocene Thermal Maximum

**Weinbaum – Hefetz, M.(1), Bialik, O.M.(2), Waldmann, N.D.(2), Hyams-Kaphzan, O.(3), Taha, N.(2), Benjamini, C.(1)**

1. Department of Geological and Environmental Science, Ben Gurion University of the Negev, Beer Sheva 84105, Israel
2. The Dr. Moses Strauss Department of Marine Geosciences, Charney School of Marine Sciences, University of Haifa, Mount Carmel, 31905 Haifa, Israel
3. Geological Survey of Israel, 30 Malkhei Israel St., Jerusalem, 95501 Israel

The period prior to the Paleocene-Eocene Thermal Maximum (PETM) was characterized by an enhanced organic carbon burial, as evidenced by a positive global carbon isotope excursion known as the Paleocene Carbon Isotope Maximum (PCIM). Previous studies show that this interval was punctuated by a short-lived negative δ13C excursion, which appears to be associated with a switch to enhanced inorganic carbonate burial. However, this δ13C excursion was identified only in deep sea sedimentary records and is not known from onshore.

A calcareous interval widely exposed in the Middle East region, most notably in Egypt and Israel (informally the 'Hafir Mbr.), records the PCIM. A high-resolution petrophysical, sedimentological and geochemical study of this calcareous interval was carried out on the RH323 continuous core record from southern Israel. The depositional conditions related to the onset, culmination and termination of this calcareous interval were evaluated.

The measured record shows that the transition to the calcareous interval is marked by diminishing terrestrial components, with pulses of high organic productivity at the base and top of the interval. This decrease in terrestrial supply can be explained by expansion of the carbonate factory at the margins of this region, and events of enhanced inorganic carbon burial in the pelagic system. These lithological transitions are therefore evidence of global climatic and oceanographic changes in the oceans in the context of the early Tertiary reorganization.

The calcareous interval belongs to the NP6 –NP9 of the calcareous nannofossil biozones. A detailed inspection of the interval showed changes both in the nannofossil assenmblage and in the mode of preservation. The shift towards a more calcareous deposition is accompanied by a peak of *Thoracosphaera spp*, and by a contemporaneous short event in which the mode of preservation is notably reduced. It is suggested that the temporal dominance of an opportunistic forms in the planktic realm also affected sea-floor conditions.

## New Quaternary map for Eilat region, 1:10,000 scale

**Wieler, N.(1), Avni, Y.(2), Ginat, H.(1), Rosensaft, M.(2)**

1. Dead Sea and Arava Science Center, Kibbutz Qetura, Hevel Eilot 88840, Israel
2. Geological Survey of Israel, Malkhe Yisrael 30, Jerusalen 95501, Israel

In accordance with generating geological hazards map for Eilat region, a new large-scale high-resolution Quaternary map was generated in order to define the different young units forming alluvial terraces in the region. The map aims to characterize the different Pliocene-Holocene alluvial units spread in Eilat area and to define their spatial distribution and their tectonic relations. The map covers the eastern parts of the 1:50,000 Eilat geological map (Beyth et al., 2012) from the Amram drainage basin at the north and the Egyptian border at its south. The map includes eight stratigraphic units that were characterized based on field survey and their absolute age, that was attained during previous dating studies carried out in this region (Amit et al., 1993; Garfunkel, 1970; Gerson et al., 1993; Porat et al., 1996; Porat et al., 2010; Rinat et al., 2016). This procedure enabled us to demonstrate the time depended development of the Quaternary units exposed on the surface and to discuss the relations between these units and the faults found in the region. The interaction between the stratigraphy and the tectonics served as key components for defining and reevaluating specific faults as 'potentially active faults'.

## Israel's national earthquake preparedness

**Yahav, A.(1)**

1. National Doctrine, Training and Exercises Division, National Emergency Management Authority (NEMA), Ministry of Defense, Israel

A powerful earthquake takes place in Israel once every 80-100 years on average. The last earthquake as such occurred in 1927 and caused much damage and hundreds of injuries and fatalities.

The Israeli government has announced that in 2017, an earthquake scenario will be lead scenario prepared for.

Supposedly, it would be proper for Israel to Invest in sturdy and quake-proof building and in the strengthening of older structures which aren't built up to such standards. And indeed the government invests many funds into these solutions, but can we truly say that it's enough? There are about 80,000 residencies 3 stories and higher and about 4,000 public buildings that have been built prior to the year 1980, during which building regulations were changed to include the aforementioned changes to structural strength. Thus far, only a few tens of public buildings and about 2,000 residencies as mentioned above have been appropriately strengthened; the implications are clear- Israel must invest a considerable amount more in preparation for an earthquake scenario and preparation for the rehabilitation of the state and its people from such an occurrence. This need has led to the creation of a national doctrine for the preparation for an earthquake scenario, which dictates a shared vocabulary, defines areas of action and sheds onto the different relevant bodies in case of a quake. As such, a reference scenario has been decided upon: 7,000 people dead, 8,000 wounded in need of hospitalization, 37,000 lightly injured, 170,000 left homeless, 28,600 buildings heavily damaged or destroyed, and 290,000 buildings lightly damaged.

An earthquake of this magnitude can impact the local economy for a period of months and even years, and will demand all available resources in order to be dealt with. The country will be divided into several disaster areas and the authorities will operate within two Circuits: an Operational Circuit, and a Support Circuit. Local authorities will operate local logistical assistance centers for the civilian population; the healthcare system will operate first aid centers. In addition, a national plan for the reception of international aid will be activated.

The challenges facing Israel in case of an earthquake scenario are many, complex and long-ranging. The country must be prepared, among other things, to keep up its public image as a powerful, advanced state capable of dealing with such an ordeal.

## Israel's national preparedness for Tsunami

**Yahav, A.(1)**

1. National Doctrine, Training and Exercises Division, National Emergency Management Authority (NEMA), Ministry of Defense, Israel

It is a documented fact that tsunami waves have occurred in the Mediterranean Sea, in the past, and have even hit the very shores of Israel.

Such waves hitting the shores of Israel today would cause a disaster on the national level and will cause the day-to-day lifestyle in the country to roll back generations.

During the last few years the National Emergency Management Authority and the National Steering Committee for Earthquake Preparedness have led the preparation of every single relevant government entity in the state: research institutions (the Geological Survey, the Geophysical institute, the Israeli Center for Oceanographic and Limnological Research), the academy (Haifa, Tel Aviv, and Ben Gurion Universities), the various governmental offices, local authorities, first responders, and the IDF for the projected scenario of a tsunami disaster on the shores of Israel.

The international awareness for the need to prepare for tsunamis on a national level began rising following the devastating 2004 tsunami that took place in the Indian ocean that caused some 250,000 deaths, and kept on rising following the 2011 Japan tsunami, which caused 20,000 deaths in its own right and further caused a nuclear disaster due to the Fukushima nuclear power plant being hit by the monster waves.

Israel has about 200 kilometers of coast that are exposed to the Mediterranean Sea, and serve as a source of income and as a place of leisure and residence for hundreds of thousands of people.

It is another fact that 45% of Israel's current electricity production is done in power plants along the coast, 99% of the importation to the country (in tonnage) arrives by sea, and 100% of the water-purification plants- upon the waters of which depends 50% of the population for drinking water- are located along the beach, and 100% of the refined oil in Israel is produced along the shore of the Mediterranean.

A tsunami in Israel can cause thousands of deaths and devastation to the national economy, the recovery from which may take months and even years.

The complex and rewarding cooperation between the aforementioned agencies has led to the creation of a doctrine for the national preparation of the country and its people for tsunamis, and has gone as far as instruction of the masses and the positioning of warning and directional signs along the beaches in case of a tsunami.

Israeli activity in the matter has aroused much interest around the world and attracts professionals in the field to come and study the local doctrine and related preparations.

## Industrial minerals under tough Israeli regulations

**Yasur, U.(1)**

1. ICL-Rotem

Israel is blessed with small amounts of industrial minerals, the foremost of which is phosphate rock. Feasible reserves mainly exist in the southern area of Israel.
ICL-Rotem produces fertilizers for agriculture from phosphate rock found throughout the Negev. In 1952 the company was established as a government industry company, beginning in the Negev.
The mining and beneficiation are carried out in open pit mines in the Negev desert and nearby factories. For the past three generations, thousands of families from the area established their homes here in - Arad, Dimona, Yeruham and several other towns in the area.
The company must maintain sufficient strategic reserves in order to remain a competitive player in the global fertilizer market. Proven Reserves that allow 25 years of work are needed in order to provide the company a good functioning atmosphere.
Our proven reserves are now below the "red line", allowing only 7-8 production years. The main impediment is phosphate rock for producing PA (Phosphoric Acid). PA is not only a standalone product, but also a crucial component in the production of fertilizers, where it is mixed with phosphate rock. Therefore, phosphate rock suitable for PA production is required for the production of both PA and fertilizers. If we run out of the PA line reserves, we will have to stop all fertilizer production, as well as PA production and the phosphate industry will no longer exist in our country.
For the last three decades Rotem has been trying, unsuccessfully, to promote Barir mining site, which is only a tiny fraction of the Zohar field that comprises more than 500 million tons of phosphate rock. The Barir reserves would allow us more than 30 years of production for the industry, together with the Zin-Oron mining sites.
Over the years, a program for mining in the Barir site has been reviewed by many experts from different fields - healthcare field, geology, infrastructure, mining, tourism, and more. All independent experts, apart from the leadership of the Ministry of Health, agreed that the plan should be promoted while performing a systematic and careful monitoring of the situation in the field before and during mining. Even the experts of the Ministry of Health, including professor Shapira and professor Sammet, did not rule out mining. On the contrary, they claimed that mining should be full along careful and accurate monitoring in the site.
We believe that Barir should be approved as soon as possible. The Ministry of Environment must start the initial monitoring right away, and enable the exploitation of the high quality phosphate rock of the Arad Valley, while imposing the restrictions required for the welfare of local residents. The current situation of ICL Rotem is a situation of "maybe" and it is the worst situation in which a mineral industry company can operate. It is the responsibility of the domestic regulator to ensure the company's continuance and turn the "maybe" into "yes". Only then can we resume long-term investments, including more investments for a better environment.

## Mineralogical, chemical and isotopic fingerprints of the dust sources in East China during the past ~80kyrs

**Zaarur, S. (1), Stein, M. (1,2) ,Mingram, J (3), Tirosh, O.(1), Erel, Y. (1)**

1. Institute of Earth sciences, The Hebrew University of Jerusalem, Jerusalem, Israel, shikma.zaarur@mail.huji.ac.il
2. Geological survey of Israel, Jerusalem, Israel
3. GeoForschungsZentrum (GFZ), Section 3.3, Telegrafenberg, Potsdam, Germany

Reconstructing and understanding changes in atmospheric circulation and its relation to global and regional climate patterns are major challenges in the field of quaternary paleoclimate. In this study, we use mineralogical, chemical and isotopic signatures of fine lake sediments to trace the sources of dust, as a tool to understand the synoptic patterns in East Asia during the past ~80 kyrs. Our study focuses on sediments from two maar lakes: Sihailongwan and Huguangyan in NE and SE China, respectively. These lakes are hydrologically confined and do not drain any rivers or streams that introduce additional particle sources other than the volcanic rims and windblown dust and therefore are ideal for our purposes. Sediment cores from both lakes were obtained by the German-Chinese drilling project, have been previously dated and their general composition had been characterized (Mingram et al. 2004, Zhu et al. 2013). To characterize the local signature we additionally collected sediments from the rim and the vicinity of the lakes. Because we are interested in windblown particles, we concentrate on fine sediment fraction (<70μm).
The fine particles from Sihailongwan Maar show large variations in the chemical compositions (e.g. ~0-9% and 2-8% for CaO and $Fe_2O_3$, respectively) and $^{87}Sr/^{86}Sr$ and eNd values of 0.711-0.715 and -2 to -13, respectively. In the eNd - $^{87}Sr/^{86}Sr$ diagram the samples lie between the values of: -3.5 and 0.71113, and 8.3 and 0.71543, suggesting changes in contributions from nearby northeast China and farther west China deserts, respectively.
The fine particles of Huguangyan Maar resemble tropical soils dominated by Fe and Al oxides. A few abrupt variations in iron might reflect changes in rain/monsoon intensity or local changes in source material. Sr and Nd isotope ratios of materials from the lakes' rim and vicinity display large variations ($^{87}Sr/^{86}Sr$ and eNd values of 0.7042-0.7202 and 6.0 to -8.8 for, respectively) and form two distinct mixing lines between the local basalt and two different end members. Isotopic values of core samples fall between the two lines and likely represent shifts in the relative contribution of each source.

## Measurements of dynamic characteristics of structures in Israel using low-amplitude motion

**Zaslavsky, Y. (1) Hofstetter, A. (1)**

1. Seismology Division, Geophysical Institute of Israel, P.O. Box 182, Lod

Relatively simple analysis of ambient noise, explosions and week earthquakes recorded by seismometers placed on the structure, facilitates determination for the response frequencies of the structure, the mode shapes and the damping ratios under linear condition (weak motion). The empirical observations can be used in modeling the structure and to analyze its vulnerability during strong ground shaking. Such a seismological analysis has been conducted in several types of structures in Israel: reinforced concrete buildings (RC), steel construction (S), prefabricated buildings and prestressed concrete bridge.
The RC structure is a seven-story hotel, which is located on the Dead Sea shore, with dimensions of 24x18 m and 26 m high. Measurements were taken at roof, third floor and basement. This building was excited by small underwater explosions and microtremors. Fundamental frequencies are 2.46 Hz (X-direction) and 3.27 Hz (Y-direction). Explosions allowed identification of additional five resonant frequencies.
The two prefabricated structures are residential buildings that are located in Kiryat Shemona. The buildings are only 50 m apart, each is eight stories high with a concrete shelter. The design of the two buildings is identical. We conducted six set of measurements in each building. The fundamental frequency of Building 2 (Y-direction) is 3.35 Hz, whereas in Building 1 several frequencies of 2.4 Hz, 2.56 Hz and 3.54 Hz appear. We note the anomalous behavior of Building 1 indicating a strong interaction between the soft and saturated soil at the foundation of the structure.
Six two and three story RC building in Eilat were instrumented with two and three component stations, on the roof and at free-field. Fundamental frequencies of the buildings were determined using earthquake and ambient noise, where the first resonance frequency of X and Y directions are between 8-10 Hz.
We measured the first mode frequencies of a boiler and streel structure in electric power plant. The dimensions are 40x40 m and 75 m high. We instrumented the construction with five stations (two horizontal seismometers at each station). Frequency of 1.1 Hz is attributed to the main torsional mode of the structure. First modes in X and Y direction of boiler are 0.84 Hz and 0.7 Hz, respectively.
For the first time we measured the empirical dynamic parameters of an existing bridge using force excitations: passage of truck, dropping of a heavy weight, and impact of truck on spring-board. First mode frequencies are 2.8 Hz, 3.8 Hz 4.20 Hz and.40Hz.

## Challenging the applicability of the Vs30 to characterize ground motion amplification on the surface of soil layers in Israel

**Zaslavsky, Y. (1), Shapira, A. (2), Gorstein, M. (1), Perelman, N. (1), Ataev, G. (1) and Aksinenko, T. (1)**

1. Geophysical Institute of Israel, P.O.Box 182, Lod 71100, Israel
2. University of Haifa Dept. for Geography and Environmental studies and Institute for Regulation of Emergency and Disaster College of Law and Business, Ramat Gan.

The Vs30 parameter was introduced by American seismologists to quantify different types of soil layers where different levels of ground motion amplification are expected. Thus, the Vs30 became widely used in building codes, seismic hazard assessments and earthquake risk analysis, in many countries including Israel. It is thus, assumed, that there is a correlation between the intensity of the site effect/amplification and the average S wave velocity in the upper 30 meters of the soil. Qualitatively, this assumption is widely acceptable, namely, we should expect amplification on sites where the S wave velocity is relatively low (compared e.g., to hard rock).

## Evidence for an evolving oxygen minimum zone in the Eastern Mediterranean during sapropel S1 controlled partly by the increased outflow from the Nile flood

**Zirks, E. (1), Goodman-Tchernov, B. (1), Krom, M.D. (1)**

1. Leon H. Charney School of Marine Sciences, University of Haifa, Israel

Understanding the nature and evolution of past Oxygen Minimum Zones are of great interest since they shed light on expanding OMZ's in the modern ocean. Furthermore, as we alter the nutrient fluxes emitted from modern major rivers there are known to major, often undesirable, consequence to the oxygen status in the marine basin both proximal and distal to the river discharge. Recent Global Climate Model of the nature and development of S-1 sapropel in the Eastern Mediterranean have suggested a four-layer system with a well-ventilated surface water (0-200 m) and intermediate water (200-500 m), a partially ventilated sapropel intermediate water (SIW, 500-1800 m) and long-term stagnant deep water below 1800 m. Our conceptual model is of the partially ventilated SIW flowing from Adriatic/Aegean towards the east and becoming depleted in oxygen as it is increasingly influenced by descending labile organic matter derived directly or indirectly from the Nile flood.

Most studies of sapropels in the EMS concentrate on the deep water below 1800 m water depths with only a limited number of samples having been taken from the SIW layer.

In this review, we focus on the several stations sampled between 500-1800 m and particularly on stations in the Eastern Aegean and Levantine basins. Data has been obtained from sediment cores (9509, 9501, SL112, PS009PC, SL123, 562MC) in which either benthic foraminifera fauna or redox sensitive trace metals data have been measured. The Shannon-Weaver diversity index and the Oxygen Index have been calculated on the benthic foraminifera fauna.

These cores reveal a distinct pattern in onset and offset of sapropel S1 and in the interruption of the sapropel at 8.2 ka BP. The onset of S1 was earlier in shallower water depths consistent with greater respiration rates from progressively less labile organic matter dropping from the photic zone. There was a clear spatial trend in intensity of the OMZ with benthic foraminifera surviving in SIW throughout S1 offshore Libya (562MC) and close to Crete (SL123) nearer the source of SIW. By contrast the diversity is reduced and in case of 562MC the Oxygen Index reached zero close to the Israeli coast and under the direct influence of the Nile. There was an observed correlation between the V/Al ratio (PS009PC), a redox sensitive trace metal used as an indicator for sub-oxic conditions in the water column and the calculated Oxygen Index as well as diversity on benthic foraminifera (SL112). Our study also shows that the intensity of S1 sapropel was greater in this region between its onset and the 8.2 interruption, than in the period from 8.2 to the end of S1. Indeed, close to Cyprus (9501) sapropel S1 ends at 8.2 ka BP and doesn't have a second sapropelic part.

# Deep learning approach for migration velocity errors detection in multi-parameter common image gathers

**Zisholz, R. (1,2), Reshef, M. (2), Bronstein, A. M. (3)**

1. The Geophysical Institute of Israel, P.O. Box 182, Lod 71100, Israel
2. The Department of Geosciences, Tel Aviv University, Tel-Aviv 69978, Israel
3. Department of Electrical Engineering, Tel Aviv University, Tel-Aviv 69978, Israel

Accurate imaging of the subsurface has been an ongoing challenge for the hydrocarbon industry. In order to obtain a proper image of the subsurface and its complex structures, a knowledge of an accurate model of migration velocities is required. Therefore, estimating the velocity model is an essential part of seismic imaging.
Migration velocity analysis (MVA) is used to iteratively define the optimal migration velocity field. Traditionally, the analysis is performed on Common Image Gathers (CIGs) calculated by Pre Stack Depth Migration (PSDM) using a single parameter such as offset or scattering angle. Recently an alternative approach which uses Multi-Parameter CIGs (MPCIGs) - utilizing additional parameters of the Local Angle Domain (LAD), has been suggested (Dafni and Reshef, 2012; Reshef, 2010).
Although the MPCIGs are more sensitive to velocity errors, especially in complex geological regions, they are not easy to update. In this study we suggest a Deep Learning approach for detecting and classifying migration velocity errors, for given MPCIGs, using Convolutional Neural Networks (CNN) and the LBP-TOP algorithm. We focused mostly on the 2D case, which provides 3D MPCIGs consisting of scattering angle, dip angle and depth.
In most cases, CNN-based approaches are superior to traditional image recognition algorithms, since it keeps the advantages of artificial neural networks (ANN), can better handle larger inputs and is more suitable for computer-vision applications.
The proposed algorithm includes several stages. The training stage consists of calculating LBP-TOP features and training the net with them. For this stage, a large synthetic dataset of 4800 constant depth slices, taken from 3D MPCIGs, was created. Finally, at the classification stage, a given MPCIG is sliced to constant depth slices, LBP-TOP features are calculated and then passed through the trained net. As a result, velocity error vectors are obtained. Those output velocity error vectors can then be used to update the velocity model.

## Pelagonian affinity of the Intermediate Blueschist Nappe in the Olympus-Ossa-Pelion area (Northern Greece)

**Zlatkin, O. (1), Avigad, D. (1)**

1. Institute of Earth Sciences, The Hebrew University, Jerusalem 91904, Israel

The Intermediate Blueschist Nappe, exposed within the Olympus-Ossa tectonic window in northern Greece, is thought to represent the Cycladic Blueschist Unit. We surveyed the blueschist lithologies in the Olympos-Ossa area and in the Pelion peninsula in order to define their provenance and reveal their origin.

The Cycladic Blueschist Unit differs from the Pelagonian terrane in its provenance and affinity (Cadomian vs. Avalonian-type). While the Cycladic Blueschist Unit shows the North-African provenance, the Pelagonian terrane shows the peri-Amazonian provenance and Avalonian affinity. Pre-Variscan (>310 Ma) rock samples from the Cycladic basement of Islands of Ios and Naxos were also analyzed in course of this study. They yield North African provenance. In addition, they contain significant Ordovician-Devonian (450-400 Ma) detrital zircon population, which is virtually abcent from the Pelagonian terrain. It also implies that the protolith of the Cycladic Blueschist Unit was deposited in an oceanic basin that was located in a more internal position relative to the Pelagonian, i.e. in the Vardar Ocean (not in the Pindos).

The oldest analyzed rock units ofthe Intermediate Blueschist Nappe are Variscan-aged (ca. Ma) orthogneiss and meta-igneous blueschist. The granitic pluton of the 315 southern Pelionyielded 255±3 Ma; the Ambelakia metabasites (Mt. Ossa) yielded 246±3 Ma. The youngest detrital zircons of the metasedimentary Makrinitsa Unit (Pelion peninsula) are ca. 250 Ma; its detrital age spectrum portrays a major peak at 320 Ma and ;minor peaks at 550-1000 Ma and at 1500 Maolder ages are absent, and Ordovician-Devonian (450-400 Ma) zircons are rare. Therefore, rather than resembling the Cycladic Blueschist, the Intermediate Blueschist Nappe reveals a Pelagonian provenance and likely represents the thinned continental margin of Pelagonia facing the Vardar Ocean.

## Diversion and morphology of submarine channels in response to regional slopes and localized salt tectonics, Levant Basin

**Zucker, E. (1,2) Gvirtzman, Z. (1,2) Steinberg, J. (3) Enzel, Y. (1)**

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of Jerusalem, Jerusalem 91904
2. Geological Survey of Israel, 30 Malkhe Israel, Jerusalem 95501
3. Ratio Oil Exploration, Tel Aviv

In the Levant Basin, submarine channels are abundant around the Nile deep-sea fan (NDSF), an area which is also affected by salt tectonics related to the Messinian salt giant. Here we focus on the relationship between submarine channels and obstacles formed by salt tectonics. Initially, we use methods developed for terrestrial morphological analysis and quantify channel sinuosity, width and slope in search for consistent relationships between morphometric parameters and channel response to obstacles. However, this traditional analysis did not yield robust conclusions. Then, we apply two new morphometric parameters suggested here to express the distortion of channels by obstacles: incident angle ($\alpha$), defined as the acute angle between the regionally influenced channel direction and the strike of the tectonic obstacle and diversion angle ($\Omega$), defined as the angle between the direction of the regional bathymetric slope and the average direction of the channel. These parameters illustrate the influence of the regional-scale basin geometry and the superimposed tectonic-influenced seabed patterns, on channel development. We found hyperbolic relationships between incident angle ($\alpha$) and diversion angle ($\Omega$) in which channels flowing approximately parallel ($\alpha \approx 0°$) to tectonic folds are (obviously) not diverted; channels nearly orthogonal ($\alpha \approx 90°$) to obstacles, crosscut them right through and, again, not diverted much. In contrast, channels with a general direction diagonal to the obstacles ($\alpha \approx 40°$), are diverted by ten degrees ($\Omega \approx 10°$). This diversion accumulates along large distances and significantly influences the regional development of channels around the NDSF. Noteworthy, this phenomenon of channel diversion, indirectly deteriorate normal slope-sinuosity relationships known from terrestrial studies. In light of these findings, we suggest that these new parameters can be applied to other basins, where submarine channels interact with seabed obstacles.