כנס החברה הגיאולוגית
אילת 2016

כנס החברה הגיאולוגית אילת
2016

חוברת תקצירים

19-21 בינואר, 2016, ט – י"א שבט, תשע"ו

עורך:

צחי גולן

אוניברסיטת בן גוריון בנגב

כנס החברה הגיאולוגית
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המועצה האזורית חבל אילות
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Lower crustal xenoliths of Northern Israel: zircon evidence for deeply-buried sediments, Paleozoic metamorphism and ca. 300 Ma magmatism

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The Lower crust under Northern Israel has been examined with geophysical tools, but direct samples of deep subsurface sections are restricted to a small number of drill holes and xenoliths sampled by Phanerozoic basalts. Previous studies based on Sr-Nd isotopic data and geochemical examination of granulite xenoliths from the Qarnei Hittin basaltic field (Eastern Lower Galillee; Gazit, 2005), concluded that the lower crust in this region formed during the late Proterozoic. A Sm-Nd reference isochron age of ca. 620 Ma was calculated for these xenoliths with an initial value of εNd(t=600 Ma)=+5.8, leading the authors to conclude that the lower crust below northern Israel could be a continuation of the Arabian-Nubian Shield basement. We revisited the granulite xenoliths from Qarnei Hittin studied by Gazit (2005), and examined the zircon U-Pb-Hf isotopic system in some of them. Zircons from the xenoliths show a U-Pb age spectrum that spreads from young ages (3.6-4.2 Ma) attributed to the Cover basalt, through Paleozoic and Neoproterozoic aged zircons, and few zircons of Archean age. The greatest clusters appear at ca. 300 Ma, and between 500-950 Ma. A population of prismatic zircon grains with igneous textures was dated to ca. 300 Ma, probably corresponding to an intrusion or melting event. The Neoproterozoic and older aged zircons represent the involvement of deeply-buried sediments in the generation of the lower crust, as they show a large spread both in their U-Pb ages and εHf values (from +10 to -25). In contrast, the Hf isotopic composition of the Variscan-aged (Late Carboniferous) zircons is exclusively negative (-0.7 to -20), and concentrates around εHf(t)= -6. The negative εHf(t) of the Variscan-aged zircons is a priori consistent with melting of a sedimentary portion which originated from a radiogeniclly evolved provenance; the Variscan-aged zircons seem to average the εHf values of the originally-detrital Neoproterozoic zircon grains. Evidence for intense metamorphism is also recorded in the zircons as many of them contain disrupted domains and metamorphic Th/U ratios. As these xenoliths resided at the lower crust and experienced temperatures greater than 800ºC, development of metamorphic features, as well as Pb loss and age resetting, might have occurred throughout the Paleozoic. Our new results show the involvement of a sedimentary component within the lower crust beneath northern Israel, a melting/intrusion event at ca. 300 Ma, as well as evidence for Paleozoic metamorphism.

References:

Gazit, O., 2005, Mafic granulite xenoliths from Qarnei Hittin and the evolution of the lower crust beneath northern Israel: Geological Survey of Israel Report GSI/11/05.

Natural controls on the evolution of the human-induced Dead Sea sinkholes

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of more than 5500 sinkholes along the west coast of the Dead Sea has probably the highest rate on Earth. These sinkholes are formed by dissolution of salt layer embedded in the sediments near the Dead Sea shoreline. This salt dissolution is caused by the invasion of fresh groundwater coming from the eastern mountain aquifer (eastern Judea Aquifer), triggered by Dead Sea shrinkage, i.e. the lowering of the Dead Sea level and eastward migration of its shoreline. This shrinkage is caused by human activity, namely, blockage of the Jordan River and pumping by the mineral industries in Jordan and Israel. Here we show the way of how changes in precipitation in the Judea Mountains can regulate the evolution of the Dead Sea sinkholes. We documented variations in the area of several sinkhole sites with long development history, by using the geographical information system (GIS), to estimate the history of rates of salt dissolution. This documentation was made on rectified aerial photographs and airborne LiDAR images. We have found two peaks in the salt dissolution rates, around the years 2000 and 2010. However, there is no discernable change in the lowering of the Dead Sea level during this time. Instead, we find two phases of enhanced fluxes of fresh groundwater by the groundwater levels in the boreholes near the springs of Qane and Samar (Tureibe boreholes). The comparison between the groundwater levels in Tureibe boreholes and rain quantities in Jerusalem shows that the Dead Sea groundwater system responds in a 3-4 years delay to the water recharge of the eastern Judean Aquifer. Therefore, the variations in fluxes of fresh groundwater record the long-term variations in rain quantities rather than annual variations. Accordingly, the phases of the enhanced rate of salt dissolution are in a delay of 5-6 years relative to the enhanced precipitation phases in Jerusalem.

Salt tectonics in the Deep Levant Basin. Structural Analysis of the Plio-Pleistocene succession

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Salt tectonics is known to be the predominant causes for the thin-skin deformation of the deep Levant basin, eastern Mediterranean Sea. It appears 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 a pre-stack depth migrated seismic reflection volume from the deep Levant basin in order to shed light on these issues. Data show zonation of folds, thrusts, reverse and strike-slip faults, diapirs, grabens and pop-up structures. Axes of the folds curve around a NW-SE trend. Strike-slip faults are grouped in 3 different categories, depending on their directional pattern. The main trend is N-S to NE-SW, while there is a group of secondary strike-slip faults that trend SW-NE cutting almost perpendicular to the main ones. Both sets of strike-slip faults are characterized by the growth of pop-up and pull apart structures developed at zones of regional transpression and transtension respectively. Initial results indicate that zonation in Plio-Pleistocene deformation corresponds to facies shifts in the underlying Messinian mobile unit. This low strain interaction serves as an example for initial deformation stages of salt giants.

The origin of the saline water in the north-western margins of the Yarqon – Taninim aquifer

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Yarqon-taninim (YT) aquifer, which extends from the Northern Negev area in the south to the foothills of Mt. Carmel in the north, is one of the main tap water sources in Israel. However, its westernmost part, where the aquifer is plunging to great depths, is filled with saline water of up to 20,000 mg Cl/L. New monitoring wells that drilled in the last 15 years helped in studying the extent and the nature of this saline water body. The aim of this study is to reconstruct the origin of the saline water body and the processes responsible for its chemical composition, based on the new data that collected in the new monitoring wells.

The studied saline water body has chemical composition similar to the water of the Eastern Mediterranean Sea. The main differences between the two are somewhat lower salinity of the groundwater, followed by relative deficit in Na, Mg and SO4 content and by enrichment in Ca. It seems that the Na, Mg and Ca concentrations are dictated by ion-exchange reactions and by water-rock interactions, whereas the SO4 decrease results from bacterial anaerobic reduction. The 87Sr/86Sr ratios in the water are in the range of 0.7080-0.7084 approving a Ca-Mg exchange due to seawater – rock interaction in the carbonate sequence of the YT aquifer. Ion exchange is considered to take place in a clay medium along the flow path, possibly in the Talme Yafe and the Item Formations located west of the YT.

Geomorphological insights into the evolution of the Israeli continental shelf since the Pleistocene

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Sea level fluctuations during the Pleistocene have had a great impact on the setup of continental shelves worldwide. Sea level drop during the last glacial maximum (LGM) exposed the shelf regions to extensive sub-aerial erosional forces. On the continental shelf of Israel sea level rose until it reached approximately its current level ~5000 years ago, with no evidence of major tectonic activity impacting this shelf area during the last 8000 years. Hence, it is proposed that changes in sea level on the Levant shelf were governed primarily by eustatic sea level fluctuations, at least during the Holocene and possibly during the entire last glacial cycle (LGC). This study concentrates on the reconstruction of the geomorphological evolution of the Israeli continental shelf through ~120 m sea level fluctuation during the LGC. The topography of the base Holocene unconformity was traced using high resolution single channel Sparker seismic lines, identifying at least three distinct terraces along the continental shelf subsurface. The 1st terrace exhibits extent of ~5 km reaching ~-40 to ~-55 m relative to mean present sea level (mpsl) depth with a rough and jagged surface. A genially inclined transition separates the 1st and second terrace. The 2nd terrace extents for ~5 km, reaching depths of ~-75 m mpsl, exhibiting a flat and locally channelized topography. The 2nd and 3rd terraces are separated by a sharp step (20 ms). The 3rd terrace extends for ~2 km, starting on the east with steep transition from ~85 to ~120 mpsl depth, similar to the maximum drawdown during the LGM, and continues with flat topography. The vertical position of the 1st and 2nd terraces correspond with sea levels during marine isotope stages 5a-d and 3, respectively, suggesting their formation during these periods. The different geometries and topographies of the terraces may express different environments of erosion: marine, terrestrial or a combination of both. This would imply that terraces differ in their genesis and evolution and pose the possibility of diachronicity of their formation.

Bathymetric pattern of Late Cretaceous benthic foraminifera from the Southern Tethys upwelling regime

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Benthic foraminifera live abundantly on the ocean floor, and are well known to be highly sensitive to environmental change on the seafloor. Consequently, they are one of the most commonly used faunal indicators for environmental changes and generally used to infer palaeodepths (shelf, slope bathyal or abyssal depths). The information on depth distributions of fossil benthic foraminifera is usually obtained from indirect evidence, by comparison with living representatives of fossil taxa, and or of functional morphology of modern analogs. Thus, most of our knowledge on fossil benthic foraminiferal bathymetry derives from normal oceanic marine environments, and a significant gap exists in respect to unique environments like upwelling regime. In such settings, the paleobathymetric signal is expected to be somewhat obscured by other dominant factors that known to enforce changes in foraminiferal assemblage composition, namely extreme food fluxes and oxygen depletion at the sea floor. Nevertheless, the dynamic and changes within ancient upwelling systems is known to be directly linked to eustatic changes, making paleobathmetric reconstruction highly valuable for understanding these systems.

The Late Cretaceous marine succession in Israel provides a unique opportunity for such effort. This sequence is composed of a variety of rock-types (chalk, phosphorite, chert, porcelanite, organic rich carbonate and marl), that are an outcome of upwelling regime that characterized by high productivity at the surface and oxygen deficiency at the bottom water. Here we present a detailed palobathymetric reconstruction of this succession based on the changes in benthic assemblages. We focused our investigation mainly on the Negev basins that exhibit the most prominent lithological and faunal changes due to their proximal position in respect to Tethys coastline and to the center of upwelling cell. These features allowed us to distinguish between the effects of two significant environmental factors on the benthic foraminiferal assemblage composition; sea level changes and the prevalence of a high productivity regime that induces both high food flux and seafloor oxygen depletion. Furthermore, this study demonstrates that depth distribution models based of known cosmopolitan Late Cretaceous benthic foraminifera species in normal marine settings are also applicable as proxies for paleobathymetry in high productivity regime.

Post-Glacial Resettlement of Larger Symbiont-Bearing Benthic Foraminifera in the Northern Gulf of Eilat/Aqaba

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During the last glacial period, the increasing isolation of the Red Sea caused the northern Gulf of Eilat/Aqaba (GEA) to become an extreme and hostile environment affecting the survival of many calcareous organisms. The sea water was much saltier (>50 psu) than present and colder by 40C, preventing stenohaline and stenothermic species survival. The full recovery of the planktonic and benthic foraminifera groups occurred only at the beginning of the Holocene. The timing of the reappearance of larger symbiont bearing benthic foraminifera (LBF), sensitive to lower temperatures and increasing salinity, is so far unknown. We use here new records from deep cores to trace the reappearance of this ecologically important group in the GEA.

Symbiont bearing LBF were examined in three piston cores. One core was taken from the lower part of a main submarine canyon at 532 m (167 cm long) covering the last ~2,500 years. The other two cores were taken from the western slope, at 316 m (253 cm long) and 390 m (256 cm long) covering the last ~13 ka and ~39 ka, respectively. The deep sea pelagic sedimentary record was interlayered by coarse sediment units, derived from shallow water. These units seem to be the outcome of Sediment Mass Transport (SMT) events associated with seismic activity occurring frequently in this area due to the complex fault system dissecting the gulf head. During the last glacial period no LBF occurred in the SMT units. Only facultative symbiont bearing Elphidiidae, known to have higher tolerance for hypersaline conditions, survived this extreme period and continued inhabiting the GEA. In the other two Holocene cores the LBF Operculina ammonoides, Amphistegina papillosa and A. bicirculata are common components occurring in all the SMT units in white, blackish and yellowish colors. The different color groups were dated yielding maximum age of 11,074 (yellowish) and 11,759 BP (whitish). We suggest that this age is the first evidence for the time of re-settlement of symbiont bearing LBF in the northern GEA coinciding with the reappearance of the stenohaline planktonic foraminifera.

Furthermore, dating results based on shell color show incoherence between the two cores. In the canyon core white shells yielded the youngest age whereas the blackish are the oldest. In the shallower slope core no black shells occur, yet the yellowish shells yielded a younger age than the white ones. These results contradict previous studies suggesting a linear process of pyritization (black) under anoxic conditions followed by limonitization (yellow) under re-ventilated conditions. According to this hypothesis, based on undated shells, yellowish shells should be of older age than blackish shells and white shells should be the youngest. Further dating and geochemical analysis is required in order to shed more light upon these results.

Inter-annual study of the reoxidative sulfur cycle in the water column of Lake Kinneret

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Lake Kinneret is a monomictic freshwater lake with epilimnetic sulfate concentrations of 0.5 mM, similar to concentrations suggested to have been present in the Paleoproterozoic Ocean. This study aims to understand the variability in sulfur cycling during two annual cycles of hydrographic and biogeochemical conditions, with a particular focus on the re-oxidative sulfur cycle. Hydrogen sulfide is produced by microbial sulfate reduction in the water column and is re-oxidized to sulfide oxidation intermediates such as polysulfides, zero-valent sulfur (ZVS), thiosulfate, polythionates, sulfite and sulfate.

Chemical (dissolved oxygen, sulfate, hydrogen sulfide and sulfide oxidation intermediates) and physical (water temperature, conductivity, pH, pe) measurements were made during five samplings (March 26 2014, May 4 2014, June 2 20145, November 12 2014 and January 8 2015) at the deepest point of the lake (Station A).

During the lake mixis (March 26), neither hydrogen sulfide nor sulfide oxidation intermediates were detected. During the lake stratification (May - January) hydrogen sulfide concentrations increased from <1 µM to 322 µM in November. The highest concentrations of zero-valent sulfur increased from 3.6 µM in May to 6.62 µM in November. Thiosulfate and sulfite concentrations were low in May (up to 0.11 µM and 0.54 µM, respectively). In June and November, concentrations of thiosulfate were up to 0.63 µM and 0.68 µM, respectively. Concentrations of sulfite were up to 1.57 µM and 1.14 µM, in June and November respectively. Directly after the lake mixis (January 8), concentrations of hydrogen sulfide, zero-valent sulfur, thiosulfate, and sulfite were up to 6.4 µM, 0.56 µM, 8 nM, and 15 nM, respectively. These observations indicate fast oxidation of hydrogen sulfide and its oxidation intermediates to sulfate after mixis of lake water column.

Although physical conditions were similar, in May and autumn 2014, concentrations of hydrogen sulfide in the water column were higher than during the same seasons in 2012 [1]. Despite this, concentrations of zero-valent sulfur and thiosulfate in 2014 were significantly lower than in 2012. Sulfite was the only sulfide oxidation intermediate detected at higher concentrations in 2014 than in 2012. These results suggest high interannual variability in reoxidative sulfur cycling in Lake Kinneret.

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

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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 be influenced by climatic variables such as precipitation. However, isolating the impact of these variables is difficult, as denudation rates are also strongly influenced by additional factors such as tectonic processes, topography, and lithology. This study focuses on deciphering 10^3-10^5 yr erosion patterns across Mt Hermon – exploiting its climatic gradient (1500-700 mm/yr) and homogenous lithology (Jurassic limestone).
In-situ cosmogenic 36Cl in bedrock and sediment samples is utilized in conjunction with topographic analysis to characterize the spatial distribution of erosion and examine its potential drivers. Samples for 36Cl analysis were collected from bedrock outcrops and sediments in order to quantify local erosion rates and basin average denudation rates, respectively. To examine the correlation between erosion rate and topographic indices, several hillslope transects were constructed across a range of geomorphic settings and topographic gradients. Preliminary results indicate differential erosion along Mt. Hermon hilltops. The subalpine region (1700-2200 m, ~1400-1600 mm/yr, mean annual temperature of 7o C) yielded an average hilltop erosion rate of 21±9 mm/ka (n=7), while hilltops at intermediate altitudes (1000-1600 m, ~800-1400 mm/yr) seem to erode faster at 41±17 mm/ka (n=8). These results, in conjunction with average hilltops lowering rates measured within the sub-humid Mediterranean climate across the Judean mountain range (500-600 mm/yr, 21±7 mm/ka), suggest that optimum conditions for carbonate erosion and chemical weathering exist at intermediate elevations where precipitation is high and soil and vegetation are wide spread. At higher sub-alpine elevations, although precipitation increases, soil and vegetation are scarce, while at lower elevations, precipitation is lower and hence weathering rates decrease.

The morphotectonic evolution of the Elat region since the Eocene – evidence for significant Oligocene tectonic deformation preceding the Dead Sea Transform

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The present landscape of the Elat region is demonstrating some complex structures. This is especially emphasized in the Neshef Massif, which is composed of a Precambrian basement complex that is well exposed on the high-elevated plateau of the "Moon Valley". In this large area, occupying over 70 km2, the entire Paleozoic to Tertiary sequence, over 1500 m thick, was removed by erosive processes. However, due to its substantial distance from the Dead Sea Rift western margin, this aggressive erosion cannot be relate to the present tectonic setting. In a contrary to the well exposed block, most of the missing section is preserved in the near-by tectonic blocks surrounding the Neshef Massif. In addition, the parallel existence of deeply truncated blocks exposing the Precambrian basement rocks, located to the East of the Neshef Massif, and well-preserved blocks exposing the top of the stratigraphic sequence, is hinting on a complex geological history that is not simply related to the present tectonic and erosion setting related to the Dead Sea Rift.

Evaluation of the present morphotectonic setting in the Elat region demonstrates two main landscape evolution stages:

1. A regional planar truncation was established during the Oligocene as part of the development of the Regional Truncation Surface (RTS) in the entire region of the Levant and the Red Sea. However, in order to achieve almost full preservation of the stratigraphic section within some tectonic blocks prior to the Oligocene truncation, an Early Oligocene tectonic activity along pre-existing faults is require. The outcome of this stage is a well-developed horst and graben structure.

2. Following the previous stage, deep incision below the RTS of the present drainage system is observed. However, in spite of the aggressive erosion, large parts of the stratigraphic sequence were preserved especially along water divides and mountain tops. This pattern developed since the Late Miocene as the region was uplifted and tilted toward the developing Dead Sea Rift.

Evaluation of the morphotectonic setting in the Elat region demonstrated that it developed during several stages:

1. Old (Late Precambrian) tectonic deformation shaped the blocky configuration of the region.
2. Oligocene tectonic deformation and truncation along these pre-existing faults created well-developed graben and horst structures expressing deferential truncation and preservation of the stratigraphic sequence. At this stage the Neshef Massif got its near-present configuration.
3. The Dead Sea Transform was initiated during the late Early Miocene as part of the Red Sea rifting process, and was emplaced along an old pre-existing tectonic damage zone that was activated during the Oligocene.
4. Post Middle Miocene tectonic deformation related to the deformation along the Dead Sea Transform, including uplifting and tilting of the Elat region toward the Arava Valley.

Iron isotope study of Late Pleistocene Eastern Mediterranean (EM) sapropels

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Iron chemistry in aqueous marine systems is strongly affected by redox (oxidation-reduction) reactions. Iron stable isotopes (56Fe/54Fe) are fractionated during redox transformations, and therefore can be used as a research tool in reconstructing paleoredox conditions during marine sedimentation. EM sapropels are dark organic rich (Total Organic Carbon TOC > 2%) sediments, whose formation is related to solar insolation maxima in the northern hemisphere. Greater rainfall in the Levant and water runoff from North Africa into the Mediterranean Sea, enhanced productivity and sea stratification leading to anoxic and even sulfidic (euxinic) bottom water conditions. The reducing seawater conditions precipitated iron as authigenic pyrite (FeS2), which is found in elevated concentrations in sapropels. Here we examine how Fe isotope composition (δ56Fe) in sapropels is influenced by changes in redox conditions. We study the δ56Fe and reduction sensitive trace elements (RSTE) abundances of Sapropels S5 (~119-124 ka BP) and S7 (~208-200 ka BP) and their enclosing sediments from ODP 967 located in the EM at ~2550 m water depth, south of Cyprus. We compare the δ56Fe of these two sapropels with most recent sapropel S1 (~10-6 ka BP) from ODP site 967 and from a Nile Fan site at water depth of ~1000m (site 9509). Both sapropels S5 and S7 show elevated concentrations of TOC, Ba, Fe, S, V, Mo and U relative to background sediments. The enrichments are stronger than those found for sapropel S1, particularly relative to sapropel S1 from site 9509.

A depth profile of the S5 core shows that it has an isotopically light δ56Fe compared to the non-sapropel sediments. The δ56Fe depletion is inversely correlated with Fe/Al elevation. This correlation is consistent with the "Benthic iron shuttle" model of Severmann et al. (2008) for euxinic basins whereby isotopically light Fe2+ is exported from the shelf environment to the euxinic basin to form authigenic pyrite. The δ56Fe depletions for S5 are similar in magnitude to those found in the present day Black Sea and show that strong euxinic bottom water conditions persisted during S5 formation. In contrast, a much weaker inverse trend found for sapropel S1 at ODP 967 points to weaker sulfidic bottom waters. Sapropel S1 at site 9509 shows no correlation between the two parameters indicating a complete absence of sulfidic bottom water. It is thus clear that Fe isotopes are a powerful proxy for redox conditions during organic carbon rich sediment formation. Sapropel S7 shows RSTE , Ba and TOC enrichments comparable to those of S5 and future Fe isotope work planned for this sapropel will allow us to assess the degree to which euxinic conditions influenced its formation.

InSAR-based modeling of sinkhole formation along the Dead Sea coastline

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Sinkholes commonly form by subsurface dissolution cavities that collapse after the overlying layers become mechanically unsupported. Sinkholes along the Dead Sea shorelines are preceded by, associated with, and followed by gradual surface subsidence that accompanies the cavities' growth. We use satellite radar interferometry (InSAR) to resolve the spatial and temporal relationships between gradual subsidence and sinkhole collapse. The geometry of the deflating cavity roof is determined by elastic inverse modeling of the cumulative pre-collapse surface displacements. A Coulomb failure stress criterion is then applied to calculate the stress field induced by the deflating cavity at the ground surface. We find that the induced stress field favors generation of sinkholes at the perimeters of the subsiding areas rather than at their centers, in agreement with field observations, providing important information for sinkhole hazard assessment. Our analysis also suggests that short-term deformation in consolidated gravel layers at shallow depths could be approximated by simple elastic modeling.

The experience of teaching Seismic Hazards Course for Civil Engineering students using the Problem-Based Learning Method

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Civil Engineering students at SCE - Shamoon College of Engineering, are offered a course titled "Introduction to Earthquakes". The course, which is a part of the Bachelor of Science syllabus at their third-year, is designed to endow the students with knowledge about earthquakes and seismic hazards. The course objective is to expose the students to basic concepts of earthquake seismology and to acquaint them with the computational tools used for engineering characterization of ground motion. Additionally, the students learn about the earthquake-related phenomena such as liquefaction, slope stability problems and tsunami, and receive basic tools to calculate mechanical problems associated with these phenomena.

In the Spring Semester 2015, as a pilot project, the course was taught using the Problem-Based Learning Method. The students had to independently study subjects they chose from the syllabus subject list and design models that illustrate these topics. The motivation was to present those models at an exhibition open to public at the end of the semester.

The course commenced with a frontal lecture that provided a general overview of earthquakes and their engineering consequences; also, the course objectives were defined and independent study milestones throughout the semester were outlined. The project stages included a meeting with an instructor who provided the students with guidelines for writing the preliminary report and citing relevant literature sources. A month later, the students submitted the preliminary report, where they described the theoretic background of the subject they studied, what purpose they would like to achieve when presenting the subject to public and the work plan for achieving it. The reports were examined and returned to the students in order to better prepare them for the task. To motivate the students, a competition was announced, whereby three of the best models would be showcased at the educational exhibitions of the Carasso Park of Science in Beer Sheva. The members of the referee panel who evaluated the models included experts in the field of earthquakes, as well as Carasso Park representatives.

Criteria for rating the models were: visibility, creativity, clarity, and the students' knowledge level. It was evident that the students put a lot of effort in terms of visibility and creativity; all of the models looked inviting and well-marketed. Nevertheless, the referees concluded that the knowledge level in most of the cases was not satisfactory and it was not always clear what point the students tried to illustrate. The main lesson derived from experimenting with this learning method was that students should be guided to use quality, sufficiently profound literature sources, and not rely on independent internet search.

Last interglacial sea levels in the Gulf of Aqaba

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Elevated fossil reef terraces along the north-east coast of the Gulf of Aqaba (GOA) provide information on the history of tectonic uplift and sea-level changes during the last interglacial period. GOA is characterized by fringing reefs with reef flats, representing sea levels at periods of corals growth. The GOA fills a narrow and deep tectonic depression within the continental crust and displays virtually no continental shelves. Therefore, it is interesting to examine the gulf's relative sea level signal and its implications to global sea level changes. Detailed mapping of the Aqaba reef terraces at three sites allows their zonation on basis of morphology and reef-facies. The terraces comprise fringing reefs, some with clear reef structure that includes a reef flat and a shallow back lagoon. The terraces' chronology was determined by U-Th dating of mainly calcitic fossil corals. We set the equations that are used to calculate the ages of recrystallization of the corals from aragonite to calcite and the age of their initial formation with aragonite skeleton. Terrace R3 was formed at ~132-134 ka upon the early sea level rise leading to MIS5e, and its corals were recrystallized to calcite at 128±10 ka. The wide and developed structure of Terrace R2 was formed during the stable sea level period of MIS5e at ~128-121 ka, and its corals were recrystallized to calcite at 103±5 ka. Terrace R1 was formed during a short stillstand at ~ 117 ka. The elevation and ages of the reefs indicate an average uplift rate for all sites of 0.11±0.07 m/ka. This relatively low figure enables GOA terraces to reveal the details of MIS5e sea level history. The three stillstands surrounding MIS5e documented at Aqaba can be correlated to other reef terraces considering the different isostatic effects. Therefore, not only that the Aqaba reefs provide a meaningful relative sea level pattern with implication to the eustatic curve, but the uplift rate that is significantly lower than in Papua New Guinea or even Barbados and still higher than Bahamas does not mask the details of the MIS5e sea level history. Moreover, the corals provide valuable information on ages of freshwater activity in the currently hyperarid GOA

Stream terraces in the Shefela region, Israel: distribution, characters and modification of the landscape

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Stream terraces are abundant in the Shefela region, at the foothill of the Judea Mountains, Israel. Due to cover of the nari (calcrite crust) over the hill slope, the soil is concentrated along the valleys, where the nari was removed. We surveyed the distribution and characters of stream terraces in two areas, a few square km in size each, near the settlements of Luzit and Amazya. We found that stream terraces characterize all the streams in the surveyed areas, up to the fourth drainage basin order, and assume that they may be found also along higher order. There are few to many terraces in each valley, most of them are arranged in an organized agricultural system. The different geomorphologic structure of the valleys is associated with the following three main styles of stream terraces:

Moderating-stream terraces: The terraces of this style characterize gentle stream-profiles. They are approximately 1 m high and at a distance of tens to few hundreds m from each other. They stand high relative to the downstream face of the terrace, as well as the upstream face. Their structure is of double-face wall, built of two rows of rough big stones filled with small stone and soil in between. They are usually well preserved and may indicate a relatively young age.

Modifying-stream terraces: The terraces of this style characterize moderate stream-profiles. They are approximately 2-4 m high and at a distance of several m to few tens of m from each other. The upstream face of the terraces is filled with soil until its head, changing the stream-profiles from a uniform to a terraced. The building type and preservation of this terraces style is varing and may indicate variable age for different terraces.

Modifying-ridge terraces: The terraces of this style characterize the top of the valleys, close to the ridge crest. They are usually >4 m high and include a secondary supporting minor terrace at the foot of the main one. The upstream face of these terraces is filled with soil which converges with the ground level of the ridge, tens to few hundred m away, widening the crest of the ridge.

Growth and death of the coral reef at the Eilat Port reflecting sea level history and local tectonics

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The history of coral reef growth at the Port of Eilat (the northern Gulf of Aqaba) is revealed by dating and characterization of fossil corals recovered from geotechnical cores. Twenty five cores, drilled near the jetties of the port along two shore-parallel lines within a 1000x50 m strip, range in length from ~20 to ~80 meters. Twenty one cores penetrated a fossil coral reef, ranging in depth from ~5.5 to 28 m below sea level. Radiocarbon dates of 23 coral fragments from eight cores span ~2 to 9 ka, corroborated by U/Th dates. Twenty corals were identified on the family level (predominantly Faviidae, a few Stylophora and Lobophyllia). The corals comprise a fossilized coral reef that overlies a sequence of clastic sediments that possibly represent fan delta deposits. The reefal unit is overlain in places by sands.

Most coral ages lie in the time interval between ~7-3.5 ka, overlapping with the period of high and stable sea-level as defined from the Tur Yam terrace and else-where. A few corals are dated to 8.5-9.1 ka, corresponding to early colonization of post-glacial coral reefs. The elevation of these samples is about 15-21 m, similar to the sea-level curve offshore Australia. Reconstructing the 4 m vertical slip documented on Eilat fault at Coral Beach ~2.4 ka, the calculated elevation is a world-wide record. Yet the coincidence with the Australian curve requires careful consideration of the lateral extent of this faulting event.

The Tur Yam terrace indicates that sea-level dropped from the high stand by a few meters at ~ 4 ka. No corals were dated in the Eilat Port from a few hundred years later, possibly suppressed by sediment cover; coral-growth resumed at ~ 2 ka similarly to the situation in the Coral Beach Nature Reserve. Later, only a single cor-al age of ~ 680 years was measured at the port. The reef's decline post 2 ka could be a result of the subsidence on Eilat normal fault and associated sediment waves.

Application of T-bar to Research the Mechanical Properties of the Goliath Submarine Slide on Southern Israel

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The abundance of recent kilometers-scale scars on the continental slope of Israel, and evidence of repeated local tsunami events, raise concerns of the potential hazards posed by submarine landslides. Landslides are initiated when the downslope shear stress exceeds the shear strength of the slope-forming material. The mechanical properties of slope sediments are therefore important controls of the initiation and mechanism of sliding. Moreover, these properties are affected by the history of the stresses acting on the sediment, which record unloading and loading related with the sliding event. Our study focuses on the Goliath slide, a major slide escarpment offshore southern Israel. Using the 6 meters long Piston corer newly built by the Institute of Oceanographic and Limnological Research, we sampled cores from selected sites on the Goliath slide tracks: the basal detachment surface exposed just below the head scar at a water depth of 463 m (PHS), the adjacent undisturbed seafloor at a water depth of 391 m (PSL), the dextral tail-depositional lobe at a water depth of 1,118 m (PTL) and for calibration offshore Haifa bay at a water depth of 303 m (PC2014). The maximum undrained shear stress of the sediments was measured by innovative use of T-bar, a full flow penetrometer developed at the Soil Engineering Laboratory at the Technion. The T-bar provides quick, continuous and accurate measurements of the maximum undrained shear stress. The results were calibrated against strength values obtained from conventional Vane shear testing. Other mechanical properties were characterized through a broad array of measurements, including: computed tomography (CT), Gamma density scans, direct measurements of density and water content. The results reveal low densities (~1.5 g/cc), regularly layered sediments and low shear strength throughout the PSL and PC2014 cores from the undisturbed continental slope. In contrast ~40 cm below the top of PHS there is a pronounced ~20% increase in the density, ~300% increase in the shear strength and a decrease of water content simultaneously. These results suggest that this sediment represents the exposed basal shear surface of the Goliath slide. Moreover, the high strength of PHS is indicative of high confining pressure experienced by these sediments, presumably prior to the instantaneous overburden removal by the sliding. The measured strength is in agreement with a pre-slide burial depth of ~30 m. At the slide tail we exposed a thin layer with ultra-low strength properties and density. We found that this layer contains a high concentration of organic particles, possibly related with suspension debris that settled in this area at the end of the sliding event.

The effects of normal stress on the roughness evolution of experimental faults through shear

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The evolution of fault surface roughness is studied here in direct shear laboratory experiments. Mating surfaces are produced by tensile fracture induced in prismatic limestone beams by means of the four point bending methodology. These interfaces are sheared, from an initial interlocked mating configuration, under constant normal stress conditions to a predetermined distance of 10 mm, under a constant displacement rate of 0.05 mm/s using a hydraulic closed-loop servo controlled system. The normal stresses tested in this study range from 2 to 15 MPa. The roughness evolution is measured and analyzed using optical profilometer scans of the surface geometry before and after slip and the geometrical evolution is analyzed through spectral methods. We find that surface roughness increases with increasing normal stress: under normal stresses below 5 MPa the surfaces become smoother in comparison to the original geometry, whereas under normal stresses between 7.5 MPa to 15 MPa, the surfaces clearly become rougher by damaging the host rock. Statistical spectral analyses of the roughness indicate that roughness increases with length-scale. Power spectral density values parallel to the slip orientation are found to be fitted by power-law with typical power value of 2.6, corresponding to a Hurst exponent of 0.8, assuming self-affine roughness. This power value is relatively stable for the post-sheared surfaces and is detected even when the original surface roughness does not follow a power-law form. The value of the scaling-law prefactor increases with the increasing normal stress. We find that the deformation associated with shearing initially rough interlocked surfaces extends beyond the tested surface zone, deeper into the intact rock. Moreover, the extent of the damage and its spatial distribution clearly increase with increasing normal stress. Wear loss is measured by subtracting the post-shear surface from the pre-shear surface matrices using known reference points. Our measurements indicate that wear loss and roughness evolution are both positively correlated with the mechanical work applied during the experiments. We argue, therefore, that normal stress plays a significant role in the evolution of interlocked surfaces, such as geological faults, and strongly affects the energy partitioning during slip.

Tectonic and hydrological controls on multiscale deformations in the Levant: numerical modeling and theoretical analysis

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Understanding the role of the dynamics of water bodies in triggering deformations in the upper crust and subsequently leading to earthquakes has been attracting considerable attention. We suggest that dynamic changes in the levels of the water bodies occupying tectonic depressions along the Dead Sea Transform (DST) cause significant variations in the shallow crustal stress field and affect local fault systems in a way that eventually leads to earthquakes. This mechanism and its spatial and temporal scales differ from those in tectonically-driven deformations. In this study we present a new thermo-mechanical model, constructed using the finite element method, and extended by including a fluid flow component in the upper crust. The latter is modeled on a basis of two-way poroelastic coupling with the momentum equation. This coupling is essential for capturing fluid flow evolution induced by dynamic water loading in the DST depressions and to resolve porosity changes. All the components of the model, namely elasticity, creep, plasticity, heat transfer, and fluid flow, have been extensively verified and presented in the study. The two-way coupling between localized plastic volumetric deformations and enhanced fluid flow is addressed, as well as the role of variability of the rheological and the hydrological parameters in inducing deformations in specific faulting environments. Correlations with historical and contemporary earthquakes in the region are discussed.

Evidence for aragonite deposition in flood plumes of the Dead Sea

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Several studies demonstrated that authigenic aragonite precipitates from the Dead Sea (and Lake Lisan) in response to mixing between flash-floods and lake brine. However, the exact timing of the aragonite precipitation was not robustly established. Here we addressed this issue by measuring the chemical composition (pH, Na+, K+, Ca2+, Mg2+, Sr2+, Cl-, Br-, B), alkalinity, DIC and d13C of flood plumes. In total seven cross shaped sampling transects (3 in Wadi Arugot, 3 in Wadi Dragot, and 1 in Wadi David) were conducted and 47 samples were collected. Our results indicate that (a) in the holomictic conditions of the modern Dead Sea flood plumes mix entirely with the underlying brine within a few days and that (b) aragonite precipitates within flood plumes of the modern Dead Sea. The amount of aragonite deposition is estimated between 0.2-4.4 mole·m-2. This value is surprisingly close to the 0-2.8 mole·m-2 estimate of Barkan et al (2001) that was calculated following the extreme winter of 1992. This observation indicates that the amount of aragonite deposition is not a direct measure of flood discharge. Furthermore, it suggests that the convention of summer precipitation of aragonite laminae should be reevaluated. We propose that the deposition of aragonite laminae requires flood alkalinity values that are much higher than those observed in modern floods. This scenario may occur during periods of high dust loads and high vegetation cover.

The Provenance of the Fine Fraction of the Cambrian Siliciclastic Sequence of Israel; an Isotope Geochemistry Study of Heavy Minerals, Clays and Feldspars

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Studying the provenance of the Cambro-Ordovician sedimentary sequence of Northern Gondwana has great implications on our understanding of the continental-scale erosion and sedimentation that took place in the aftermath of the Pan African Orogeny. In this study, heavy minerals, clays and K-feldspars were studied using isotope-geochemistry of Sr, Nd and Pb in order to identify the provenance of these sediments in the section of Eilat, southern Israel. Geochemical measurments suggest that these sediments are a mixture of sediments derived from several sources of distinct geological and geochemical nature; the adjacent juvenile Arabian Nubian Shield, alongside remote, ancient remobilized terrains. These results complement previous studies that focused primarily on heavy minerals and zircons in particular. Furthermore, these results demonstrate the strength of this methodology in the field of provenance, and can be applied for comparison with future studies of adjacent siliciclastic sedimentary cycles.

The Role of External Forcing characteristics on Hillslope Denudation Flux

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Hillslopes are a prominent landscape feature of the Earth and main suppliers of sediments to the fluvial routing system. Despite their importance for landscape evolution and for surface mass redistribution, the meso- and macro-scales physical laws and parameters that control sediment flux out of soil ¬¬mantled hillslopes are still debated. Leading theories consider either a linear relation between hillslope angle and the total sedimentary flux, which leads to a diffusion-like transport law, or more recently, a non-linear relation that emphasizes the role of a threshold slope. Nevertheless, a universal agreement is still missing, and its dependency on the characteristics of the environmental external forcing that act on the hillslope (climate, tectonic and biological activity) has not yet been thoroughly investigated.

In this work, we employ a granular dynamics numerical model, in a setting that simulates the regolith layer of a soil-mantled hillslope. This model operates at the granular, micro-scale level, by solving granular interactions in response to body and surface forces. We examine slopes that are below the angle of repose for the simulated grains, such that grain motion downslope is the result of the external perturbations applied to the system, consistent with the conditions of natural hillslopes. The external forcing is manifested by assigning each grain with an acceleration drawn randomly from a configurable range. An increase in the bounds of the range represents forcing of larger magnitude (or amplitude), while an increase in the number of time steps between draws represents an increase in the forcing wavelength. The grains thus respond to the combination of contact forces, body forces, and the random acceleration equivalent forces. The numerical model allows meticulous measurement of the total flux and the flux and velocity profile of sub-surface layers (usually a few grains in thickness). We can additionally observe the behavior of individual grains and the interactions with their surroundings at high resolution.

Our results reveal a non-linear relation between flux and slope under all tested conditions. We further find indications for the control of forcing frequency and magnitude on the total flux, and on the flux-depth profile, where low frequencies and high amplitudes promote instability and facilitate higher flux values. Additionally, we observe a shift in the inclined layer dynamics, with creep motion at low angles and landsliding at higher slopes. Our results indicate that the external forcing effectively reduces the angle of repose, and that the depth distribution of the grains velocity and the total flux depend on a combination of slope angle and external forcing magnitude and frequency.

In-situ 21Ne in Precambrian and Cambrian sediments and implications for surface process rates along the margin of northern Gondwana

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We present cosmogenic 21Ne concentrations measured in 20 Precambrian arkose (Zenifim formation) and Cambrian sandstone samples (Amudei Shelomo and Shehoret formations) collected from the Sinaf and Ramon boreholes and from a shielded outcrop at Timna (Amudei Shelomo pillars). 21Ne is a stable isotope produced in-situ in quartz during episodes of exposure to cosmic radiation. While 21Ne has been frequently used in Quaternary geomorphological research, this is the first time it has been used in the investigation of extremely old (>107 yr) sediments. Cosmogenic 21Ne concentrations measured from the Zenifim formation at Sinaf are low compared to the background signal. Although speculative, these low concentrations may suggest very fast erosion rates at the source of these sediments and rapid transport and burial, which is consistent with the immature nature of Sinaf arkose. In comparison, cosmogenic 21Ne concentrations from the Zenifim formation at Ramon borehole are much higher, 2-3x106 atoms/g quartz, suggesting slower erosion rates at the source area and/or prolonged transport to the depositional basin. This prolonged source-to-sink cycle could be explained by a hypothesized difference between the depositional environment of Sinaf (alluvial fan) and Ramon (sea margin). 21Ne concentrations measured in the Cambrian Amudei Shlomo and Shehoret formations are ~2x106 atoms. Similar concentrations were measured in samples collected from the boreholes at depths exceeding 600 meters and samples collected from shielded outcrops, suggesting rapid and recent erosion of the overburden at the Timna area.

While this research is at its infancy and further work is still needed to determine erosion rates, the preliminary results of this novel application of stable cosmogenic nuclides shows great promise for paleo-geomorphological research. It can be used to assess long-term erosion rates and may provide a new understanding of surface processes shaping the northern Gondwana margin over the entire Phanerozoic.

Drainage basin evolution on the exposed Israeli shelf during the Messinian Salinity Crisis

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The sea level drawdown of the Messinian Salinity Crisis (MSC) exposed the Levantine margin to subaerial geomorphological processes. To understand these processes we interpreted the 'Isramco' 3D seismic reflection volume, located offshore Israel. The data indicate that an erosional surface was formed on the exposed continental shelf. Thirty six discrete drainage basins developed on this surface were recognized across an area of ~100 km2 with drainage areas ranging between 0.1-12 km2. Dendritic channel systems (up to 5th order) drained the basins and incised up to 70 m below the erosional surface. These are low sinuosity (<1.1) and high width-to-depth ratio (10-20) channels and are sub-parallel. Their longitudinal profiles are linear to concave with average gradients of 0.042-0.055. The interfluves on the shelf in-between the channels are generally convex. Drainage densities are 5.5-11 km-1 with a mean value of 7.8 km-1.

These sub-paralleling low sinuosity MSC channels indicate formation during low Mediterranean Sea levels, probably when incision into the exposing shelf followed the regressing Messinian coastline. As incision migrated upslope, the catchment area of each channel increased and with it discharge and stream power. The channels with highest rates of catchment area expansion dominated and cut the shorter channels from their respective upslope watershed on the shelf. Drainage density of a region on a particular lithology is in part controlled by climate. The density of the abovementioned 36 drainage basins was compared to 360 contemporary drainage basins in Israel with similar morphology and lithology, but varying climatic conditions. The average drainage density on the MSC exposed shelf in the study area is similar to densities under Mediterranean climate characterized by mean annual precipitation of 600-700 mm - wetter than the contemporary climate of that region.

The Elat area as a field school for Geology

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The goal of the present report (Beyth and Calvo, 2015) briefly presented in a poster and available from the Geological Survey of Israel, is to make the unique geology of the Elat area more attractive to the student, amateur geologist and tourist based on the up-to-date research and recent mapping. Special efforts were given to areas around the Israel National Trail. The final goal is to make the area accessible to each visitor through a mobile multi-sensory cellular application which will be available to iPhone and Android user. A similar approach was presented previously for the Timna Valley by Beyth and Calvo (2014). The stratigraphy and structure of the well-exposed rocks in the extreme arid desert climate of the Elat area document the evolution of three major processes from Neoproterozoic to the Holocene and thus make the geology of this area so unique. The extensive research done here has turned this region into a field laboratory for geoscience students. The Elat sheet geological map was recently prepared with explanatory notes attached by Beyth, Eyal and Garfunkel (2012 and 2013) as part of the 1:50,000 scale geological mapping project of the Geological Survey of Israel. The geological map and the explanatory notes are available from the Geological Survey of Israel web-site (www.gsi.gov.il). Names used and trails mapped are from the Mapping Center of Israel, hiking trail map of the Elat mountains 1:50,000, Sheet 20 (in Hebrew). The major geological sites described are from north to south: Raham Syncline; Themed Fault; Mt. Neshef and Mt. Uziayhu; Amram Block; Amir Syncline; north and south Roded Block including Yedidia, Shelomo and Asa mountains; Shelomo Graben and Yotam Graben; Rehavam and Taba synclines; east and west Shehoret Synclines; Gishron Fault; north and south Elat Block including Mt. Tzefahot; Yotam Caldera; Givot Shehoret and Avrona Playa. The Elat 1:50,000 scale geological map was divided into eight 1:25,000 scale maps with marked numbers for the different field stations. Short explanatory notes and coordinates for each station are attached to the maps in excel tables. The location of the stations relating to the explanatory notes of the 1996, 2001 and 2010 field trips of the Israel Geological Society are integrated and the full field trip guides are available from the Israel Geological Society web- site (www.igs.org.il). Generalized site descriptions are included in the poster (for full references list see Beyth and Calvo, 2015).

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Sources of iron in the sediments of the Gulf of Aqaba

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The Gulf of Aqaba is an oligotrophic marine system situated in hyperarid region with negligible atmospheric precipitation, rare seasonal flashfloods and robust aeolian dust plumes from adjacent deserts. This study is aimed to provide constraints on the biogeochemical cycling of redox-sensitive elements in the sediments of the Gulf of Aqaba, with a focus on potential sources of these elements in the sediments.

Redox zonation was studied in the upper 30-50 cm of the sediments in shallow waters (up to 420 m) [1] as well as in the upper 90 cm of the sediments in deep waters (694 m). The speciation of iron was studied in airborn dust and material from seasonal creek channels that were suggested as significant sources of redox-sensitive metals in the sediments of the Gulf of Aqaba [2]. Fe(II) extracted from carbonates (mainly siderite and ankerite), comprised a mean of 5% of the highly reactive iron (FeHR) pool in both the dust samples and sediments, whereas the reduced iron pool in dry creek beds was 1-2%. The Fe(III) fractions associated with easily reducible iron (oxy)hydroxides (e.g. ferrihydrite and lepidocrocite) were similar in both aeolian dust and sediment samples (12% and 16% of the FeHR pool respectively). In contrast, the content of these minerals in seasonal stream beds was lower (5%). The composition of the largest FeHR fraction, which includes hematite and goethite, was similar in dry creek channels and sediments collected at 694 m depth (66% and 65% of FeHR respectively). Near-shore sedimentary iron content in the vicinity of the creek channels was lower (29% of FeHR). However, the increase in pyrite content and the presence of free H2S at these depths [1] may reflect enhanced consumption of reactive iron due to its reaction with abundant hydrogen sulfide. Less reactive iron mineral (magnetite) content varied in dust storm samples, seasonal creeks, and sediments from both shallow and deep waters with averages of 6%, 27%, 14% and 19% respectively. The similarities between iron speciation in the highly reactive fraction in sediments with average of FeHR content of 51% and aeolian dust (FeHR of 56%) implies strong influence of the dust deposition on the biogeochemical cycling of iron in the Gulf of Aqaba, whereas highly reactive iron content in desert floods does not exceed 34% (average FeHR of 31%).

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Earthquake-explosion discrimination using diffusion maps

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Discrimination between earthquakes and explosions is not only an essential component of nuclear test monitoring but it is also important for the maintaining the quality of earthquake catalogs. For example, wrong classification of explosions as earthquakes may cause the erroneous estimation of seismicity hazard.
The currently used discrimination methods provide a partial solution to the problem. In this work, we apply advanced machine learning methods and, in particular, the diffusion maps for automatic earthquake-explosion discrimination. Diffusion maps enable us to construct a geometric representation of the seismograms that capture the intrinsic structure of the signal. As a pre-processing step, the seismograms are converted to the normalized sonograms.
We demonstrate our approach on a data set comprising seismic events from the Dead Sea area that were taken from the seismic catalog of the Geophysical Institute of Israel for years 2004-2014 with duration magnitudes Md≥2.5. The diffusion-based algorithm provides correct discrimination rate that is more than 90%.

Gravity surveys for subsurface explorations: faults locating near Bet-Arava, Tiberius, kibbutz Gezer and Caesarea\Jisr az-Zarqa

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The Geophysical Institute of Israel (GII) is a geophysical service provider and has been conducting gravity measurements for commercial and academic subsurface explorations. Our work includes locating faults, shallow subsurface voids, salt diapirs and other local geologic structures. The gravity method is based on measuring changes in the earth's gravity field caused by horizontal and lateral density variations within the subsurface. The gravity measurements are made using a highly portable land gravimeter (Lacoste & Romberg, with an accuracy of 0.01 mGal) and a differential GPS system. Using the gravity method is a relatively simple and fast way to explore the subsurface either as a "standalone" method or, more commonly, with other geophysical methods. Here, we demonstrate recent results of gravity surveys made along four 2D high-resolution seismic lines, near Bet-Arava, Tiberius, kibbutz Gezer and Caesarea\Jisr az-Zarqa. These surveys were conducted for the objective of fault mapping. Free-Air and Bouguer anomalies are calculated using standard measurement corrections (drift, tide, and latitude) and datum corrections (elevation, and density). The ~8 mGal free-air anomaly in Caesarea\Jisr az-Zarqa line exhibits a significant change of slope above an extensive fault plane, whereas in the other surveys a residual Bouguer anomaly was calculated to emphasize short-wavelength anomalies. These anomalies are of amplitudes smaller than 1 mGal and associated with shallow structures.
The results show significant correlation with the seismic data and contribute to a more accurate interpretation of geologic structures, faults location, and characterization. These results can be used for advanced analyzing and modeling in further research. All gravity measurements acquired during those surveys are added to the National Gravity Database of Israel managed by GII.

The decomposition of dimethylpolysulfanes in aqueous systems in the absence of solar irradiation: kinetics, products and mechanisms

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Dimethylpolysulfanes (MeSnMe, DMPS) are formed during the decomposition of algae in both marine and freshwater environments, as well as through the oxidation of sulfur-containing organic matter. 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.

In aqueous media and the absence of sunlight dimethylpolysulfanes with three or more sulfur atoms undergo disproportionation reactions. Two DMPS molecules with n sulfur atoms react to form one molecule with n+1 atoms and another with n-1 atoms. Dimethyldisulfane (Me2S2) decomposes into currently unidentified products. Dimethylpolysulfanes with ten or more sulfur atoms may decompose into S8 and dimethylpolysulfanes with a congruently smaller number of sulfur atoms.

We measured the kinetics and determined the products of the decomposition of dimethyldisulfane, dimethyltrisulfane, dimethyltetrasulfane and dimethylpentasulfane. The decomposition rates were measured as a function of temperature, pH and dimethylpolysulfane concentration in order to calculate the reaction rate constants and reaction orders for this complex decomposition process.

These kinetic data allow an estimation of the residence time of these compounds in natural systems to be made. In the absence of sunlight, in the natural aquatic systems we have DMPS concentration data from, - Lake Kinneret, Israel and the pipes leading from the water reservoir at Perth, Australia, the half-lives of DMPSs vary from months for Me2S5 to million years for Me2S3.

Is the intensive veining of the metamorphic rocks of the Hatrurim Formation a retrograde process or a weathering product?

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Most of the country rocks of the Hatrurim Formation are crisscrossed by light-colored veinlets of variable directions and dimensions. The country rocks were dated to have formed between 16 to 3 Ma ago as a result of near surface combustion of bituminous chalks, followed by dehydration and decarbonation processes. Jointing and vein filling by rehydrated and recarbonated phases were considered as retrograde processes that occurred during cooling or even while high-T metamorphism was still going on.

The assumption of a retrograde phase closely related to the prograde metamorphism, was recently re-examined: veins in spurrite and gehlenite prograde rocks were sampled in several outcrops in the Hatrurim basin near Arad and their carbonate bearing minerals (calcite, aragonite, vaterite) were dated by the 230Th–234U dating method. The ages of most veins are significantly younger than the combustion events and range between 250 ka to 30 ka, with only a minority being older than 450 ka (the method limit). Analysis of the dated veins did not detect any correlation between the type of veins (orientation, width, composition) and age of filling. The 'lighter' (up to -14‰) d18O values of the carbonate veins, compared to the present-day rains in the area, suggest that crystallization in the veins was in equilibrium with Pleistocene-Holocene meteoric water. Evidences of such 'light' paleo rains were reported in speleothems and fossil waters below the Negev dessert. Intermediate d18O values imply on mixing of 'light' water with "normal" Negev rain of -4‰ to -5‰. δ13C values of the veins cover a wide range of -5 to -18‰. The very low values reflect a contribution of dissolved carbon from the metamorphosed country rock, or may be the result of CO2 adsorption on a primary formed Ca hydroxide, while the 'heavier' C was contributed from the Negev flood waters. 87Sr/86Sr (0.70786–0.70811) ratios indicate interaction between rain-derived circulating solutions and country metamorphic rock-affected water.

We suggest that contrary to the previously assumption, veins in the Hatrurim Formation are much closer related to young weathering than to retrograde metamorphic processes. The intensive veining and the vein filling by low-T phases postdate the high-T events and occurred in different time periods since the termination of the prograde metamorphism (Pliocene) till today, in which intermittent rain reacts with recarbonated metamorphic rocks to yield highly alkaline aqueous solutions. Cr zoning in several veins points toward multiple episodes of vein filling that are related to changes in oxidation/reduction and pH conditions of the fluids.

Sustainability on the Fringe: An Investigation into the Fuel sources of the Timna Valley's Iron Age Copper Industry

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For roughly 150 years during the Iron Age (11th – 9th centuries BCE [3,100 – 2,900 ybp]), the copper mines of the Timna Valley experienced their greatest degree of exploitation until the modern era, and served as one of the largest industries of the valuable metal in the southern Levant. This, however, came at no small cost to the region's other natural resources. As the copper ore itself was found in relative abundance, fuel was one of the greatest limiting factors for the industry's continued activity. The arid desert environment of the southern Aravah, climatically similar then to what is experienced today, provides little by way of large, adequate and sustainable vegetation for the production of charcoal fuel. Consequently, unless certain other subsidizing measures were implemented in order to ensure the metallurgical industry's high demand for fuel, the workers would have needed to continually expand their gathering range until the endeavor likely became too costly and the environs denuded of its vegetation. Given these considerations, two slag mounds dating to the Iron Age were probed in multiple stratigraphic horizons, and the charcoal gathered from within analysed and identified on the basis of their wood anatomy. The results were able to give insight into the selective preferences made by the workers as well as changes in the fuel sources throughout time and therefore may provide an answer to the question of why the industry came to a sudden halt by the 9th [2,900 ybp] century BCE.

High-resolution temporal dynamics of planktonic foraminifera assemblages from sediment traps in the modern Gulf of Aqaba waters

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Planktonic foraminifera (PF) are one of the most common calcareous groups of pelagic organisms in the open ocean. The global distribution dynamics of these unicellular organisms are controlled by oceanographic and climatic conditions. Although PF dynamics have been shown to follow seasonal to monthly cycles, the documentation of these patterns is limited and even more so on the higher-resolution, daily-timescale, imposing strong limits on our understanding of PF temporal and vertical dynamics and inhibiting the interpretation of down-core sedimentary marine records of PF assemblages.

The Gulf of Aqaba (GOA) is recognized as a “natural laboratory” for the study of open ocean processes at high temporal resolution. Previous studies of PF in the GOA focused on standing-stocks and species assemblages obtained from plankton tows and cores, yet information of the open water population dynamics and their fluxes to the sedimentary record are nonetheless still very poorly constrained. Similarly, there is currently no knowledge of the temporal size or composition variations of PF in the GOA.

Here, we report the first systematic time-series of open-water PF assemblages in the northern GOA, collected using sediment traps. The traps, deployed vertically at five different depths (600m water-depth), provide monthly resolution from January 2014 until present. These efforts aim to characterize the interplay between PF fluxes, species assemblages, distribution and sedimentation rates, in the context of environmental conditions such as nutrient availability, water column stratification, and of other water column particulates. Quantifying PF fluxes to the sea floor will have important implications for the reconstruction of paleo-productivity and paleo-oceanography of the northern GOA.

Our results demonstrate strong seasonality of PF fluxes, whereby low fluxes are observed during the spring-summer months (min: 31±35 Ind. m-2 d-1), gradually rising to higher fluxes during the autumn-winter (max: 766±432 Ind. m-2 d-1). This pattern follows the bulk particulate mass flux and primary productivity during 2014, but does not correspond to previous studies of the PF standing stock in the GOA from 1974-1976, possibly reflecting a change in the PF population over recent decades; indeed, a notable example is the total absence of G. sacculifer from our samples, despite the fact that it used to be the most dominant species 40 years ago. These discrepancies may also stem from our poor knowledge of the temporal and spatial PF distribution patterns in the

GOA, emphasizing the importance of the current study. Moreover, the results indicate that the most significant PF size fraction in terms of mass and fluxes is in the range of 63-125µm (83%, compared to 17% and 0.25%, for the 125-500µm and of 500-1000µm size-fractions, respectively), which has not previously been studied in this area, and only very rarely in comparable studies around the world.

The effect of Petrophysical and Hydrogeological properties on CO2 storage in the saline Jurassic aquifer of the Negev

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Anthropogenic emission of CO2 and related climate change is one of the most important environmental challenges facing our society. A promising solution to this problem is CO2 Capture and Storage (CCS) in deep geological formations. In Israel, hydrogeological and economic considerations identified the Jurassic middle aquifer in the Negev as the prime target for CO2 storage. The aquifer consists of a highly porous and permeable sandstone layer (Inmar formation), overlaid by alternating shale, sandstone and carbonate layers, some of which are fractured (Daya, Sherif and Zohar formations). The top of the aquifer is sealed by thick shale units (Kidod, Beer Sheva and Haluza formations) that are likely to act as a barrier for CO2. In order to identify the key aquifer properties which control CO2 migration and trapping and feasible storage capacities and injection rates, we perform sensitivity analyses by running tow-dimensional simulation using the TOUGH2 simulator. We show that an increasing porosity and decreasing permeability cause a decrease in the aerial extent of CO2 plume. A decrease in residual gas saturation and in water retention (through the van Genuchten parameter), on the other hand, enhances the extent of the CO2 plume. In our simulations, the maximum percentage of CO2 leaked into the caprock was ~0.15% of the total injected CO2. Our results help understanding the processes taking place when injecting CO2 to the subsurface and will assist in selecting an appropriate injection site and planning of a monitoring program.

Towards better Attenuation Curve for the 1927 Jericho Earthquake

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On July 1927 a crustal rupture generated a strong earthquake in the northern part of the Dead Sea, Israel. Up to five hundred people were killed and extensive destruction was recorded, even in 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 is low, the seismic intensity in places far from the focus might by greater than expected from a standard attenuation curve. In this work we use the refraction method and the Multi Analysis of Surface Waves (MASW) method to estimate seismic wave velocity at anomalous sites in Israel. From the 133 sites that Avni (1999) investigated and estimated seismic intensities, we chose 10 amplification sites and 14 reduction sites. We expect that the anomalous amplification and reduction in certain sites are direct results of low and high shear velocity, respectively. According to preliminary results from Zemach (south of the Sea of Galilee) which had seismic intensity VII, rather than VI as expected, the average shear wave velocity in the shallowest 30 m (Vs30) is 230 m/sec. This is significantly lower than the standard (~750 m/sec), and indicates local amplification. After measuring all the sites we will be able to build a more accurate attenuation curve which will improve existing maps of seismic risk.

Ground motions in Eilat Induced by Scenario Earthquakes and intended for Economic Damage Evaluation

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The city of Eilat is situated within the active deformation zone of the Dead Sea Transform (DST), with several branches of the fault system running within or adjacent to the urban parts of the city. Historical accounts supported by paleoseismological observations indicate that Eilat-Aqaba region has experienced devastating earthquakes.

As a prerequisite for earthquake economic damage evaluation (Finzi et al., this meeting), we use an updated regional seismo-tectonic model (Davis and Dor, 2014). Probabilistic analysis using the new model, shows that the 10% and 2% in 50 years top bedrock (Vs = 760 m/s) Peak Ground Accelerations (PGA) for Eilat are on average 0.27g and 0.52g, respectively (and >30% higher, on average, than the corresponding SI413 PGA values). The input ground accelerations for the Hazus damage and loss estimation models are based on shakemaps generated by the open source software OpenSHA, and include five scenarios ranging from moderate to very strong earthquakes (M=5.5, 6.5, 6.6, 7.0, 7.5), representing realistic and/or historical events. The scenarios were selected with intent to capture the full scale of potential ground motions (0.12-0.40 g PGA at top bedrock) and subsequently, the changes in damage levels. The scenarios emphasize the proximity of the rupture to Eilat as the major factor that affects the strength and spatial distribution of ground motion throughout the city, with the M=6.5 epicenter within the city on the Eilat fault generating the strongest motions.

The city is situated on unconsolidated coarse alluvial to fine sediment fill of highly varying thickness and thus requires a model for local ground conditions and seismic amplification. Local amplification or site effects can be assessed using: i) analytical computations based on a geothechnical model for the subsurface, ii) Empirical data from earthquakes and micro-tremors, or c) site effect parameters such as average shear wave velocity. In the case of Eilat, a local shear wave velocity map (Vs30) was created based on existing data that was collected throughout the years in different parts of the city. The Vs30 map is used during the generation of the shakemaps as a site factor in the seismic attenuation relations.

Patterns of submarine channels in the southern continental slope of the Levant Basin, late Messinian and Pleistocene - Quaternary examples

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In this study we investigate submarine channel patterns in the subsurface of the southeastern part of the Levant basin using 3D seismic data. The study focuses on the top of the Messinian surface and the overlaying Pleistocene to Quaternary sedimentary section. Within the section we map paleo-channel systems and examine their morphology and possible origins. The work presents two distinct flow directions that are likely associated with different mechanisms and settings. On the top Messinian surface a single channel is identified, extending form the Levant continental slope to the northwest. This is the only channel visible in the top Messinian horizon and it is divided into two segments: (A) an eastern canyon-like segment incising the continental slope (B) a western segment with a curvilinear appearance that begins on the edge of the continental slope and extends northwest out of the study area. Examining the channels western segment through cross sections, reveals an erosional pattern with no evidence of sediment deposition such as channel fill or levee systems. This could suggest a bypass of sediments to the deeper part of the basin. In contrast, channels in the upper Pleistocene to Quaternary show a developed complex channel fill and levee systems. This section appears in the seismic data as a chaotic high amplitude section and is confined below by a low amplitude, laminated section. The chaotic section onlap the older laminated strata on the continental slope which confines it's extant. The occurrence of two different types of channel morphologies suggest different depositional settings and sediment transport mechanisms in the southeastern Levant Basin that will be further investigated in the second part of this study.

A direct analysis of C-H-O liquids coexisting with mantle material

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The dominant volatile components in the upper mantle are H2O and CO2. Studying the lherzolite-H2O-CO2 system is important in determining the phase abundance and the fluid and melt compositions, thus understanding melting and metasomatism of the mantle at subduction zone conditions. Previous studies focused mainly on lherzolite-H2O systems and lherzolite-CO2 systems but little is known about the lherzolite-H2O-CO2 system due to difficulties in measuring the liquid composition and determining the volatile species in it.

Here, I present for the first time, liquid compositions determined directly via a new technique we developed, the QTS technique combined with the cryogenic technique. Using these techniques, the phase diagram of lherzolite- H2O-CO2 system was determined between 4 and 6 GPa and 900 to 1100 °C in order to determine of location of solidus and the major element composition of both solid and liquid. Two compositions were studied, both containing 10 wt% H2O. The first composition contained 1 wt% of CO2 while the second composition had 5 wt% CO2. Our results indicate that at 4 and 5 GPa the fluid in equilibrium with hydrous lherzolite containing 1% CO2 has ~50-60 wt% H2O and ~0.5-0.7 wt% CO2 at 900°C. A hydrous melt is stable at 1000-1100 oC, containing ~35 wt% H2O and ~3 wt% CO2. The solidus at 6 GPa is between 1000 and 1100oC.

At 4 GPa, a hydrous carbonated melt is in equilibrium with a hydrous lherzolite with 5% CO2 containing 25-35 wt% H2O and ~12-13 wt% CO2. At 5-6 GPa, a fluid phase is stable with ~50-60 wt% H2O and ~5 wt% CO2 at 900°C while a hydrous melt is stable above 1000oC. At 5-6 GPa, the solidus crosses between 900 and 1000 oC.

The solidus of a hydrous lherzolite with only 1 wt% of CO2 is identical to that found for hydrous lherzolite. With increasing amount of CO2 in the system, the solidus temperature decreases. With increasing amount of CO2 in the system, the melt becomes richer in Ca and Mg and poorer in Si and Al.

Fluids and melts in equilibrium with carbonated hydrous eclogite system at 4-6 GPa and 900-1200°C

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The solidus of eclogite is significantly lower than that of peridotite. Eclogites play a significant role in geodynamic processes, transferring large amounts of basaltic material and volatiles (chiefly CO2 and H2O species) into the earth's mantle via subduction .Previous studies focused on a two end-member systems: either carbonated or hydrous eclogites. Here, for the first time we address a hydrous carbonated eclogitic system in order to define the position of its solidus and determine both fluid/melt and solid phase compositions. Experiments were conducted at 4-6 GPa and 900-1200°C using a rocking multi-anvil press. Equilibrated fluids/melts were analyzed using LA-ICP-MS for total metal oxide content using the freezing technique. H2O and CO2 content were determined by mass balance calculations. Solid phases were chemically characterized using an EPMA. Redox conditions were calculated using an Ir-Fe sliding redox sensor.

Garnet and clinopyroxene are present in all experiments, assembling the eclogitic rock. A carbonate phase was detected at all temperatures at 4 GPa and at temperatures below 1200oC at 5 and 6 GPa. Coesite was observed at all pressures below 1200oC. At conditions where coesite is stable, the fO2 is buffered between FMQ~-2 at 4 GPa to FMQ~ -3 at 6 GPa shifting to more reduced conditions after the dissolution of coesite and magnesite into the melt phase. At 4 and 5 GPa hydrous carbonated fluid is present at 1000oC. With increasing temperature, the solidus is crossed and a hydrous carbonated melt is stable at 1100°C. At 6 GPa a relatively smooth decrease in the H2O and CO2 content in the liquid phase with rising temperature is observed, suggestive of the presence of a supercritical fluid. The second critical endpoint is thus defined in this system at 5.5 GPa and 1050oC.

Comparison of the composition of the liquid phase to the compositions of the high density fluids (HDF) found in micro inclusions in diamonds, suggests that the liquid compositions fall along the array formed by the HDFs, between the silicic and the low Mg carbonatitc end-members. As such, the hydrous carbonated eclogite system is a possible source rock for the intermediate low-Mg to silicic HDF's.

High resolution dating of normal faults offshore Israel and inferred displacement rates: implications for salt tectonics and landslides

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Numerous normal faults expressing thin-skinned salt tectonics are detected along the Levant continental slope, 15-30 km west of the Israeli coast. The beginning of faulting along these faults was interpreted many years ago as Late Pliocene or Early Pleistocene. However, considering that only a few years ago the Plio-Pleistocene boundary was considered to be 1.8 Ma and now it is considered as 2.6 Ma, the uncertainty about the beginning of faulting is about 30%. In addition, to date, there is not even a single report about displacement rate and if and how it changes with time.

The purpose of this study is to better date these faults and to calculate the rate of displacement. We anticipate that results will contribute to the understanding of how faults interact with slope failure processes (landslides), sedimentation, and salt tectonics. In particular, this knowledge will allow better assessment of geohazards risking offshore infrastructures (i.e., gas pipelines). For this, biostratigraphic data were combined with seismic and sequence stratigraphy to assign an absolute age for 5 Plio-Quaternary reflectors. High resolution pre-stack depth-migrated seismic data were used to accurately measure displacement of dated horizons across faults and thickness variations of half grabens adjacent to growth faults. Dividing displacements and thicknesses by unit durations constrain the rate of faulting activity.

The chronostratigraphic analysis conducted here reveals the absolute ages of five seismic reflectors: 5.33 Ma (top Messinian evaporites), 2.6 Ma, 1.8 Ma, ~0.6 Ma, and ~0 Ma (seafloor) Ma. Structural analysis of faults displacing all five reflectors indicate that faulting occurred mainly after 2.6 Ma, that the rate of displacement reached a maxima at around 2 Ma and that it decreases since then. Analyzing thickness variations towards faults that do not displace all five horizons independently confirm this conclusion.

This conclusion further explains thickness anomaly of a seismic unit bounded between the 1.8 and 2.6 Ma reflectors that include a giant slump previously termed the Israel slump complex (ISC). It is, therefore, suggested that slumping and faulting are interrelated.

In a general view it is suggested that faulting began when the continental shelf had progressed and reached the underlying Messinian salt layer. At that point the accumulating overburden had reached a threshold that caused the underlying salt to start moving. Then, when salt flow attenuated, faulting rate also decreased.

Ediacaran (~620 Ma) high grade regional metamorphism in the northern Arabian Nubian Shield: U/Th-Pb monazite ages of the Elat schist

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Ediacaran times witnessed a hemisphere-scale orogenesis forming the extensive Pan-African mountain ranges and resulting in the final assembly of Gondwana supercontinent. The Elat metamorphic basement (S Israel) located at the northernmost tip of a major Pan-African orogenic suture, the Arabian Nubian Shield (ANS), comprises amphibolite facies schists and gneisses and was most likely shaped by this major continental collision. However the timing, number and duration of metamorphic events in Elat and elsewhere in the ANS are non-conclusive and a major emphasis was given to pre-Ediacaran island-arc related tectonics. This is mostly because U-Pb dating of zircon, widely used in Elat and elsewhere, is very successful in constraining the ages of the igneous and sedimentary protoliths, but is 'blind' to metamorphism at grades lower than granulite. Here U/Th-Pb dating of monazite, a precise chronometer of metamorphic mineral growth, is systematically applied to the Elat schist and unveils the tectono-metamorphic evolution of the Elat basement.

Previous U-Pb dating of detrital zircon has shown that the sedimentary protoliths of the Elat schist are the oldest basement components (≥800 Ma), and detailed structural observations of the schists portrayed a complex deformation history including four successive phases (Shimron, 1972). The earliest three phases were defined as ductile and penetrative, but some of the available geochronological data apparently contradict field relations. In-situ analysis of metamorphic monazites by LASS (Laser Ablation Split Stream) involves simultaneous measurement of U/Th-Pb isotope ratios and REE contents in a single 10 µm sized grain or domain, thus allowing determining the age of specific texture and metamorphic assemblage. Monazite dating of the Elat schist yielded two concordant age clusters at 712±6 and 613±5 Ma. The corresponding REE patterns of the dated monazite grains indicate that porphyroblast growth, either garnet or staurolite, took place only during the younger event (M2). Likewise the regional south dipping penetrative foliation, common to the Elat schist and to all of the rocks of the Elat association, formed during the Ediacaran event (M2). This profound event started at ~630 Ma and reached peak conditions of mid amphibolite facies at ~620 Ma. Retrogression and stress relaxation shortly followed and were contemporaneous with the intrusion of andesitic dykes that were immediately metamorphosed (M3) to green-schist at ~613 Ma. Staurolite schists were overprinted by a retrograde cordierite-bearing assemblage. This metamorphic P-T-t path corresponds to the collision of East- and West-

Gondwana as constrained by large goechronological database of post collision batholiths from all around the Arabian-Nubian Shield.

Is There a Meaning to the Differentiation of Education to Formal and Informal? - The Israeli Earth Science Class as an Allegory

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The program of the ESCC class is identical to the earth science high school curriculum, which is based on the constructivist approach. According to this approach, learning is done by the student and under the guidance of his teachers in personal-internal information processing and transfers it to knowledge. The learning materials, the teacher and the surrounding are all serve the goal of supporting 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.

Although the literature review indicates two dichotomous types of science education: formal and informal, the current study crosses this artificial boundary. It deals with a formal earth science program, which is based on components such as participation by choice, learner-centered, learner-led and out-of-school learning environment that are labeled as "informal". Furthermore, the ESCC program attracts learners who are active within informal settings. Along its four years of operation, the ESCC attracts a relatively large number of the students who active in 'sayarut' youth group. Our findings indicate that 61% of the graduated of the ESCC class were active members of the 'sayarut' youth group during their studies. In light of these characteristics, the ESCC is an ideal framework to examine the relationship between formal and informal science education. The current study explores the learning process of the students of the ESCC class who are participate in 'sayarut', and their personal characteristics such as motivation, independent learner and external variables such as school/parents support, social contact and guidance in 'sayarut'. The study is based on qualitative methods of observations, interviews and open questionnaires. Preliminary findings indicate that ESCC students who participate in 'sayarut' are characterized by high motivation to learn, time management ability, responsibility and independence. These characteristics encourage students to be more involved in the learning process thus succeed in the assignments. It is important to note that these students usually deal with overload of activities and yet they constitute a substantial part of the graduates of the ESCC.

Natural dose response curve as a proxy for luminescence dating underestimation: An example from Kerem Shalom sequence

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Luminescence dating techniques, especially optically stimulated luminescence (OSL) on quartz, are widely used for dating middle Pleistocene to late Holocene sediments from different geological settings. However the OSL signal saturates at doses of ~200 Gy, equivalent to ages of 150-300 ka. Thus, ages beyond that could be underestimated. When given step-wise increasing laboratory beta doses, the OSL signal grows and a laboratory dose response curve (DRC) can be constructed. A natural DRC is constructed by plotting the natural (normalized) OSL signal of samples from a sediment profile against their expected dose (Chapot et al., 2012). Apparently, the natural DRC saturates at lower doses than the laboratory DRC.

We investigated saturation properties of luminescence signals of quartz grains from Israel, using samples from Kerem Shalom, western Negev. The section is exposed in a 15 m-deep quarry and is composed of alternating sands and calcic sandy paleosol units, which have low dose rates of ~1 Gy/ka. The section was previously investigated and dated with OSL to 0-480 ka (Zilberman et al., 2007). Here we report new age data from the Kerem Shalom sequence using OSL and the thermally transferred OSL (TT-OSL), a signal that does not saturate as rapidly as the OSL signal. A natural DRC was constructed for both signals.

The natural DRC of OSL shows that below 2.5 m the natural signal is constant and no longer grows with depth (and age). This implies that the natural OSL signal is saturated and ages of samples below 2.5 m are underestimated. The natural DRC of the TT-OSL signal showed that all samples below 6 m are saturated with respect to this signal.

Our results suggest that Kerem Shalom section of older than previously thought. One should be cautious about OSL ages when the laboratory DRC is near signal saturation. All OSL ages corresponding to equivalent doses over 150-200 Gy should be suspected as underestimated.

Chapot, M.S., Roberts, H.M., Duller, G.A.T., Lai, Z.P., 2012. A comparison of natural- and laboratory-generated dose response curves for quartz optically stimulated luminescence signals from Chinese Loess. Radiation Measurements 47, 1045-1052.

Zilberman, E., Porat, N., Roskin, J., 2007. The Middle to Late-Pleistocene sand sheet sequence of Kerem Shalom, western Negev – an archive of coastal sand incursion. Geological Survey of Israel Report GSI/13/2007, 23 p.

Measuring thermo-mechanical properties of concrete samples for modeling rock slope stability

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A new model for thermally-induced wedging mechanism has been recently suggested. The model consists of a discrete block that is separated from the rock mass by a tension crack and rests on an inclined plane. The tension crack is filled with a wedge block or rock fragments. According to the suggested mechanism, plastic displacement occurs during heating and cooling cycles. While a preliminary analytical expression for this model has been suggested, the model has not been tested on a large scale in lab.

In this research a large scale concrete physical model (50x150x60 cm^3) will be examined in a climate-controlled room at the Department of Environmental Hydrology and Microbiology, Zuckerberg Institute for Water Research (ZIWR), at BGU. In order to select the appropriate concrete mixture, the mechanical and thermo-physical properties of concrete samples are determined in the lab. Friction angle and shear stiffness of the sliding interface are determined utilizing the hydraulic, servo-controlled direct shear apparatus at BGU. Uniaxial and triaxial compression tests are performed to determine the uniaxial compressive stress, Young's modulus and Poison’s ratio of the intact block material. Thermal conductivity, thermal expansion coefficient, and thermal diffusion coefficient are determined experimentally using a self-constructed measuring system. The selected concrete mixture consists of 41% send, 36% cement, 7% aggregate, and 0.46 water-cement ratio. This mixture has uniaxial compressive strength of 61.58 [MPa], thermal expansion coefficient of 3.16 [10-6/°C], and thermal conductivity of 1.42 [W/m/K].

The large scale physical concrete model will be installed on an inclined steel construction, and will be inserted to the climate-controlled room. The room temperature will be changed between 5 to 40 Celsius degrees. The thermo-mechanical response of the model to the thermal fluctuation will be measured using displacement transducers and visual range camera.

Test results will be used to check the validity of the proposed analytical solution and to further understand environmental effects on rock slope stability.

Lithology and characteristics of the Messinian evaporite sequence of the deep Levant Basin, eastern Mediterranean

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As the lithological composition of the Messinian salt sequence of the Levant Basin is still controversial and unconstrained, we reveal for the first time the lithology of the entire evaporite sequence from deep basin depth migrated seismic and borehole data. The data presented here shows that the seismic transparent layers are composed of pure and uniform halite while the reflective layers are bundles of thin clay layers interbedded in the halite background. The thin clay layers inside the deep basin evaporites have a cumulative thickness of 25-40 m. High amplitude fan structures are observed on the deepest internal reflector which may suggest clay transportation. Among all the internal reflectors, the shallower units are more deformed while the deeper units are more coherent and flat. Two sets of folds/faults are shown on the shallower intra-units: folds with NEN-SWS trending axes and thrust faults strike NW-SE. On a regional scale, the top salt reflector (commonly known as reflector “M”) is generally horizontal while the other internal reflectors dip toward the NW. The shallowest intra-unit is the only one that has a wedge shape thickening to the NW, while the other intra-units generally have uniform thicknesses.

(Nano) particle formation along redox gradients in the marine environment

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Recent research has demonstrated that previous classification of filtered fractions (< 0.2 or < 0.45 µm) as “dissolved” does not represent the actual complexity of this operationally defined category, which may contain nanoparticles as well as dissolved species These nanoparticles can be stable to precipitation and oxidation, and thus represent a way for reduced species such as sulfide and trace metals to be transported from reduced to oxic environments. The presence of metal sulfide and elemental sulfur nanoparticles was investigated along redox gradients in two different systems: the water column of the Chesapeake Bay and in buoyant hydrothermal vent plumes along the Mid-Atlantic Ridge. Differences in the partitioning of trace metals (Fe, Cu, Cd, Zn, Pb, Cd, Co) into sulfide phases was observed between three vent sites along the Mid-Atlantic Ridge (Rainbow, TAG, and Snakepit) due to differences in the metal to sulfide ratio of the vent fluid. At all three sites, significant concentrations of these metals were incorporated into nanoparticulate pyrite, which has been shown to be resistance to oxidation and thus may contribute to the flux of Fe and other metals from vents to the global oceans. Furthermore, elemental sulfur nanoparticles were found to be a significant percentage of total S0 in both the Chesapeake Bay water column as well as in vent plumes. In the Chesapeake Bay, elemental sulfur is formed by both abiotic and biotic sulfide oxidation. In the vent plumes, sulfide oxidation is abiotic, and elemental sulfur forms through an iron catalytic cycle with oxygen. The observation of elemental sulfur and metal sulfide nanoparticles in both environments has implications for the transport and biogeochemical reactivity of these elements.

The Makhteshim Country initiative to become part of the Global Geopark Network

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Global geoparks are territories with geological heritage of international significance that implement strategies for holistic management, promotion and sustainable development that are respectful of local traditions and desires. Geoparks promote the links between geological heritage and all other aspects of the area's natural and cultural heritage. Geoparks provide geo-scientific knowledge as a substantial element for nature conservation, geoheritage protection, environmental education, and geotourism development and proper management. Many of the 112 global geoparks authorities have taken positive policies towards stimulating 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, maps, educational materials and displays, seminars and so on. A geopark also fosters scientific research and cooperation with universities and research institutes; stimulating interactions between the geoscientists, and the local populations is another geopark activity for the popularization of Earth knowledge.

The Makhteshim Country has been identified years ago by E. Mazor as a natural candidate for acceptance to the Global Geopark Network (GGN). It features numerous unique geologic phenomena and a rich cultural and natural heritage which showcases the everlasting struggle of life in hyper-arid climate conditions. In addition to the several unique erosional craters and its exceptional geo-diversity, the Makhteshim Country is home to various endemic plants and animals. Due to its remoteness and a decline in mining activity, the economy of the local communities has over the past decades become more dependent on tourism and outdoor educational and holistic activities. To support this process and to strengthen the peripheral communities and their connection to their environment, the Geological Survey of Israel, Dead Sea and Arava Science Center and Negev Highland Tourism are promoting awareness to the advantages and potential of applying to be part of the Global Geopark Network. This would promote local and global initiatives that will invest in local economy, education and environmental science – with the benefit of the local communities and the conservation of their natural and cultural heritage. The presentation will describe the GGN, a few of the geoparks and the initiatives leading the Makhteshim Country towards recognition as a member of GGN.

Evaluating economic damage in Eilat due to plausible future earthquakes

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The social and economic impact of an earthquake depends on the severity of damage to buildings, infrastructure, industry, trade and essential supply lines. In order to better prepare for and reduce the impact of future earthquakes, a model is required to analyze the economic implications of such events. Historic earthquakes in Israel reveal that damage and economic impact is a function of building quality and design and is locally enhanced by geologic effects and hazards such as landslides and ground shaking amplification. The current study presents a procedure to evaluate economic damage and applies this procedure on Eilat as a case study. In order to assess plausible future financial damage, earthquake scenarios were determined and local hazards evaluated as input for HAZUS economic loss models tailored to the specific characteristics of Eilat. In particular, we account for local ground amplification (Davis et al., this meeting) and dynamic directivity effects which enhance shaking in certain parts of Eilat. Analysis of structural and economic damage is tailored to specific characteristics of Eilat by collecting a wide range of economic, demographic and structural data of building in the various neighborhoods of Eilat (Levi & Cohen-Shrem, this meeting). The lecture will present the methodology for assessing local economic damage, the earthquake scenarios and the analysis of local amplification of ground motions in Eilat. Finally - preliminary damage and cost estimates will be described and some spatial damage patterns illuminated.

Application of ground penetrating radar and electrical resistivity tomography for underground karst locating

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Since underground karst cavities are known to appear randomly in carbonate rocks their accurate prospecting is still challenging and there are no unambiguous solutions yet, especially if spot-wise methods like borehole drilling are being used. One way to avoid such a difficulty is to utilize the methods enabling continuous underground scrutiny. The engineering geophysical methods can frequently assist in such a situation. However, data interpretation suffers from uncertainties due to non-direct measurements which are based on rock physical properties. To avoid such an intricacy, integration of two or more geophysical methods are usually being employed. Our study was motivated by a potential danger to heavy building equipment on the site under study since an inlet to an underground cavity was known in the vicinity of Salit village (Israel). Since the drilling excavation would not be satisfyingly used to examine the subsurface, the survey of underground karsts was applied by integrating the electrical resistivity tomography (ERT/IP) and the ground penetrating radar (GPR) methods. The GPR method resembles the seismic reflection method, while the former uses electromagnetic wave, and the latter uses seismic wave. Five GPR lines (with antenna 250MHz) were performed in the study area being 70 m in length each, when the recorded data was post-processed with the industrial software Reflex. The ERT method is based on underground measurements of electrical resistivity values using modern multi-electrodes manner. The Dipole-Dipole array was employed for this study, is known to be the best issue for the underground karst prospecting. The 2D ERT line was 124 meter long with 32 electrodes and four meter inter-electrode spacing. The recorded data were post-processed with the geophysical software (EARTHIMAGER). The integration of the two methods and the cross-correlation of their results enabled to locate several underground anomalies, which were interpreted in high certainty as a system of eight cavities and to define their size and volume. The results showed that the cavity system is consisting one dominant cavity with Hydraulic connection to the others.

The joint employment of the ERT and the GPR methods has been proved to be efficacious in locating subsurface cavities and improving the mapping certainty as well in the cases of mapping ground water, lithology, fracture zones, graves and archeological sites.

Radium isotopes in saline water of coastal aquifers

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We present here the results of radium isotope activities in saline groundwater and their application to seawater circulation in coastal aquifers. Sampling mainly included groundwater of the Israeli Pleistocene coastal aquifer, with some additional sampling of the underlying Cretaceous carbonate aquifer.

Activities of 223Ra, 224Ra, 226Ra and228Ra in groundwater of the Pleistocene aquiferare between 0.1-0.1.4, 1-12, 0.4-4, 0.2-4 dpmL-1 respectively, with the highest activities reported from Dor Bay. These activities are 1-3 orders of magnitude higher than in seawater. No significant trend was found with distance from the shore.

Activities in the underlying Cretaceous carbonate aquifer were significantly higher (e.g. range of 5-8, 1.8-17, 1.2-64 dpmL-1 for 223Ra, 224Ra, and226Ra respectively), in particular in the Menashe borehole (8, 17, and 64 dpmL-1 respectively).

224Ra/223Ra ratio is close to 8.5 in all the Pleistocene aquifer groundwater, and there is no trend with distance from sea. In the carbonate aquifer, a ratio of 2.5 was observed. The ratios of the long to short-lived isotopes226Ra/224Ra are 0.2-1, with a slight increasing trend with distance from the sea in the Nitzanim area. 226Ra/223Ra ratios are2-5,and there is no increasing trend with distance from the sea or in deeper units. The water in the Cretaceous Menashe borehole has higher ratios: 226Ra/224Ra is 4, and 226Ra/223Ra is 8.5, while in the Gaash boreholes ratios are similar to thee Pleistocene aquifer.

Assuming natural parent nuclide ratios (238U/235U) of 21.7, and considering 226Ra half life of 1600 yr, we expect water at 800 m from sea to show elevated 226Ra/223Ra. Mainly, waters from the deep sub-aquifers, with 14C ages of 10,000-15,000 yrs, are expected to show 226Ra/223Ra similar to their radioactive progenitors, which is not the case (ratios of ~3 instead of 20). It is suggested that the coastal aquifer system is not in secular equilibrium with respect to the radium isotope parents. While the 223Ra parents could be relatively close to secular equilibrium (its parent 227Ac has half life of 21.7 yrs and its grandparent 231Pa has half life of 32,760 yrs), the 226Ra parent 230Th, with a significantly longer half life (75,000 yrs) is probably far from equilibrium. Assuming most of the radium parents resides in the carbonate cement of the sandstone aquifer, and considering the expected high U/Thin this secondary carbonate, it is suggested that this cement is not older than several thousand years, resulting in low 230Th/231Pa ratio in the sediment, thereby low 226Ra/223Ra in the groundwater. This could be further related to the post-glacial sea (and groundwater) level rise, which should be further studied.

Lava emplacement in Al-Laja' (Syrian Hauran): The longest lava tube in the Levant

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When a lava tube is near the surface, sections of its roof may erode or collapse, creating a 'puka' or 'skylight' holes in the roof, as well as elongated unroofed caves. The continuous nature of such partially collapsed lava tubes and/or lava channels can thus be identified by remote sensing as 'dashed lines' of intact lava tube segments, pits, and channels, collectively referred to as a 'lava tube system'.

The intuitive and easy-to-use Google Earth with its improved SPOT Images has rapidly emerged as a global medium with increasing potential for lava tube prospection, outflanking other types of orbital imagery and remote-sensing sources.

The largest volcanic region of the Levant is Harrat Ash-Shaam, covering some 40,000 km2 in Syria, Jordan, Saudi Arabia, and Israel. Several lava tubes are known in its northeastern area, the Hauran, all of them are thought to be of Quaternary age.

Tawk et al. (2009) reported a 562 m long, 21 m wide, 4 m high lava tube in Ariqa village, NE of Jabal ad-Druze. This region of Harrat Ash-Shaam, called Al-Laja' ('refuge'), is covered by rough late-Quaternary basalt, with limited human access. Here I report that Ariqa Cave is a small portion of the longest lava tube system in the Levant.

The lava tube system is identified by its remotely sensed collapsed segments, forming an elongated line of troughs. These troughs are either unroofed lava tubes, or open lava channels, inferred by what seems to be lava levees. The relief of the channels is emphasized by the typical shade of its southern wall. In addition, the channel/collapsed segments act as sediment traps, which become natural 'flowerpots' supporting denser vegetation, compared with the surrounding rocky lava. Some topographic troughs of the lava tube system are large enough to be indicated on topographic maps. A corroboration for the existence of an uncollapsed lava tube segment is given by the cave survey (Tawk et al., 2009), as well as cave attributes on topographic maps, where all are aligned along the inferred lava tube system. The topographic maps, based on photogrammetry, show clear trenches, which are segments of collapsed lave tubes/channels. In addition to Ariqa Cave, two unexplored lava tube caves are indicated on topographic maps east of Ariqa: Meg'arat Hamid and Meg'arat a-Shatab. Additional segments of the lava tube system are observed on Google Earth imagery but not on topographic maps.

The lava tube segments are compiled and reconstructed from all the above mentioned data. The entire system is 20.5 km long, descending from 890 to 650 masl, in a mean gradient of 1.2%. It spans most length of the recent pahoehoe lava field that flowed westward from Tel Shihan region, shedding light on the lava emplacement mechanism.

Estimation of original and remaining hydrocarbon potential for Heletz sand and Kokhav dolomite reservoirs at the Kokhav-Heletz-Brur oil field

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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) 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) 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.

1. The Total Original Oil in Place for the Heletz Sand Reservoir ('A'+'W'+'K' sands) at the Kokhav-Heletz-Brur oil fields is 28,190,671 bbl.
The Total Estimated Cumulative Production for the Heletz Sand Reservoir at the Kokhav-Heletz-Brur oil fields is 14,629,181 bbl.

The Total Remaining Oil in Place for the Heletz Sand Reservoir at the Kokhav-Heletz-Brur oil fields is 13,561,490 bbl.
Percent Produced is 51.9 %.

2. The Total Original Oil in Place (P90+P50) for the Kokhav-Heletz-Brur oil fields is 8,148,835 bbl.
The Total Estimated Cumulative Production is 689,320 bbl.
The Total Remaining Oil in Place is 7,459,515 bbl.
Percent Produced is 8.5 %.

Live-dead bivalve assemblages as recorders of anthropogenic modification of the Gulf of Eilat (Israel)

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The Gulf of Eilat is a naturally oligotrophic environment with a prosperous coral reef, however anthropogenic nutrient input over the last 50 years is suspected to have had a strong impact on the biota and reef. Some of the factors influencing the Gulf were eutrophication due to the deployment of fish cages between 1995 and 2008, runoff of the city sewage during 1980-1990, phosphate dust from Aqaba harbor and accidental oil spills.

Molluscs are sensitive indicators to changes of the marine environment and sea floor conditions. This study aimed at testing for significant mismatch in the composition of modern time-averaged death assemblages (dead remains from the top sediment) and the local living community as a signal of a recent shift in baseline. “Live-dead mismatch” has been shown to be associated with recent, rapid, anthropogenic changes.

To test this approach, triplicate diver-acquired bulk-quadrate samples (down to 5 cm sediment depth) were taken at 15 and 30 m water depths along two primary transects positioned (1) off the mouth of Wadi Arava, the former fish farm location (FF) and (2) opposite the Dan hotel (DAN), located 500 m west of FF, and distant from any known past point source of pollution. Sites were sampled during 2012-2014 over six seasons and the sediment was sieved for dead and live bivalve-molluscan assemblages using a 2mm sieve. In order to augment the sampling for live bivalves, we also used a vessel-operated 2mm dredge over a distance of 30m at each site (insertion depth of 5 cm).

A total of 155 samples were examined. Over 27,800 live and dead bivalve individuals were obtained from the northern beach. Univariate and multivariate analyses of the live assemblages revealed significant differences in species composition, distribution, and feeding types between the shallow DAN station and the rest of the northern stations. Multivariate analysis revealed significant difference in community structure of the dead assemblages, with DAN 30 differing from all other stations. These differences can be explained by sea-grass density and distribution and by distance from the source of past disturbances.

Analysis of live vs. dead bivalve assemblages showed a discrepancy between high fidelity in species richness and low similarity in species abundance. Life strategy of the bivalves shifted from that of chemosymbiotic species dominating in the past (chemosymbiotic species of the family Lucinidae) to suspension and mixed-feeder species dominating today (Tellinidae), which may be a first indication of recovery of the marine ecosystem. Although live-dead fidelity assessment is a conservative test, it was able to indicate past human impact on the macro-benthic fauna at the shallow FF station, beneath the former location of the commercial fish farms, in contrast to the pristine conditions at the deeper DAN station.

High School Students' Research Projects in Earth Sciences as a Pedagogic Tool

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Students in Ma'aleh Shacharut High School write two Independent Research Projects (IRP) as part of their earth sciences studies: a Geotope and a final project. The projects can cover a wide variety of topics in geology, geomorphology, hydrology and even environmental education. The IRP is a dynamic project in which the student has to deal with scientific material. Each student should go through all the main stages necessary for real research: planning, focusing, collecting data from different environments (as lab and field experiments), reading relevant literature, collating, writing, preparing figures, editing, presenting and publishing. The students work on this project in the course of 12 months during the last two years of school, and it is assessed by an academic expert. The IRP becomes the most meaningful and enjoyable learning activity in school. Therefore, students often consider it as their main positive, challenging and significant school experience.

The following are some examples of projects that were completed during the last years by Ma'aleh Shacharut students: "Magmatic incisions in Timna Valley", "Geological aspects of extreme events in the Biblical story", " Tsunami in the Gulf of Eilat - probability, risk and preparedness", "Limestone concretions in the Southern Negev" and "Retreat and advance of glaciers during the last years in New Zealand and Norway".

The IRP is supervised by a post-graduate teacher. Each one of the teachers who takes part in this project becomes a partner in the research, and doing so improves his/her research skills. Teaching thus becomes more interesting and enjoyable for teachers. Figures and texts that were prepared during the project may be used for further teaching and guiding. Working together on the IRP also helps to develop good personal relations between the student and his/her teacher. In some cases, the teacher continues to expand the project and it becomes an advanced scientific study.

Seismo-acoustic observations in Israel from peculiar explosive sources in neighboring regions

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Infrasound signals from a bolide, that exploded over Iran city Zanjan (July 30, 2015), were observed at Israel acoustic sensors (microphones) and infrasound array IMA, at distances 1200-1350 km. This bolide was witnessed by thousands of people in the area (time between 15:40 and 15:50 UTC), and reported widely in the mass-media. A farmer, who witnessed the fireball, reported 4 distinct bursts and sonic booms, and found a meteorite (located in the town of Moshampa, at roughly 36.942N 47.674E).

After band-pass filtering 0.2-5 Hz of array IMA records, in the time window where the bolide signals were expected, four consistent infrasound phases were found (with the group velocity ~303 m/s), presumably corresponding to the four reported sonic booms. We applied f-k analysis to these phases and estimated the same azimuth 67.8 deg. for the first 3 weak phases and a close azimuth value 65.2 deg. for the maximal fourth phase, that corresponds well to the actual azimuth 65.3 deg.; close apparent velocities for all phases 343-349 m/s were obtained.

We conducted a yield evaluation for the bolide explosion, based on the empirical relation between the yield and the dominant period of the infrasound wave. The period (To=1.105 s) was calculated from the averaged amplitude spectra maximum of the main phase recorded at 5 elements of the IMA array. The TNT equivalent yield was roughly estimated as about 7.3 tons. There were many reports of broken glass and shaking houses which suggests that it was a large event. Based on an estimate of between 15 km/s and 25 km/s for the bolide velocity, its kinetic energy suggests that the pre-atmospheric size of the meteoroid was on the order of 100 kg to 300 kg.

Seismic signals from a military explosion in Syria (May 14, 2014) were observed at Israel stations (IMS and ISN networks). Internet news websites reported that Syrian rebels blew up a government army base by detonating about 60 tons of explosives planted in a tunnel under the base.

The EMSC presented this event as an earthquake with local magnitude ML=2.8, location 35.74N, 36.64E, depth 10 km, OT 15:58:51.4 UTC. We analyzed Israel seismic records and obtained location parameters, similar to EMSC data, using the regional velocity model. We determined moment magnitude of the event, based on the low-frequency spectral amplitudes of P and S-waves, manually measured from displacement spectra. The TNT equivalent yield was evaluated as ~30 tons using an empirical equation between yield and magnitude, based on underground calibration explosions previously conducted by GII. We also applied to the records a new spectral discriminant developed recently in GII: ratios of P- to S-wave corner frequencies, averaged over recorded stations. The discriminant identified this seismic event as a clear underground explosion.

DIC mass balance of the Dead Sea under limited inflows- indirect evidence for aragonite precipitation and CO2 degassing

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Throughout their geological histories the saline lakes in the Dead Sea basin precipitated calcium carbonates, mostly as aragonite. The aragonite sediments precipitated as a result of the high Mg/Ca ratio in the brines and the common ion effect induced by mixing of high bicarbonate freshwater runoff with the extremely Ca-rich Dead Sea brine. However, during periods of arid conditions with limited freshwater inflow, water level declined, salinity increased and gypsum and halite precipitated.

The present study investigates the carbon cycle of the Dead Sea under limited inflows and supply of carbonate to the brine. Decrease of inflows to the basin in recent years resulted in changed limnological and sedimentological regime, and since the 1980s halite is the dominant mineral precipitating from the brine.

During 2013-2014, bi-monthly depth profiles of total alkalinity, dissolved inorganic carbon (DIC) and its isotopic composition ($\delta^{13}C$) were conducted in the Dead Sea, from surface down to the bottom of the lake (290 m). Mass balance calculations conducted for the period 1993-2013 show that while the reservoirs of conservative components such as Mg^{2+} remained constant, the DIC reservoir of the lake decreased by ~ 10%. During this period carbonate inflow to the lake supplied additional ~10% DIC to the reservoir of the lake. Thus, over the studied period the water body lost the equivalent of 22% of the 1993 DIC reservoir. Nucleation and crystal growth experiments showed that in the presence of aragonite alkalinity rapidly drops before stabilizing.

Compilation of historical data (Luz et al. 1997, Barkan et al. 2001) with our data shows that during the past decades DIC concentrations and PCO_2 remained relatively constant, suggesting that a quasi steady-state situation prevails. Nevertheless, during this period $\delta^{13}C_{DIC}$ increased from 1.4‰ to 2.7‰. This, the high PCO_2 of the brine (1800 ppmV) and isotopic mass balance indicate that most of the DIC loss is through CO_2 degassing to the atmosphere (63±7%), while the rest precipitates as aragonite (37±7%). However, nucleation and crystal growth experimental show that the Dead Sea remains oversaturated with respect to aragonite. It is thus conclude that: 1) the high PCO_2 of the brine is maintained by the low piston velocity of the brine, calculated to be only ~ 4.5 $m \cdot yr^{-1}$ (over an order of magnitude slower than seawater value). 2) Oversaturation of the Dead

Sea with respect to aragonite is maintained, by kinetic barrier for nucleation, despite the reduced inflow of freshwater.

Luz et al. 1997, in: Niemi et al., The Dead Sea: the lake and its setting, 184-192.
Barkan et al. 2001, GCA, 65(3): 355–368.

Preserved Offshore Tsunami Deposits Recognized in a 'Low Risk' Zone: an undocumented tsunami in the northern Red Sea

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The Red Sea generally, despite all of the necessary components for tsunami production, has been generally defined as 'low-risk' with regard to tsunami damage on the basis of historical records, observations of small-scale tsunami production in recent periods, and a lack of field evidence. While some regions are known to be prone to tsunami events, other areas are considered safe because of their geographic and bathymetric settings, seismic disposition, and lack of written descriptions of past tsunamis. Models that are produced to estimate said risk rely on catalogues of written records and field studies that summarize known events. There are multiple failures in this approach. First, written records are not evenly distributed worldwide, nor has writing always existed; thereby limiting the possible timeframe for reference. Field studies of preserved tsunami deposits focus primarily on terrestrial or coastal deposits, which modern observations of post-tsunami deposit diagenesis are determining that they are quickly eroded and rarely preserved, thus leading to a considerably patchy record, ultimately underrepresenting the actual number of past tsunamis. Offshore sedimentary deposits may hold promise as better recorders of these events. Here we present recently published evidence for a rare, yet significant and potentially very destructive tsunami event that impacted a presumed low-risk location in the northern Red Sea's Gulf of Aqaba. The anomalous deposits were recognized within sediment cores collected offshore (-16 to -12 msl) and were identified using a suite of common tsunamigenic indicators such as sedimentological characterization, granulometry and micropaleontology. Given rapidly expanding coastal populations in the region and worldwide, these findings are a warning that the current practice of determining risk based solely on models and historical catalogues, without offshore field studies, is insufficient.

Acoustic and petrophysical anisotropy of organic-rich chalks from the Shefela and Golan basins

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We report the first measurements of velocity and acoustic anisotropy in kerogen-rich chalks. These chalks, from the late Cretaceous Ghareb and Mishash formations include sections with varying degrees of thermal maturation. Compared to previous studies of kerogen-rich shale source rocks, which exhibit large acoustic anisotropy (Vernik and Nur, 1992), these kerogen-rich chalks display much lower but still measureable transverse anisotropy.

In order to have different levels of thermal maturity, cores were extracted both from the Shefela basin of central Israel and two wells in the southern Golan Heights. The chalk is transected by horizontal bedding planes and therefore exhibits transverse isotropy where five elastic constants are required to completely describe the elastic compliance matrix. We measured ultrasonic velocities of P, SH, and SV waves in different directions using the ultrasonic transmission method. Velocity was measured using both dry and water-saturated samples, with confining pressures and pore fluid pressures simulating borehole logging conditions. The dynamic stiffness constants, Young's modulus, Poisson's ratio, bulk modulus and Thomsen parameters were calculated to describe the mechanical anisotropy of the rock.

The level of kerogen maturity was measured using Rockeval geochemical measurements (Tmax and Hydrogen Index). Porosity, bulk density, grain density and SEM images were used to study the physical characteristics of the rock and its microstructure. The results of the study show the experimentally obtained elastic moduli and Thomsen anisotropy parameters primarily reflect porosity, kerogen content and maturation level as the kerogen stiffens during thermal maturation. The ultrasonic P & S velocities on the cores were compared with sonic velocities measured with a cross-dipole acoustic logging tool (Baker Hughes XMAC) which measures compressional and fast and slow shear waves (azimuthal anisotropy) over the cored interval in the field.

On the formation of low-relief high elevation surfaces by drainage network reorganization

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High elevation low-relief surfaces are commonly interpreted to be remnants of old, relatively flat, topography that formed during a tectonically quiet period, and were later passively elevated by tectonic uplift. We examine this view of landscape formation in the southeastern margin of the Tibetan Plateau, where three immense rivers, the Salween, Mekong and Yangtze form up to three km deep gorges with scattered low-relief four km high surfaces in between the gorges. According to the common perception, these surfaces preserve to some degree the local topography before India collided with Eurasia and the Himalayas rose, some 50 million years ago. We perform a geomorphic analysis that relies on the transformation variable, χ, which scales the distance along the river by its drainage area distribution. Our analysis reveals that different tributaries that drain the same low-relief surface to a common proximal fluvial confluence appear to have experienced variable incision histories. This observation is inconsistent with the present theory of passive uplift and preservation of an old, low-relief surface, which is expected to manifest as a common incision history for proximal tributaries that drain to the same junction. Instead, we propose an alternative model, supported by numerical experiments, in which tectonic deformation in this highly tectonically active region has disrupted the regional river network causing reorganization of the drainage and mobilization of water divides. As a result, some tributaries have lost large portions of their drainage area and thus have insufficient power to incise and balance tectonic uplift. This in turn leads to active formation of low-relief high elevation surfaces. Thus, the state of low-relief high elevation is forming dynamically and locally, rather than preserving past environmental conditions.

First insight into kaolinite nucleation kinetics

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Quantification and understanding precipitation of silicate minerals in general and of clay in particular have important implications for many geological and environmental problems. Many studies of silicate minerals growth were published, however, nucleation experiments of silicate minerals from aquatic solutions are lacking. Under environmental conditions that relevant to chemical weathering of granite in the field (close-to-equilibrium, low temperature and circum-neutral pH), –kaolinite ($Al_2Si_2O_5(OH)_4$) and gibbsite ($Al(OH)_3$) are commonly stable, although in natural environments and the geological record, kaolinite is vastly more common.

Kaolinite induction time (the time period elapses before the detection of the formation of a new phase in a supersaturated system) was determined in six single point batch experiments (SPBE) that were conducted under five different degrees of over saturation (Ω) with respect to kaolinite, and at pH 5.2 and 25°C. Different degrees of over saturation were attained by changing Si concentrations. Germanium oxide crystals were added to the sixth experiment in order to examine the effect of existing surfaces on the induction time. Data points were obtained by stopping the reaction in one reactor by separating the solids from the solution. Afterwards, Al and Si concentrations were analyzed using spectrophotometer and isotope dilution, respectively. The solids were characterized using scanning electron microscope energy dispersive spectrometry (SEM-EDS).

For the first time, this study observed kaolinite nucleation from oversaturated solutions without seeds. With the increase in the degree of over saturation with respect to kaolinite, a decrease in the induction time was observed. The results show a linear dependency between the log of the induction period versus $\log(\Omega)^{-2}$, as is predicted by the classic nucleation theory. The SEM and EDS analysis confirmed that the precipitated phase is indeed kaolinite.

New constraints on the nature of the Eastern Mediterranean crust

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Some of the fundamental tectonic problems of the Eastern Mediterranean remain unresolved due to the extremely thick sedimentary cover (10 to 15 km) and the lack of accurate magnetic anomaly data.
I conducted a magnetic survey across the Herodotus and Levant Basins (Eastern Mediterranean) to study the nature and age of the underlying igneous crust. The towed magnetometer array consisted of two Overhauser sensors recording the total magnetic anomaly field in a longitudinal gradiometer mode, and a fully oriented vector magnetometer. Accurate navigation together with the gradiometer data allows the separation of the magnetic signature of the lithosphere from the contributions of the external and the geomagnetic fields. The total field data from the Herodotus Basin reveal a newly detected short sequence of long-wavelength NE-SW lineated anomalies that straddle the entire basin suggesting a deep 2D magnetic source layer. The three components of the magnetic vector data indicate that an abrupt transition from a 2D to 3D magnetic structure occurs east of the Herodotus Basin, along where a prominent NE-SW gravity feature is found. Altogether, these new findings confirm that the Herodotus Basin preserves remnants of oceanic crust that formed along the Neotethyan mid-ocean ridge system. The continuous northward and counterclockwise motion of the African Plate during the Paleozoic and Mesozoic allow predicting the evolution of remanent magnetization directions, which in-turn dictate that shape of the anomalies. The shape of the Herodotus anomalies best fit Late Carboniferous to Early Permian (300±20 Myr old) magnetization directions. Finally, I will discuss the implications of these findings on various tectonic and geodynamic processes.

The Varied Geological Landscape of Timna as a Source for Working Tools in Ancient Metallurgical Contexts

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The archaeological study of the Timna Valley began over 50 years ago, during which it has become a key site for understanding ancient copper production technologies in the Near East and beyond. The varied geological landscape of Timna provided various types of rocks that are reflected in the ground-stone tool assemblages of the copper smelting sites. These include, among others, grinding slabs, pounders, hammering stones, mortars and anvils. In the framework of the renewed excavations at Site 34 (Slaves' Hill) - an Iron Age (11th – 10th centuries BCE) copper smelting site - we conducted a pioneering study of these tools and assessed their function within the copper production process (in addition, observations on the ground stone assemblage helped improve our understanding of components of the smelting process itself).

The assemblage represents an assortment of rock types carried up the hill to Site 34 from nearby locations within the Timna Valley (the local fragile sandstone that makes up Site 34 was hardly utilized for the copper smelting industry). Most of the tools were manufactured of compacted coarse sandstone (Amudei Shlomo) and granite rocks, exposed in several locations in the valley. The smelters, who were probably highly esteemed professional artisans, were familiar with different raw material properties and the requirements dictated by the tool purposes; the entire assemblage suggests that much effort was expended on the raw material procurement, and artifact manufacture and maintenance.

Heaven on Earth: tistarite (Ti_2O_3) and other "nebular" phases in corundum aggregates from Mt. Carmel volcanic rocks

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The minimum oxygen fugacity (fO_2) of Earth's upper mantle probably is controlled by metal saturation, as defined by the Iron-Wüstite buffer reaction (2FeO àFe + O_2). However, the occurrence of moissanite (SiC) in kimberlites worldwide suggests that much more reducing conditions (5-6 log units below IW) must occur locally in the mantle. Moissanite is also abundant in Late Cretaceous volcaniclastic rocks on Mt. Carmel, N. Israel, and in related alluvial deposits. These same volcanic rocks contain abundant xenoliths made up of aggregates of corundum crystals with skeletal to hopper-like structures. Pockets of melt trapped in these aggregates contain a remarkable array of phases (>60 identified, half not previously described as minerals) that require extremely low fO_2.

The pockets contain three basic types of melts. Type S, the most abundant, consists of crystalline phases in a matrix of Ca-Al-Si- Ti-Zr glass (or so finely crystalline as to be amorphous to Raman spectroscopy). Some pockets show quench structures with radiating blades of anorthite in the Ca-Al-Si glass. Type A melts were Fe-Ti-Si-C-P alloys, and have crystallized to a range of phases, including gupeiite (Fe_3Si), FeTiSi, FeTi, khamrabaevite (TiC) and native V. Type N is represented by osbornite (TiN), locally intergrown with TiB_2. The textural relationships in and among the melt pockets suggest that these three "melts" were mutually immiscible. The conditions of crystallization are constrained to between ca 30-100 km (within the lithospheric mantle) and 1450-1550 °C, by the peritectic reaction corundum + melt à anorthite.

One of the more abundant phases in Type S pockets is tistarite (Ti_2O_3), previously known only as a single grain from the Allende carbonaceous chondrite. It is believed to have formed during the early evolution of the solar nebula and is associated with TiC and other highly reduced phases. The low fO_2 (IW -10 to -12) implied by the reduction of Ti^{4+} to Ti^{3+} or Ti^{2+} in the solar nebula reflects the dominance of H_2 in the solar wind. We suggest that similar conditions prevailed in parts of the upper mantle beneath Cretaceous northern Israel, due to the streaming of deep-mantle fluids dominated by CH_4 + H_2, related to deep-seated magmatic activity.

Interaction of such highly-reducing fluids with mafic-ultramafic magmas in the volcanic plumbing system would lead to desilication ($SiO_2 + CH_4$ à $SiC + H_2O$), reduction ($2FeO + CH_4$à $2Fe + C + 2H_2O$) and oversaturation in Al, leading to the rapid crystallization of the hopper-structured and skeletal corundum crystals. The quenching of the glasses implies that crystallization was ongoing at the time of eruption, and was terminated by the eruption. The desilication-reduction reactions also would generate abundant CO_2 and H_2O, and may have been instrumental in producing the violently explosive eruptions on Mt Carmel.

Deep-Earth methane, mantle dynamics and mineral exploration: insights from northern Israel, southern Tibet and Kamchatka

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The oxidation state of fluids in Earth's mantle affects processes ranging from volcanism and the formation of the crust, to the generation of many types of ore deposit. In general, the lowest oxidation state of the mantle (and hence its fluids) is defined by the buffer reaction 2FeO à 2Fe+O2 (the iron-wüstite or IW buffer); at this point the mantle becomes metal-saturated, which fixes the oxygen fugacity (fO2) because the mantle is a near-infinite reservoir of FeO. However, moissanite (SiC) is a common trace mineral in kimberlites worldwide, and requires fO2 of more than 6 log units below IW (IW-6). In addition, unusual mineral assemblages, including moissanite, native elements, alloys, carbides and silicides, which require far more reducing conditions (down to IW -8) are now being found in volcanic rocks and mantle peridotites from a variety of geotectonic settings. These discoveries raise questions about how such conditions can be generated in the mantle, and why the highly reduced products have not been oxidized by the ambient mantle.

Abundant moissanite in Cretaceous pyroclastic rocks in northern Israel is accompanied by xenoliths and xenocrysts of skeletal and hopper-structured corundum crystals, which have trapped pockets of the melts from which they grew. The melts contain highly reduced mineral assemblages, including native elements such as Ti and V; these imply fO2 as low as IW-12. Detailed study of this material suggests it crystallized due to interaction (reduction and desilication) between mafic-ultramafic magmas and highly reducing fluids. Such fluids can be derived from the deep Earth, since C-O-H fluids at the fO2 of the IW buffer are completely dominated by CH4+H2. Similar mineral assemblages (+ diamond) have been described from mineral separates of chromitite layers and their enclosing peridotites in "ophiolites" along the Yarlung-Zangbo suture in southern Tibet, but their context is poorly defined. Mafic pumice from the 2011-2014 explosive eruptions of the Tolbachik volcano on Kamchatka contain abundant diamonds, similar to the Tibetan ones, moissanite and native metals.

The presence of highly reduced mineral assemblages from such a range of geodynamic settings suggests that CH4-H2 fluids derived from the deep Earth have generated highly reducing conditions within some volcanic plumbing systems, and may be an integral part of such typically explosive volcanism. Such systems appear to be related to the margins of tectonic plates, including

zones of continent-continent collision and/or deep oceanic subduction, and transform faults (e.g. the Dead Sea Transform) extending deep (up to 200km) into the Earth's mantle. This represents an important but previously unrecognized fluid-transfer process within the mantle, and emphasizes the important role of major lithospheric sutures in the movement of mantle fluids.

Can sea water enhance chemical weathering of silicate minerals?

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Many studies described the effects of various environmental conditions (e.g., deviation from equilibrium, temperature, pH and the surface reactivity of the dissolved mineral) on the dissolution rates of silicate minerals. These studies described each of the effects under relatively low ionic strength conditions (<0.001m). Recently, based on geochemical and isotopic cycles mass balances, some studies suggested that most of silicate minerals dissolution on the earth surface occurs in the oceans and seas, where the ionic strength is relatively high (>0.7). Therefore examination of the effect of ionic strength on silicate mineral dissolution rate is needed. Seven Multi-Point-Batch-Experiments of Amelia Court House albite (99.8Ab) were conducted under far-from-equilibrium conditions (i.e. within the dissolution plateau) and 25 °C. Five experiments were conducted under five different ionic strengths (1, 0.1, 0.01, 0.001, 0.0001 m) using NaCl as the electrolyte at pH 5. A control experiment was conducted using solution where the pH was adjusted to 5 without any addition of electrolytes. One experiment was conducted using sea water from the Red Sea.

Since in all seven experiments the albite powder is identical, the differences in dissolution rates may be solely attributed to the effect of solution chemistry. The dissolution rate in the control experiment is in agreement with dissolution rates from previous studies under slightly acidic pH and 25 °C. Compared to the control experiment, under low ionic strengths (0.0001-0.01 m) a decrease in albite dissolution rate was observed. On the contrary, under high ionic strengths (0.01-1 m) albite dissolution rate was faster than in the control experiment by up to a factor of 4. The dissolution rate in the experiment using Red-Sea water was about 3 times faster than the control experiment, suggesting that the contribution of silicate minerals in natural saline systems (oceans, seas and costal aquifers) may be indeed more significant than was thought before.

The combined effect of temperature and pH on albite dissolution rate under far-from-equilibrium conditions

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Two of the most studied aspects of albite dissolution kinetics are the effects of temperature and pH. Previous studies suggested that the effect of pH on dissolution rate can be attributed to three independent dissolution mechanisms: proton-promoted (dominant under acidic conditions), water-promoted (under neutral conditions) and hydroxide-promoted (under alkaline conditions). Based on experimental results, those studies developed an empirical rate law to predict albite dissolution rate as a function of pH, assuming that the effect of pH is temperature independent. The effect of temperature was attributed either to the temperature dependency of the rate under constant pH or that of the empirical rate law coefficients. When applying the empirical rate law in order to predict the dissolution rate at pH of about 5 and various temperatures, the predicted rate overestimate the rate by 0.5-1 order of magnitude.

The current study develops and suggests the use of mechanistic rate law that is based on two fast adsorption reactions of protons and hydroxides on two different surface sites. The new mechanistic rate law considers the effect of surface coverage of protons and hydroxides that is temperature dependent. The new mechanistic rate law successfully describes the variation of albite dissolution rate (about 8 orders of magnitude) under wide temperature (3.6-300 °C) and pH (1.20-12.40) ranges.

Under slightly acidic conditions (pH 5-7) the new mechanistic rate law predicts a minimum rate zone that was not observed before. In order to confirm whether this minimum rate zone does exist, three single-point batch-experiments of albite dissolution were conducted at pH 5 and temperatures of 3.6, 25 and 50°C. The experiments confirm the existence of a minimum rate zone predicted by the independent mechanistic rate law. The new mechanistic rate law constrains the expected dissolution rate under far-from-equilibrium conditions and allows extrapolation of rate coefficient under a wide range of temperatures and pH with relatively low uncertainty.

Levant jet system—effect of post LGM seafloor currents on Nile sediment transport in the eastern Mediterranean

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Sedimentary development of a continental margin is directly related to seafloor current dynamics. Yet the linkage between the processes remains vague due to the different time scales they represent. To narrow this gap we focus on the thoroughly studied distribution system of Nile derived sediments across the Levant continental margin (eastern Mediterranean). These sediments dominate the Late Quaternary stratigraphy of the entire margin. Their mobilization has been explained exclusively by longshore transport, while oceanographic evidence from the basin and margin are not incorporated in the known mechanism. New data indicates that longshore mechanism is part of a much larger system. Based on integrated interpretation of multibeam bathymetry, high-resolution single-channel seismic reflection and oceanographic (temperature, salinity and chlorophyll) data we suggest a jet current system mobilizes the Levant Surface Water (LSW), Levant Intermediate Water (LIW) and Atlantic Water (AW) northwards along the margin, between 0 and 400 m water depths. On the seafloor, contourite currents form elongated along-strike morphologies. Below 400 m along-dip gravity flows dominate sediment transport to down the slope, below the Eastern Mediterranean Deep Water (EMDW). Initiation of this mechanism during the Pleistocene–Holocene transition and not at the end of the Last Glacial Maximum (LGM) indicates a gradual recovery of the thermo-haline circulation. Current intensification in the early Holocene may have also increased water stratification. This comprehensive mechanism explains sediment transport along the entire depth range of the continental margin, while integrating seafloor currents, morphology, as well as their relation to sea level rise and stratigraphy of water masses in the Levant basin since the LGM. Given the consistency of seafloor currents throughout the Holocene we propose to address them as the Levant Jet System.

Quaternary development of the Coastal Plain, Israel: landscape dynamics and sedimentary accretion

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We present here reassessment of the Quaternary history of the Coastal Plain, Eastern Mediterranean based on systematic field survey and chronologies.
The Coastal Plain Quaternary sequence is a product of cycles of shifting sands, phases of stabilization and pedogenesis followed by burial or by incising and redeposition by fluvial activity in association with sea level changes and eolian activity.
The chronology indicates that the first order control on these cyclic accretion are glacial-interglacial eustatic sea level changes associated with glacial exposers of stretches of coastal areas to wide activity, deposition and movement of sand, and interglacial erosion of the coastal cliff. This cyclic processes in a dynamic environment result in gradual spatial buildup of sedimentary sandy complexes westward, mostly observed in the coastal cliff of the central Coastal Plain. The chronology shows that paleo-dune fields deposition comprises the majority of the complexes' thickness, but most of time is in pedogenesis. Active dunes are adjacent to the coast or up to 10 km inland from their respective Quaternary coastlines. These dunes, under suitable conditions are cemented to form aeolianites primarily through soil calcic horizon formation. Nevertheless, the chronology and field observations indicate limited preservation of these dune fields that are best preserved as a series of narrow, coast parallel sandy complexes which vary in ages. The synthesis of all data indicates that eustatic sea regression is followed by intense wind activity; the sand fields extend eastward and accrete at the foot of the previously abandoned sea cliff, climb and even cover the cliff top, enhancing its morphological expression, later termed 'kurkar ridges'. During glacial maxima the sands stabilize by vegetation cover, pedogenesis and erosion together with movement of the sand and fine eolian sediments into the lows in the topography. During interglacial transgressions, coastal dune fields are active near the shore, blocking and changing the drainage system. Cliff erosive processes result in partial erosion of the former regressive deposits. Erosion of the sedimentary complexes and mouth of fluvial systems is followed by incision of the fluvial systems within the complexes due to high gradient and stream capture process.
This sequence of glacial-interglacial scale processes results in east to west accretion of the Quaternary Coastal Plain, forming the typical series of coast parallel relict sedimentary complexes and fluvially filled troughs

Gulf of Aqaba and Red Sea sediment provenance during the last 150 kyrs from major and trace element concentrations and neodymium isotopes

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The Gulf of Aqaba (GOA) is a northern extension of the Red Sea, located within the hyperarid Saharo-Arabia desert belt. This region experienced significant glacial-interglacial climate variability, as well as millennial timescale perturbations during intensified tropical monsoon activity and Heinrich stadials. In order to deconvolve transport pathways of terrigenous material to the GOA and north Red Sea during various climatic settings, and to identify possible episodes of fluvial contributions reflecting wet conditions, we aim to categorize the provenance of sediments in these basins.

Here, we have determined the major and trace element compositions and the Nd isotopic signature (εNd) in five GOA and two north Red Sea cores. In each sample, we studied the Fe-Mn oxide fraction, representing the paleo-deep-seawater composition, and the siliciclastic fraction, representing the terrigenous input component. In all cores we compared the Last Glacial Maximum (LGM) and Holocene signal, and established high resolution down core records for the last 150 kyrs in the southern GOA and northern Red Sea.

A GOA transect yielded a gradual increase of ~ 1 εNd unit of the detrital component during the Holocene from north to south. Conversely, εNd is uniform (~ -4.0) across the GOA in the leachate fraction during the Holocene. Three LGM samples in the southern GOA suggest the siliciclastic fraction was dominated by a single end member characterized by an εNd value of -5.7 whereas the leachate fraction shows a radiogenic influence at a site in proximity to Wadi Dahab, perhaps suggesting the impact of fluvial runoff on deep seawater εNd composition.

In the down core records, the detrital εNd values range between -2.5 and -6.4. In the Red Sea, the terrigenous εNd signal co-varies with sea level changes, especially in a stepwise pattern during Marine Isotope Stage (MIS) 5, when an εNd maximum value (-2.5) corresponds to MIS 5e. This excursion can indicate the dominance of eolian components originating from Arabian-Nubian Shield or Ethiopian Highland outcrops. Major element abundances reveal the influence of a high Mg/Ca end member at both core sites during the last deglacial, which does not correspond to modern aerosol compositions and is thus likely associated with local fluvial inputs.

In order to further understand the composition of end members influencing the GOA and Red Sea, we determined for the first time the εNd value of modern aerosols and seawater from the GOA. Combined with the full down core records, we will present a mass balance for Nd in the Red Sea

and GOA, which considers both distal and local sources, as well as temporal trends, and can ultimately be applied to understanding Nd cycling in marginal basins.

Rockbursts in discontinuous rock masses: theoretical analysis and field results from the Jinping hydroelectric project in China

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We study rockburst generation in discontinuous rock masses using theoretical and numerical approaches. We begin by developing an analytical solution for the energy change due to tunneling in a continuous rock mass using linear elasticity. We show that the affected zone where most of the increase in elastic strain energy takes place is restricted to an annulus that extends to a distance of three diameters from the tunnel center, regardless of initial tunnel diameter, magnitude of in-situ stress, and in-situ stress ratio. By considering local elastic strain concentrations, we further delineate the Rockbursting Prone Zone (RPZ) found to be concentrated in an annulus that extends to one diameter from the tunnel center, regardless of original stress ratio, magnitude, and the stiffness of the rock mass. We proceed by arguing that in initially discontinuous rock masses shear stress amplification due to tunneling will inevitably trigger block displacements along preexisting discontinuities much before shear failure of intact rock elements will ensue, because of the lower shear strength of discontinuities with respect to intact rock elements, provided of course that the blocks are removable. We employ the numerical discrete element DDA method to obtain, quantitatively, the kinetic energy, the elastic strain energy, and the dissipated energy in the affected zone in a discontinuous rock due to tunneling. We show that the kinetic energy of ejected blocks due to strain relaxation increases with increasing initial stress and with decreasing frictional resistance of preexisting discontinuities. Finally, we demonstrate how controlled strain energy release by means of top heading and bench excavation methodology can assist in mitigating rockburst hazards due to stain relaxation.

We demonstrate our numerical approach using geometrical characteristics and material properties encountered during tunneling of four headrace tunnels below rock cover of 2500 meters, within the framework of the Jinping hydroelectric project in Sichuan province, China.

New Constraints on Pleistocene slip rates across the Arava Segment of the Dead Sea Transform

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Scarce markers for lateral offsets and complications in age determinations have resulted so far in limited constraints for Pleistocene slip rates across the Dead Sea Transform (DST). Here, we address this data gap using a suite of satellite observations along the Arava segment of the DST. Spectral data from NASA's Advanced Spaceborne Thermal Emission Radiometer (ASTER) was used to correlate between sinistrally offset alluvial surfaces and radar data from Japan's Advanced Land Observation Satellite Phased Array type L-band Synthetic Aperture Radar (ALOS-PALSAR) was used to quantitatively estimate the age of the offset units. These observations allowed us to obtain new constraints on the average lateral slip rate of the DST since ~1 Ma.

Quantifying Earthquake Effects on Ancient Arches, Example: The Kalat Nimrod Fortress, Dead Sea Fault Zone

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Arches have been in use for more than three millennia. Deformed arches are often key elements of archaeoseismic studies, in which damage, particularly moved keystones, are considered clear indications of seismicity. We introduce a damage evaluation scheme that allows a straightforward determination of the degree of damage of an arch based on laser scan models and digital images. The scheme is applied to 99 arches of Kalat Nimrod, a 13th century Castle near the Dead Sea Fault, which was heavily damaged during the 25 November 1759 Lebanon earthquake. The analysis shows that the a-priori assumption of a correlation between arch orientation and damage degree does not hold for the entire building. Exception is a large tower with a secret passage in which voussoirs have dropped along a 20-m-long section interpreted as an overall uniform E-W extension.

Designing special algorithms for the production of earthquake scenario maps in real time

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Development of damage scenarios in the first hours after an earthquake event is a vital process needed to address the expected lack of information at the time required in order to improve the preparedness and optimal response of the emergency authorities. Throughout the simulation process a lot of data is generated and it is no trivial matter to screen out the scale of the damage and the essential information that should be presented to the decision makers in the shortest possible time. For this purpose special algorithms based on a GIS platform have been developed which can in a very short time make dozens of different types of scenario maps available to the decision makers. The maps are user friendly and are specially designed to give a general picture of the damage to be expected in Israel, including the uncertainty interval present in all earthquake damage simulations. We do believe that this special procedure will minimize error in anticipating the damage and quicken the response of the country-wide systems shortly after an earthquake event.

Petrofabrics of deformed rocks revealed by magnetic fabrics and geochemical methods

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Magnetic fabrics evolve due to preferred crystal orientation and grain shape alignment of the different mineral phases (i.e., magnetic phases) within a rock sample. They are relatively easy to measure and have a great potential for studying sedimentation, deformation and flow processes in different geological settings and environments. For detailed analysis and separation of the rock and magnetic phases, we developed and applied special rock magnetic and geochemical techniques at the magnetic and geochemical laboratories at the Geological Survey of Israel. The room temperature anisotropy of magnetic susceptibility (RT-AMS) method sums the contribution of diamagnetic, paramagnetic and ferromagnetic minerals in the rock samples while the low temperatures anisotropy of magnetic susceptibility (LT-AMS) method enhances the contribution of paramagnetic minerals like clays and other phyllosillicates. The LT-AMS method has been associated with large errors However in this study we were able to reduce the errors significantly by novel shielding of the kappabridge. Another magnetic method is the anisotropy of anhysteretic remanent magnetization (AARM) This method enables to measure the magnetic fabric of ferromagnetic minerals as magnetite, hematite, iron sulfides, etc. In addition, we applied geochemical procedure which allows to measure the composition of the different mineral phases in the rock (i.e., carbonate, insoluble residue, oxides) and correlate them to the parameters of the magnetic fabrics. Integration of all these methods enables us to evaluate the contribution of all mineral phases and to determine the sources of magnetic fabrics in the rock. Such is the case of the Maresha Formation in southern Golan Heights where three different sources to the measured magnetic fabrics were identified: (1) carbonate coccoliths consisting of calcite, (2) clay fibres consisting of palygorskite and (3) grains of iron oxides consisting of greigite and oxidized magnetite. The iron-related magnetic fabric preserves its original sedimentary fabric while that of calcite and clay fabrics evolve due to deformation and are most likely affected by the Dead Sea Fault related strain.

Shoreline reconstruction of the Ancient Maya Port Vista Alegre using marine geoarchaeological methods

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The environmental and morphological history of the ancient Maya port site of Vista Alegre, located along the north coast of Mexico's Yucatan Peninsula, is being investigated within a larger multidisciplinary effort called the Costa Escondida Project. The project's main goals are to learn how the ancient inhabitants adapted to their environment and the changes it underwent through time, as well understand how this coastal site was integrated into broader maritime trade routes. This project is first of a kind in this area, chosen by its strategic location, at the connection between the Caribbean Sea and the Gulf of Mexico. The portion of the research presented here concentrates on the site's shoreline changes during the past 3000 years, studied through a multiproxy analysis of cores and surface samples. This study aids our understanding of the environmental challenges the local inhabits contended with, the site's possible functions and possible ancient harboring locations. Results from the research may make it possible to locate underwater manmade seafaring artifacts and facilities, determine the range of economic opportunities for past inhabitants and quantify the availability of potable water sources.

Zalmon Cave: A Unique Window to Paleoclimate in the Eastern Galilee, Israel

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The newly discovered Zalmon Cave offers an opportunity to study the Eastern Mediterranean paleoclimate in the northern Dead Sea Rift. The cave is located in the Dead Sea catchment approximately 8 km west of the Sea of Galilee, within the Turonian B'ina Formation. Speleothems have long been used to gain a better understanding of paleoclimate, and researches have been conducted in numerous cave locations in Israel, however the Eastern Galilee, in the northern Dead Sea Rift has yet to be studied. Here for the first time in this region, we show an isotopic record of speleothems from Zalmon Cave. Our findings suggest that speleothems were deposited in this cave both during glacial and interglacial intervals, in contrast to Ma'ale Efrayim cave, located further south along the Dead Sea Rift, where deposition occurred only during glacial intervals. Comparison of the isotopic record of Zalmon Cave to published records from the Northern Galilee (Peqi'in) and Soreq Cave shows that the carbon profiles are similar. This suggests similar vegetation types, in agreement with present conditions. In contrast, the oxygen isotopic profiles are similar only during interglacial periods. During glacial times the d18O is lower than Peqi'in cave by ~1 permil and lower than Soreq and Ma'ale Efrayim caves by about 1-3 permil. We tentatively interpret this to suggest either warmer temperatures in Zalmon region and/or depletion in rainfall d18O as the rain migrated farther east. Addressing the prominent 18O depletion eastward during glacial periods, we consider the lower sea level and probably different rainfall amounts during these times.

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

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Episodic rainfall over the hyperarid desert may cause flash floods in ephemeral rivers surrounding the Gulf of Aqaba-Eilat. These floods constitute an essential factor in the region's ecology but may also damage infrastructure and risk lives. Some floods reach the head of the Gulf of Aqaba and their sediments are deposited 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 recognize them in the microstratigraphy (1 cm intervals) of dated cores from the shallow and deep seafloor. Interpretation of flooding sequences from the sediment profiles will be based on these results and findings from a complementary study on the deposition, removal and preservation of flood sediments in recent (2013-2015) events. Our preliminary results show that characteristics of suspended flood sediment, e.g. grain size distribution and elements and mineral composition, are distinguishable and recognizable in the stratigraphy of the cores. Flood sediment concentrations 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 the long core from the shelf show recurring fluctuations, but also three more long term environmental shifts that require further explanation. These promising results will be complemented with more chemical and 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.

Regional differences in site-response with respect to V_{S30}

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V_{S30}, the time-averaged shear-wave velocity of the top 30 meters, is extensively used as a primary parameter to describe site-effects in many world-wide Ground Motion Prediction Equations (GMPEs, formerly known as attenuation relationships) and building codes. Despite its known limitations and simplifications (for example, it does not account for 2-D and 3-D effects), no alternative thus far has been suggested for a single, effective, continuous parameter that can work well for a large global ground-motion dataset, and hence V_{S30} will probably continue to dominate GMPE site classification for the near future. The Israeli practice, for example, adopts the NEHRP site factors that were derived in the 1990's in California. Recent GMPEs (e.g. NGA-West2, 2014) still use V_{S30} as the main proxy for site-characterization, but some provide different scaling for different regions, mostly regions with sufficient ground motion data to constrain such regional scaling (e.g. California vs. Taiwan, Japan, Italy, and China).

In this presentation, will first review the history of site-classification in the practice of seismic hazard analysis and shortly explain the logic for using V_{S30}. I will show why this simple proxy works well for predicting the average site-response of similar sites and how regional site-response scaling is correlated with the shape of the entire velocity profile. I will analyze large databases of measured shear-wave velocity profiles from three global regions (California, Taiwan, and Japan) and explore their velocity gradients at depth. The analysis will highlight differences and similarities between profiles from different regions and how these affect the response to seismic ground motions.

Critical evaluation of application of metal-based redox-paleoproxies for marine systems affected by aeolian dry deposition, Gulf of Aqaba, Red Sea

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The Gulf of Aqaba, Red Sea, is dominated by aeolian dry deposition from the adjacent deserts, mostly from Sahara. This study was designed to understand a biogeochemical cycling of the redox-sensitive elements in the sediments of the Gulf of Aqaba with focus on an impact of aeolian dust deposition on distribution and speciation of the redox-sensitive metals in the sediment. Speciation of these elements, especially of iron, is successfully applied as a paleoproxy for redox conditions in the water column of ancient oceans.

The depth distribution of electron acceptors available for mineralization of organic matter was studied in the upper 90 cm of the sediments of the Gulf of Aqabasampled at the 694 m water depth. Concentrations of sulfur species and dissolved iron and manganese in the pore-waters were measured. AVS, CRS, and elemental sulfur contents, total and highly reactive iron, molybdenum and aluminum concentrations were measured in the solid phase. Concentrations of total and reactive iron, molybdenum and aluminum were also measured in aerosols, including the samples collected during the dust storm.

Manganous zone was found in the upper 1-10 cm of sediments, ferruginous zone was found in the upper 50 cm of sediments, with the maximum concentrations of dissolved iron at the 7-23 cm bsf depth (up to 14.9 µM). Enrichments in total and highly reactive iron contents observed in the sediments result in oxidation of hydrogen sulfide to sulfate and intermediate sulfur species. The molybdenum profile exhibited an overall decrease with depth with maximum concentration of 4 ppm near the sediment-water interface. Similarity in speciation of iron in the sediments and dust suggests strong influence of the dust deposition on the biogeochemical cycling of iron in the Gulf of Aqaba.

The enrichment of sedimnets with aeolian dust-derived redox elements results in strong bias in interpretation of paleo-proxies. Results from iron-based proxies suggest the water column of the Gulf of Aqaba to be anoxic and ferruginous, which contradicts the well-established fact that water column of the Gulf of Aqaba is oxygen-rich. In addition, the various molybdenum content-based proxies reflect oxic and euxinic water column.

We suggest that multi-paleoproxy techniques based on the analysis of the concentration, speciation, and isotopic composition of specific redox-sensitive elements in sediments are to be developed in order to determine whether marine systems were significantly affected by aeolian dry deposition, and thus were likely situated in arid regions and surrounding semi-arid margins throughout Earth's history.

3.5-D model of sediment age and grain size for the Northern Gulf of Aqaba-Elat using submarine cores

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We aim to characterize the top sedimentary cover across the Northern Gulf of Aqaba-Elat (NGAE) in order to check the effect of tectonics on the sedimentary column, using high resolution grain size data and radiocarbon dating of core sediments.We analyzed 11 piston cores and 9 short cores: high resolution grain-size and radiocarbon age determinations were used to compile a 3.5-D (3.5 dimensional) model of age-depth-grain size for the top 3-5 meters of the NGAE. Two general trends of the grain size spatial distribution are observed: grains are coarsest at the NE corner of the NGAE (Aqaba coastline) and grow finer with the distance to the west on the shelf and with the distance from shore to the south. Long- and short-term accumulation rates were compiled for the entire NGAE, demonstrating a distinct E-W trend on the shelf and a NNE-SSW trend in the deep basin.

The 3.5-D age-depth-grain size model conforms and validates the tectonic structure of the shelf detailed by previous authors. We suggest that the impact of tectonic structure of the shelf is highly significant in terms of spatial variations across the shelf, both in age of the sediment and its grain size characteristics. The temporal-spatial distribution of the grain size in the deep basin of the NGAE reveals fine-grain, old sediment in the margins (Late Pleistocene, as old as >40 ka on west margin; Early Holocene, as old as 7.5 ka, on the east margin), and Late Pleistocene sediment farther south from the active diagonal fault which underlies the Elat Canyon. Young coarse sediment is present in the middle of the basin, where most of the active sediment transportation (and tectonic activity) take place. The dominant sedimentary activity follows the tectonic migration from east (Ayla Horst) to west (Avrona Fault) between 40 ka to present.

A spatial/temporal evolutionary model is presented for the sedimentary processes of the NGAE since 40 ka to present, suggesting three phases of development: (a) Late Pleistocene 40 to 12 ka; (b) Early to Mid-Holocene 12 to 5-4 ka; (c) Late Holocene 5-4 ka to present.

Submarine landslides hazard offshore Israel

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Submarine landslides pose significant natural hazards. They can damage seafloor infrastructure, such as that used to recover oil and gas or seafloor telecommunication cables, and even generate tsunamis. We recently mapped 447 submarine landslides across the east Mediterranean continental slope, offshore Israel (hereafter the studied area). The mapped landslides are found at water depths of 130 m to 1,000 m and their volume ranges 10^-5 – 10^0 km^3. Landslide scars are typically related to a critical slope angle of >4°. Landslides at the northern part of the studied area are spatially associated with fault scarps and are smaller than the ones on the southern part. In this work we evaluate the potential hazard to population and to on- and off- shore facilities posed by submarine landslides across the studied area.

We integrate three independent probabilities: (1) the probability for a landslide event of a given volume, based on the size distribution of the mapped landslides; (2) the probability for a landslide event in a given time, based on the reoccurrence time of triggering earthquakes with M >7, and on a 50,000 years general time frame derived from submarine landslides identified across the Mediterranean Sea; (3) the probability for a landslide event in a given area, based on the distribution of slopes exceeding the critical angle. Overall, the fraction of potentially destructive landslides (size > 0.1 km^3) is small, 0.05. Thus, considering typical planning time scales of less than 100 years, the calculated hazard is only moderate.

The small fraction of landslides with tsunamogenic potential (size > 0.1 km^3), suggests that the hazard for landslide-induced tsunamis along the open slope part of the studied area is small. Landslides in the southern part of the studied area are larger and thus present a somewhat bigger potential source of tsunami waves.

Recent findings on the deposition and dispersal of flashflood borne sediments in the Gulf of Aqaba (Eilat)

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Most of the discharge of alluvial sediments into the sea along arid and hyper-arid coastlines occurs via ephemeral rivers (wadis) during flashflood events. Because desert flashfloods are infrequent and difficult to predict and quantify, little is known of their effects on marine sedimentary processes. Our ongoing research from the hyper-arid head of the Gulf of Aqaba (GOA) shows that flashflood-borne sediments constitute the majority of the seafloor sediments. When entering the sea, these sediments may disperse as hyperpycnal flows near the seafloor or as hypopycnal flows at the surface, depending on the sediment concentrations in the discharged floodwater. These concentrations are likely controlled by particle settlement in the salt flats to the north of the gulf. Accordingly, floods originating from the north of Wadi Yutim in Jordan and “Nahal Shchoret” in Israel discharge with lower sediment concentrations and are less likely to form hyperpycnal flows. Owing to the bathymetry of the head of the GOA, hyperpycnal plumes entering the gulf in the east and west, where the slope is steep, can flow uninterrupted to the deep basin. Hyperpycnal flows entering from the north are primarily deposited on the moderately sloping shelf; though intermittent, these deposition events suffices to prevent the growth of coral reefs therein. A time series study shows that most flashflood deposits are efficiently transferred from the north shelf to the deep basin in less than one year. Our results suggest that this transfer is largely controlled by biological mixing and resuspension. Nevertheless, a multiproxy analysis of cores from the shelf (and the basin) shows notable vertical fluctuations in fine, flood sediment concentrations. These results are currently being processed to reconstruct paleoclimate conditions in the study area.

Comparing Alternative Proxies for Linear Site-Response Estimation in Israel

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Predicting ground motions during a future earthquake is a fundamental aspect of any seismic-hazard analysis. Performing a local site response analysis, thus characterizing the site specific properties for amplification predictions, is typically the preferred method. Nevertheless, sitespecific studies are inapplicable on national scales, in which case an index parameter is used for site-characterization. Vs30, the time-averaged shear wave velocity in the top 30 meters of the geological profile, is the accepted parameter in most countries for site evaluation. This parameter was developed in California and was adopted by the Israeli building code (SI 413) for site categorization. Vs30 shows good correlation between the top 30 meters of a soil profile and the deeper structure in California, and is used in the prediction equations for local amplification with respect to a reference rock site. Zaslavsky et al. (2012) performed measurements at Israeli sites and showed significant differences in site effects within short distances, thus concluding that using Vs30 for calculating site effects in Israel is not recommended.

In this study, we collect data of local soil profiles in Israel (courtesy of GII and others). We compute the linear 1-D site-response using the transfer function method and explore common characteristics of typical Israeli profiles. In search of an updated approach for characterizing sites in Israeli building codes and seismic hazard analyses, we test the correlation between the calculated amplification and Vs30, and compare it with the correlation to other alternative profile parameters, such as depth to rock, other averaged velocities, and more.

Beyond critical acceleration pseudo-static analysis

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Common geotechnical earthquake engineering design approaches utilize the acceleration levels to evaluate slope failure triggering and resulting permanent displacements, using pseudo-static stability analyses together with Newmark method. These approaches involve an implicit assumption of a single sliding mechanism of a constant volume, and do not take into account the possibility of multiple (increased in size) mechanisms due to higher acceleration than the critical one. That is, evaluation of the slope under higher acceleration than the critical one only results in a factor of safety smaller than 1.0 and cannot capture the possible impact of greater acceleration on the developed mechanism and displacements.

The paper presents an analysis framework which allows evaluation of the effect of higher acceleration (beyond the critical one) on the mechanism and the volume of the slide. The approach combines concepts from pseudo-static analysis together with plastic flow, such that the developed mechanisms are restricted from transferring greater stresses than their yield values (and by that preventing factor of safety lower than 1.0). The approach may be said to be “quasi dynamic” in which the failing mass continues to accelerate under the unbalanced forces (beyond the critical one), while the remaining stable body is static, until an additional, new, mechanism develops. In the paper, the approach is applied to slopes characterized by ideal elasto-plastic material, without any strain softening, to demonstrate that in certain conditions an increase in the acceleration level, by itself, may alter the slope failure mechanism.

It is demonstrated that changes in failure mechanism occur at distinct acceleration levels (the first of which is the classical pseudo-static value), and the volume of the sliding mass correlates with the integrated unbalanced force.

The effect of mechanism alteration due to increase in acceleration may be more relevant to natural slopes, in which individual local modes of failure may unite into a larger global failure mode, but not necessarily to manmade embankments in which a change of mechanism requires drastically high accelerations.

Impact of vegetation on speciation of redox-sensitive elements in sediment pore-waters in Lake Kinneret

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In freshwater sediments, microbial degradation of organic matter is dependent upon the availability of various electron acceptors. Oxygen, which is the most favorable electron acceptor, is the first to be consumed. Then nitrate reduction takes place, followed by MnO2 reduction, Fe(O)OH reduction, sulfate reduction, and methanogenesis. In Lake Kinneret, sulfate concentrations are c.a. 50 times lower than those in sea water, thus it is consumed in the upper centimeters of the sediment and methanogenesis becomes the main energy source for microbiota.

The focus of the presented research is to investigate the impact of vegetation on the speciation of redox-sensitive elements in pore-waters of Lake Kinneret. The composition of the sediments is affected by vegetation, through which both the oxygen supply and organic matter content of the sediment are augmented.

Water level fluctuations influence the littoral vegetation in a seasonal cycle. The common cordgrass Cyperus articulatus L. grows on the shore of Lake Kinneret when the water level is low, and dies when the area is flooded.

Concentrations of hydrogen sulfide in the pore-waters of the upper 30-40 centimeters of sediments were higher in non-vegetated sediments (up to 0.8-5.8 µM) than in vegetated sediments (<0.8 µM). The highest concentrations of sulfide oxidation intermediates were detected in sediments with high hydrogen sulfide concentrations: up to 8.4 µM of zero-valent sulfur, 9.1 µM of thiosulfate, and 1.6 µM of sulfite. The highest concentrations of dissolved iron (1010 µM) and manganese (89 µM) were detected in non-vegetated sediments at 0.1 m water depth. Lower concentrations were detected in vegetated sediments above the water level (up to 323 µM dFe and 41 µM dMn), and the lowest concentrations were detected at 12-38 m water depth (up to 86 µM dFe and 13 µM dMn).

This observation suggests that in Lake Kinneret sediments, interactions between reduced iron and hydrogen sulfide is more important for the redox zonation of sediments than the presence or absence of vegetation. Analysis of solid phase sulfur and iron speciation in the sediments should further elucidate the conditions that control the composition of Lake Kinneret pore-waters.

Smoothing the Basin – Interplay between Deep-Water Channels and Structures within the Levant Basin

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This study focuses on the smooth part of the Levant basin, which before the last formation of deep-water channels, was characterized by complex geomorphology. Isochore maps of the last interval containing channel-form features indicate that the palaeochannels “saw” mini-basins and a series of conjugate faults. These structures” are well expressed today along the eastern part of the study area, where the studied interval is thin and does not contain channels-form features. This suggests that currents conveyed by deep-water channels deposited sediments within mini-basins and by doing so smoothed the sea-floor morphology.

The high quality 3D seismic dataset used in this study allows for the detection, not only of palaeochannels, but also of their main architectural elements. Recognition of architectural elements revealed relative ages among 7 channels, within the studied interval, and also their interactions with various structures. The identified field relationships indicate that the channels deviated around, or converged between, anticlines and fault walls, and deposited sediment within mini-basins. The field relations also indicate that the quantity and intensity of the identified interactions decreased with time.

The reconstruction pattern of the carbonate factory after the P-T crisis and during the Early Triassic in a heterolithic sedimentary system, and its relation to a hinterland aridization (SE tropical tethyan seaway, Levant Basin)

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The sedimentary system since the Permian and during the Triassic in the Levant region was prevailed by siliciclastics associated with a varying percentage of a carbonate component. The supply of the siliciclastics is considered to be hinterland-climate controlled, and the siliciclastic record indicates at least six times that this climate-induced was changed over the Early Triassic – early Middle Triassic sections (David 1 and Pleshet 1 boreholes, central Israel). Intense environmental change occurred before, during and after the P-T boundary. The extinction of the Permian benthic foraminifers was gradual, accompanied by change in the diversity in the skeletal fossil record. The gradual decline in the foraminiferal diversity is not keyed to any gradual change in the sedimentary pattern until slightly before the P-T event.
In the Early and Middle Triassic, the sedimentary environment began to be carbonate dominated, but introduction of siliciclasts as event beds, or sand as a random component of the grainy limestones was continuously common.
Intermittent horizons in the sedimentary successions exhibited extirpation of foraminifera and other skeletal remains (named as “Dead Zones”(; their presence in the siliciclastic dominant intervals seemed obvious, but their occurrence in the carbonate dominant intervals is not straightforward, particularly where they were associated with low diverse burrows and high content of initially reactive iron. When the “Dead Zones” occurred in siliciclastic dominant intervals, they were assigned to hinterland humidity and basin suppressed carbonate. When they occurred in carbonate dominant intervals, they were assigned to stress conditions, probably anoxic, and tied to the hinterland aridization. Aeolian-derived suffocation is considered as a possible mechanism.
The following recorded foraminifera exhibited sensitivities manifested by differential occurrences and distributions to the environmental changes mentioned above:

1. The “disaster” species group contains the porcelaneous (miliolid) tests of Postcladella kahlori, Calcitornella sp., Hoyonella sinensis, and monospecies of hyaline nodosariid which were tied to the initial stages of a siliciclastic system which prevailed, to the initial stages of the carbonate as it replaced the siliciclastic system, and to other initial stages of unfavorable conditions that gained control when carbonates were dominant.
2. The encrusting foraminifer Tolypammina gregaria indicated initiation of epifaunal tiering and environmental amelioration.

3. The advanced typical Early – early Middle Triassic species group contained mainly larger microgranular, agglutinant and non-nodosarids hyaline tests, all of which were tied to the main attempt of the local carbonate system to recover.

Stability of thiocyanate in natural aquatic systems

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This presentation focuses on the study of decomposition kinetics of thiocyanate in natural aquatic systems. Despite the importance of thiocyanate transformations for biogeochemical sulfur cycling [1,2], the kinetics of SCN- degradation in natural aquatic systems are poorly constrained. We measured the rates of thiocyanate decomposition in aquatic systems characterized by various redox conditions (oxic, ferruginous, and sulfidic).

The degradation of thiocyanate in non-sterilized samples of Mediterranean Sea water, Lake Kinneret water, and Milli-Q water was studied during a 64-126 day incubation period. Experiments were conducted at 25±1oC. The initial concentrations of SCN- in the solutions were within 3-122 µmol·L-1. Control experiments on the degradation of SCN- in autoclaved samples were performed under conditions identical to non-sterilized samples.

In sterilized (autoclaved) samples, thiocyanate was found to be chemically stable over the incubation time period. In non-autoclaved samples, thiocyanate decomposition was observed after a 24-85 day lag time (except for oxic Mediterranean seawater samples with low initial SCN- concentrations, in which a lag time was not observed). These observations indicate that thiocyanate decomposition in natural aquatic systems is a microbial process under both oxic and anoxic conditions.

The Michaelis-Menten model was applied to these data to determine the thiocyanate decomposition rates, and the parameters fit to this model were then used to estimate thiocyanate degradation rates and half-life times.

The half-life time of thiocyanate in all systems was in the range 18-710 days (not including the lag period). The shortest half-life time was calculated for oxic Mediterranean Sea water (18 days at 3 µmol·L-1 concentration). It was 9 times and 12 times shorter that at oxic Lake Kinneret water and at Milli-Q water at the same thiocyanate concentration, respectively. It was found that SCN- was degraded faster in the presence of hydrogen sulfide in Mediterranean seawater (250 days at 4 µmol·L-1 concentration) than in H2S-rich samples of Lake Kinneret water (315 days at the same concentration). In the presence of Fe(II), in Mediterranean Sea water, the degradation time is 1.6 times shorter than in Milli-Q water in the presence of Fe(II) (258 days and 401 days, respectively, at 3 µmol·L-1 concentration).

In all experiments using water sampled from natural aquatic systems, under anoxic conditions, a longer half-life time was observed than in the oxic samples.

We applied our results to determine the half-life time in other natural aquatic systems: Lake Rogoznica, the Delaware Great Marsh, and the North Sea. Concentrations of thiocyanate in these systems were reported to be 0.288, 2.72, and 0.013 µmol·L-1, respectively [1,3,4]. Half-lives of thiocyanate in these systems were calculated to be 239, 310, and 1 days, respectively.

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Study of the early stage immature oil produced from the Israeli oil shale, Ghareb and Mishash formations

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Recent attempts to develop the Senonian oil shale deposits of Israel sparked an interest in studying the properties of the oils produced from this type of source rock. Israeli oil shale of the upper Cretaceous Ghareb and Mishash formations are organic-rich chalks with up to 20% of kerogen by volume. The kerogen has high percent of sulfur which classifies it as Type II-S kerogen (Orr, 1986). During the maturation of a type II-S kerogen, the oil initially released is sulfur-rich due to preferential breaking of weak sulfur bonds (S-S, S-C, S-H). This leads to release of high concentrations of asphaltenes, resins and aromatics that all together make the initial oil dense, viscous and rich in sulfur (Orr, 1986). An additional outcome of breaking weak sulfur bonds is the release of thermally unstable alkyl thiophenes; these compounds might play an important role in determining the viscosity of the early produced oils as they can act as solvents for other compounds in the oil, thus lowering the bulk viscosity of those oils.

Here we present preliminary results of pyrolysis experiments of oil shale from the Aderet and Zoharim boreholes in the Shfela basin at various stages of maturation. API gravity and viscosity of the produced oils were determined by pycnometer and viscometer measurements (Zeitfuchs, Cannon). N-alkanes, alkyl thiophenes (Cn > 10) and benzothiophenes concentrations were determined by GC-MS (7890A, Agilent). Total sulfur content was determined by LECO carbon - sulfur analyzer (SC632, LECO company).

Produced oils were found to contain high sulfur content (1.6%-19.2%) which decreased in their concentration upon maturation of the rock. The total decrease of sulfur content seems to be continuous and cannot be explained by the formation and decomposition of the analyzed thiophenes and benzothiophenes alone, suggesting an additional, more abundant sulfur species that controls the observed decrease. Variation of API gravity with respect to sulfur content and thermal maturation agrees with the trend observed by Baskin and Peters (1992). However, the viscosity of oils varies irregularly with respect to thermal maturation and seems to be unrelated to the alkyl thiophene content of the oil. Correlation to other type II-S oils from Israel and California show similar trends of viscosity, density and sulfur content.

Plio-Pleistocene development of the Levant continental margin based on 3D seismic stratigraphy

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Stratigraphic buildup of continental margins is dictated by interplay between vertical tectonics, isostasy, eustatic sea level variations and the rate of sedimentation. These components varied throughout the Plio-Pleistocene development of the Levant continental margin. Tectonic motions and flexural isostasy accentuated land topography and tilted the continental margin. Nile River sediment flux intensified while proximal fluvial systems were shortened. Expression of these modifications across the sedimentary sequence was previously studied based on 2D seismic reflection data. Here we re-examine these sequence through integrated interpretation of two 3D seismic reflection volumes and four boreholes. Our analysis includes chronostratigraphic division, sedimentation rate calculation and morpho-tectonic reconstruction of the Plio-Pleistocene section. Data indicate two main patterns. Pliocene to early Pleistocene (Gelassian) sedimentary aggradation occurred along with short wavelength E-W horizontal shortening (~10 km). Morphology of the consecutive thirteen mid-to-late Pleistocene forth-order sequence boundaries indicates that this strain ceased during the early-to-mid Pleistocene tectonic transition. It was replaced by long wavelength basinward tilting of the margin.

Live and dead molluscan assemblages as a proxy for ecosystem modification in the shallow Israeli Mediterranean shelf

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The mismatch between live and dead shelly molluscan assemblages in the Eastern Mediterranean has been attributed to recent, rapid, anthropogenic changes. This region is naturally oligotrophic, but recent urbanization of the Israeli coastal plain has led to nutrient enrichment of the littoral environment by injection of wastewater onto the shelf. The Dan region wastewater project (Shafdan) that discharges sewage sludge through a seabed pipeline 5 km offshore south of Tel Aviv is the largest point source. The Shafdan sludge accumulates on the seafloor when the water column is stratified and there are no strong bottom currents, and is dispersed in winter by storms and biological consumption.

The taxonomy and community structure of modern (sediment-top) death assemblages vs. live-collected molluscan assemblages was compared from two control (PL29, PL64) and one polluted station (PL3), near the Shafdan sewage sludge outlet at ~36 m water depth. Seasonal variability was captured by dredge and box-core sampling in winter (January), spring (May), summer (July) and fall (November) of 2012. A vessel-operated dredge was used to acquire a larger volume of sediment containing live mollusks. Over 11,000 individuals of bivalves and gastropods were collected and analyzed.

Live and dead assemblages were dominated by the bivalve <i>Corbula gibba<i>. The high frequency of storms in the winter of 2012 prevented a substantial amount of sludge from accumulating on the seafloor, which in turn resulted in the similarity between the live assemblages of the polluted and the control sampling sites. However, the accumulation and dispersion of sludge was successfully tracked by relative abundance of the pollution indicator species <i>Nuculana pella<i>.

Univariate and multivariate analysis showed significant differences in community structure and composition between the live and dead assemblages, even though the dominant species remained similar, and Spearman rho correlation coefficient of the rank order of species was high. Live-dead agreement of molluscan assemblages was preserved in the Shafdan area by the naturally high abundance of species that are tolerant to pollution, and by the annual dispersion of the sludge by winter storms, which prevent development of long-term anoxia.

Live-dead agreement is a conservative test that proved insensitive to the pronounced impact of the Shafdan sludge on the macrobenthic fauna in the Israeli shelf. It is the low diversity of live species, and the increase in the abundance of deposit-feeding pollution-tolerant species in the live assemblage that demonstrate the ongoing impact of sludge injection on the benthic community.

Field weathering rates of carbonate rocks NOT limited by mineral dissolution kinetics

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The rate of carbonate rock weathering is thought to impact the global carbon cycle over geological timescales. At low levels of precipitation, the rate of carbonate denudation increases linearly with rainfall; however, at higher levels (>1000 mm y-1) the rate reaches a plateau. This effect has been attributed to the transition from water- supply-limited to kinetically-limited geochemical regimes. Here we present a novel study that compares long-term field denudation rates, determined using cosmogenic isotopes (36Cl), with the reaction rates measured in laboratory experiments conducted on the same rocks collected from sites in the Soreq drainage in Israel. Although the samples were taken from locations with similar mean annual precipitation, the denudation rates varied significantly from 6 mm ky-1 to 20 mm ky-1. We found that the laboratory rates also varied, decreasing as the ratio of dolomite to calcite increased. However, no correlation was evident between the long term denudation rates and the laboratory rates, suggesting that field rates were not controlled by kinetic factors alone. Moreover, the rates we measure in the lab are 5-10 times faster than the highest denudation rates calculated for carbonate terrains anywhere in the world. This simple comparison demonstrates that the apparent plateau in carbonate denudation rates is not due to kinetic limitations. Instead, other factors, such as biological activity or secondary calcite cementation, may inhibit the weathering of carbonate surfaces in natural settings.

The Geomorphic response of sediment flux sensitive fluvial channels to climatic and tectonic perturbations

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River incision rate provides an important control over landscape evolution. In recent years, the effect of sediment flux on river incision rates and patterns has been demonstrated, and sediment flux dependent incision models were shown to be able to predict observed fluvial dynamics such as fluvial hanging valleys, and episodic and mobile patches of sediment cover on the bedrock. Sediment flux has a dual role in fluvial streams: particles can act as tools for incision by impacting the river bed while moving in a stream, or they can inhibit incision, when they are covering the bedrock and protecting it from impacts. Most models that describe these effects rely on grain dynamics observations, and are useful for estimating local instantaneous incision rates at the reach scale. Such models, however, cannot address the evolution of drainage systems at the basin or mountain range scales over millions of years.

In this study we focus on two sediment flux sensitive incision models: The Saltation Abrasion Model (SAM), that assumes that only particles that are transported as bedload contribute to incision, and the Total Load Model (TLM) that accounts also for incision by suspending particles. We develop a basin scale version of the TLM, which so far has been formulated only at the grain dynamics scale, and compare its emergent dynamics to an existing basin scale version of the SAM and to the classic Detachment-Limited Model (DLM).

We study the steady-state geometry of a main trunk with relation to tectonic uplift rate, climatic conditions and sediment grain size. Additionally, we study the transient response of a channel, over long time scales, to changes in uplift rate. We observe that in the TLM and SAM a diffused knickpoint appears at the very early stages of channel adjustment along the low reaches, and than disappears, and the channel long profile approaches the new steady-state conditions almost uniformly. This is in contrast to the DLM that is characterized by an upstream propagation of a knickpoint. Further study is needed to better understand the effects of climate, sediment grain size and uplift rate on channel steady state behavior and transient evolution.

Developing economic loss scenarios for the Elat case study

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Elat was chosen as a case study for evaluating economic loss on a local scale as it is located close to the Dead Sea Fault system and constitutes a major tourist attraction in Israel. In order to evaluate economic loss for Elat and to understand its significance information was collected this year from various sources regarding the building, demographic and economic characteristics of the Elat area. Analysis of the data revealed that the majority of civilian and educational buildings are located mainly in the neighborhoods to the west of the coastal strip. Most of these are concrete structures of one to three stories high that are not resistant to earthquakes. On the other hand, it was found that the majority of hotels and employees are located on the strip of coast on which the town is situated. Accordingly, it was found that the value of buildings is highest in the coastal strip area.

Based on this detailed data a number of initial economic damage scenarios were simulated. The damage simulations were based on several synthetic earthquakes in the magnitude range of MW=6-7.5, whose epicenters were located along the major faults close to Elat.

It was found in these scenarios that the number of injured expected to need hospital treatment could reach thousands, the number of those requiring shelter could also reach the thousands and what's more, thousands of buildings could be extensively damaged and the weight of the debris reaching millions of tons. The preliminary results show that the direct economic loss could reach a billion dollars or more, depending on the earthquake magnitude and its location. Classifying the direct economic loss by damage to civilian structures, which includes hotels and commercial buildings, also shows that the greatest economic loss is expected to occur along the coastal strip. Up till now no estimate has been made of the cost of dealing with such large amounts of debris resulting from an earthquake, especially in isolated areas such as Elat. The conclusion from a preliminary analysis of the “Elat scenario” (MW=6) is that in an event of this kind the amount of debris is liable to be more than 106 million tons and most of it is expected to be in the coastal strip area. There is no doubt that besides the expectation that large obstructions will block the main arteries of Elat, there will also be significant economic loss.

Fault processes revealed by Anisotropy of Magnetic Susceptibility (AMS)

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There is a growing need to reveal the local strain field and the size of the damage zone next to faults in order to better understand the mechanics of rupture propagation and growth. For that we applied the Anisotropy of Magnetic Susceptibility (AMS) method to identify characteristic magnetic fabrics formed by faulting, determine the size of the related inelastic damage zone, and test the possibility that these fabrics indicate the fault-plane solutions of past earthquakes. The AMS was measured in different localities mainly next to normal faults that cross late Pleistocene soft lacustrine rocks in the Dead Sea basin and Eocene chalks south of Beer-Sheva. The results demonstrate that variations in the AMS fabrics record the size and shape of the inelastic strain surrounding the fault planes. In the Dead Sea basin, the AMS results show that the damage zone width is crudely similar to the amount of displacement during a single faulting event. Most of the AMS fabrics show a striking similarity to that of the fault-plane solutions, i.e. the principal AMS axes and instantaneous strain ellipsoids are coaxial. These results suggest a novel application of the AMS method for defining the shape and size of the damage zones surrounding the paleo- faults and determining the principal axes of the local strain field.

Seismic Risks for Urban Design at the Salt Pools in Eilat

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New urban design of Eilat playa will be one of the challenges for architects and engineers in the next ten years. The completion of the new airport in Timna will rapid the evacuation of the old airport and it will encourage the developing of new master plan for adjacent areas like the salt pools. Eilat is located along the Dead Sea Transform (DST) one of the most active seismogenic zone in Israel. The DST is the source of strong and destructive earthquakes in the region. The combination of active faults with young playa sediments require evaluation of the level of seismic risk for each one of the risk components: surface rupture, amplification; land slides, liquifaction and tsunami. Therefore the involvment of qualified engineering geologist in the design team is essential in order to implement special instructions in the master plan.
During the years 2007 and 2014 and 2015 a series of geotechnical investigations were part of the seismic risk assessement. The investigations performed in the area of the salt pools and the NBT farm. The investigation included geophysical study and measuring the seismic velocities up to depth of 30 meter with correlation to drilling and SPT tests. The evaluation of seismic risk is related to the the israeli standard SI 413 (version 5) which still needs modification in order to clarify the complicated situation of developing areas at the vicinity of active faults.

Determination of Rock Mass Properties by In Situ tests In the Gilboa Pumped Storage Project

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The Gilboa Pump Storage Project (2 X 150 MW) will supply 300 MW of peak power to the Israel Electric Corporation (IEC). The project will include two pump-turbines that are able to convert hydraulic energy into mechanical energy and vice-versa. The project will also involve the construction of 4.5 km of tunnels, two large underground caverns for the powerhouse, and a vertical shaft of 500m depth. The geotechnical site investigation included deep core drilling to a depth of 570 meters.

The geotechnical study of the Gilboa Pumped Storage Project included two stages of investigations. Five geotechnical geo units were defined with great differences which were noticed in the modulus of deformation. The modulus of deformation is an essential parameter for the design of the steel and concreate lining along the tunnels especially in depth of 500 meter below the surface where the in-situ stresses may lead to failure of the rock mass. During the preliminary design stage only data from laboratory test on core samples and a limited number of dilatometer tests were the basis for the evaluation of the deformability modulus. During the construction stage further in-situ tests were performed in order to verify the design base parameters of the rock mass. These parameters were calculated during the preliminary design stage by reduction of the intact rock properties by using the GSI method and later on by a series of Plate Loading Test (PLT). The PLT was conducted using hydraulic jack, which was installed in test adits in order to measure the horizontal and vertical deformation modulus. The results of the in situ tests were analyzed and verified the base parameters of geo unit IIb while for geo unit IIa further reduction of the deformability modulus was necessary probably due to effect of blasting. The in situ tests included collaborative study between the Rock Mechanics research team at Ben-Gurion University and Geotope Geo-engineering Monitoring Ltd. Further approach based on a series of in situ tests using flat jacks lead to analytical solution of the complete stress tensor. This approach and the suggested solution were published by Ben-Guo He and Professor Yossef H. Hatzor as technical note in the International Journal of Rock Mechanics and Mining Science.

The geotechnical work done by Geotope Ltd is being founded by the Israeli companies Shikun & Binui Arison group and Electra Ltd.

The Cross-Country Class - Majoring in Earth science via a web based platform

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Five years ago, The Earth Science Cross-Country (ESCC) class was launched. The ESCC class is a web based program allowing high school students to major in Earth Science regardless of location and school type.

The motivation for launching the cross country class was an ongoing lack in teachers. Yet shortly after the release it became clear that this is a powerful way to work directly with students who are genuinely interested.Converting the high school curriculum into a web based program takes a lot of adjustments. The first challenge was doing so without modifying the core pedagogical principles of the classic Earth science program: (1) Inquiry based learning in the lab and the field (2) A persistent dialog between student and teacher (3) Passing responsibility of learning to the learner (4) Creating a live functional learning community.

In order to support this complex pedagogy array, the ESCC class provides: (1) an un-synchronic learning platform and a home-experiment kit, which allows the students to perform all lab activities at home at their own pace. (2) Field-trips and seminars. These keep the students on a collective yet loose progress schedule, and give them a chance to directly interact with geological phenomena that do not fit in the kit. (3) One-on-one ongoing feedback and tutoring is available for the students at all times.

Today, students in the ESCC class perform reasoning and observation analysis both at home and outdoors while forming a unique bond with their classmates and teachers.

The program faces numerous challenges. Most converge to the gap between technology and student-teacher needs. Among these, an example for Short term challenge is the fact that ESCC students learn and manage their time independently. Yet they have very little experience in doing so. Technologically and pedagogically it is a complex task to Support their process of taking responsibility, find out what interests them, and fit both into a schedule.

An example for a long term challenge is the enrichment of the program with possibilities and norms that are a part of everyday life on the web. This is a major condition for a significant growth of the program. the questions of: what? Why? And mainly - how? are under research today.

Compound specific sulfur isotope approach to study the redox cycling in the Ghareb Formation, Israel

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The upwelling marine high-productivity systems along the Tethyan margins are responsible for the formation of the Ghareb oil shales in the Upper Cretaceous, Israel. The paleo-environmental history and mechanisms responsible for this upwelling regime are still not well understood and are of great interest. Sulfur cycling and their redox pathways in such environments are very complex. Reconstructing these cycles should be useful for understanding the paleo-environmental history of this system. These sulfur and redox cycles may be recorded in the d34S distribution of both organic and inorganic sulfur species of the oil shale.

The coupling of a gas chromatograph with MC-ICPMS allows the compound specific sulfur isotope analysis (CSSIA) with a very high sensitivity and precision. The present study focuses on the application of CSSIA to a detailed investigation of sulfur cycling in nine cores, from the Aderet borehole, that represent the whole sequence of the Ghareb Formation. Then we attempt to utilize these records for reconstruction the redox cycling in the Ghareb oil shales from the Shefela basin, Israel.

The core samples are organic rich (up to 20% TOC) and sulfur rich (up to 3%). The d34S depth profile of the kerogen sulfur is consistently 34S enriched relative to co-existing pyrite up to about 38‰, higher than the global average of 10‰. This difference is unusual and may point to diverse diagenetic processes. Sulfates and volatile sulfides (AVS) have in general similar δ34S values of kerogen sulfur reflecting a similar sulfur source. Therefore, sulfate in the Aderet borehole cores do not represents the original seawater sulfate (17-20‰), but rather is the oxidation product of reduced sulfur species, including AVS, pyrite and possibly organic sulfur or the combination of them. The δ34S values of individual sulfur compounds of the bitumen extracted from the cores varied by up to 13‰, from the identified organic S compounds (OSCs), which may point to their different reactivities and pathways of formation. Many of these OSCs have not yet identified for their chemical structure, which is an ongoing challenge. However, we could observe between 4 to 8 ‰ δ34S depletion of C20 isoprenoid thiophene compared with C18 thiophenes. This can be explained by the fact that phytol derivatives are prone to rapid sulfurization relative to C18 ketones. Therefore, the phytol derivatives react first with the more 34S depleted H2S/Sx-2, while the C18 ketone is left with the more 34S enriched H2S/Sx-2.

These results show the potential of individual S compounds to act as tracers for redox changes in a paleo-environment, and reflect the variable conditions and pathways that exist during the preservation and sulfurization of organic matter.

Advanced seafloor imaging techniques with applications for the marine research and offshore development

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We introduce several advanced imaging techniques we use in seafloor studies: Chirp sub-bottom profiling surveys, as applied to geo-archeology, coastal studies and infrastructure development projects, usually aim at delineating the sub-seafloor structure at <0.1 m resolution. However, the customary exclusive usage of trace envelope enhances the coherency of major features, but in practice significantly reduces the resolution. Also, these data are normally utilized 'as is' with very little processing. The extraction of full-phase traces and their combination with the traditional envelope data in the interpretation process, wave shifts removal procedure and processing allowed us to produce highly coherent images of the sub-surface with full resolution and detail.

A GeoMarine Surveys 48-channel streamer with receivers spacing of 3.25 m, newly purchased by the Department of Marine Geosciences is intended to be used in conjunction with our high (<0.5 m) resolution GeoMarine Surveys sparker source. This resolution allows the seismic profiles to be correlated with sediment cores, extracted from the seafloor. In shallow waters the short spacing multichannel streamer improves the imaging, extends it beyond the first multiple-window and allows the estimation of velocities and other offset dependent attributes. The streamer's recording system is capable in practice of continuous recording, allowing for the use of the system in short term monitoring tasks. Moreover, through the use of multi-pinging we successfully utilize the new streamer in deep water seafloor imaging, while avoiding spatial aliasing. There the usage of this system allows for the application of depth migration and the recovery of the sub-meter horizontal resolution. We argue that this new technique is an essential step in driving deep sea coring expeditions.

Spectral Decomposition of commercial 3D seismic volumes separates the original seismic traces to series of frequency-band-limited traces. Different attributes of the frequency limited traces are then compared and co-interpreted. These techniques exploit local frequency dependent effects of seismic interferences and wavelet shaping to identify and map sub-resolution structural variations. In particular we use these techniques in detecting and mapping sub-resolution (<~5 m) seafloor features. The procedure allows for detailed studies of the evolution of seafloor channel levee systems, and other recent sediment transport processes.

The newly purchased AUV purchased by the Department of Marine Technologies is intended to be operational in summer 2016. This 3,000 m depth rated vehicle is equipped with a full range of sensors, including: oceanographic sensors, video cameras, a Chirp sub-bottom profiler and a synthetic aperture sonar (SAS). This SAS will image the seafloor with a pixel resolution of ~3 cm while mapping the bathymetry at a grid resolution of 25 cm, over a swath of 200 m. With its state-of-the-art capabilities the new AUV is a leading seafloor surveying capability, um-matched in the entire Eastern Mediterranean region.

The Geomorphology and Morphotectonics of the Jordan Valley Fault

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The Lower Jordan River (LJR) runs from Lake Kinneret to the Dead Sea and constantly changes due to tectonic, climate, hydrological and anthropogenic factors. The basin location along an international border and the physical obstacles along it inhibit classic geological fieldwork and require remote investigation by alternative methods. In this research, we use geographical information systems (GIS) to preform temporal and spatial statistics based on topographical maps, aerial photography and satellite images. Geomorphological features of the Jordan flood plain (Zor) and the valley floor (Ghor) are compared with morphotectonic lineaments, seismic data and sub-terrestrial gravity data. As a study case, we introduce the central LJR valley, a zone where hydrological and anthropogenic influence is small, and discuss the relation between geomorphological changes of the LJR to the active tectonics of the Jordan Valley Fault system.

The geodynamic significance of the structural basins along the Levant rift

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The tectonics of the Levant rift is characterized by series of down-thrown central blocks bounded by elevated flanks. The rift is segmented into sections of well-developed grabens, distinguished by the large vertical throw of their normal boundary faults, which are interspersed by transfer zones where the border faults are subdued, the grabens are shallow and the flanks - gentle. The structural setting of the basins located along the Levant rift resembles that of the East African rift, where large normal faults constrain deep structural basins of limited length, separated by transfer zones, where the boundary faults are less developed. Numerous investigations emphasized this structural similarity, even though it is generally recognized that the tectonics regime in East Africa is that of oblique rifting, and in the Levant – transform faulting.

The initiation of the Levant rift is constrained by the Miocene fluvial deposits in the Levant, indicating that the flow of major rivers from the mid-Arabian plateau to the Mediterranean Sea preceded the rift and its uplifted mountainous flanks. Geomorphological analyses advocate that some of the rivers kept flowing across the trace of the rift during the Pliocene, and even in the early Pleistocene. However, the deposition of thick sequence of early Pliocene salt in the southern Dead Sea and Kinnarot basins suggests the occurrence of several segments of the rift at that time. Analog modeling indicates that co-occurrence of westward-flowing rivers and N-S trending rift system could have occurred. Multi-layered sandbox experiments of 15o-30o oblique rifting show that under such structural constraints, early rifting comprises a linear series of fault-bounded small basins scattered along an axial zone, separated by threshold zones. In time, the basins gradually propagate and interconnect. Therefore, if the development of the Dead Sea Rift started in the late Miocene, some of the Hazeva rivers could have continued to flow to the Mediterranean in the Pliocene, concurrently with the propagation of the basins, which enabled the landwards incursion of seawater and the deposition of the Dead Sea and Kinnarot salts.

Defining and quantifying natural mechanisms that control the dispersal and preservation of flashflood deposits in the Gulf of Aqaba (Eilat), Red Sea

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Flashfloods flowing through the desert wadis into the Gulf of Aqaba (GOA), Red Sea are heavily loaded with sediments, and some have been recorded to form hyperpycnal plumes. Although much of the flood borne sediments primarily deposit on the north shelf, it has been suggested that the majority of these deposits are later transferred offshore; thus playing a major role in the sedimentary regime throughout all depths of the GOA. Very little is known about the sediment processes, dynamics, and mechanisms that either preserve or disperse these flood deposits. The aim of this ongoing study is to understand and, if possible, model these mechanisms in order to both add to our knowledge of the sedimentary workings in the GOA, and to provide the means for better identifying and interpreting hyperpycnal flow deposits in recent and earlier geological records.

Our main study site is located at 13 m water depth in front of the Kinnet Canal outlet, which is the dominant drainage basin into the Red Sea from the north. To constrain the removal rates of the flood sediments, sediment cores were taken at tri-monthly intervals for 16 months after the May 2014 flood to create a time series, and record any changes in the flood deposit. Preliminary results show that the top sediment layer returned to background conditions within a time scale of months (<1 year). During this period fine flood deposits were removed at a mean rate of >100 g m-2 day-1. The evolution of flood deposit profiles obtained from grain size and chemical markers (related elements and minerals) suggests that biological processes (sediment mixing and resuspension) may greatly contribute to the flood deposits' removal mechanism. To better define the predominant mechanisms affecting deposition, preservation, and removal of flood sediments over the shelf, an underwater monitoring system will be set up in front of the Kinnet Canal that will measure current speeds, waves, tides, and suspended sediment concentrations. Biological resuspension near the study site will be monitored by observing epibenthic fish activities with automated time lapse photography. Time series of bioturbation depths and mixing rates will be measured in situ using luminophore sediment tracers.

A possible connection between methane cold seeps and colonization of Anthozoa, Porifera and Echinodermata of the pelagic Levant ramp in the Late Maastrichtian and Early Danian

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The Upper Cretaceous organic-rich sequence of the Levant has been extensively studied for its scientific as well as economic attributes. However, primary diagenetic features of the Maastrichtian organic-rich interval, its preliminary stages of microbial degradation and potential methane flow paths have been generally overlooked.

We have re-visited and identified new localities containing an extensive occurrence of deep-sea Anthozoa, Porifera and Echinodermata fossils around the K/Pg boundary in Israel (Ghareb-Taqiya boundary), shortly overlying the Maastrichtian organic-rich deposits. Paleobathymetry analysis shows that the water depth in this interval was ca. 800 m, indicating that this is a peculiar assemblage.

An interesting possibility is that these organisms thrived in the chemosynthetic community environment which developed around deep sea methane cold seeps, in a similar manner as some of their modern analogues. Furthermore, the source for these shallow sediment gas emissions might have laid within the recently deposited Upper Maastrichtian organic-rich sequence, buried about 60 m bellow the K/Pg seafloor. All five sections in which these faunal occurrences were identified overly thick Maastrichtian oil shale basins, supporting a potential depositional link between the two. Conversely, down-shelf progradation of shallower organic-rich deposits might have facilitated the development of these faunal assemblages. Here we present preliminary results from the sedimentary study of the K/Pg, which will be followed by a multi-parameter investigation in the future.

This is a critical time in the history of our planet because it appears that one increasingly abundant, heterotrophic species has become a global scale force of rapid environmental and biotic change. The K/Pg boundary represent an analogue for rapid environmental changes and extinction events, and is currently extensively studied. A better understanding of the last major extinction event on earth is crucial for the modelling and evaluation of present and future climatic changes.

Timing, stratigraphy and composition of Messinian evaporites in the deep Eastern Mediterranean: Controversy resolved?

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The elaborate and ongoing study of the Mediterranean Messinian evaporites (Messinian salinity crisis; MSC) is focused on marginal and intermediate sections from which material was previously available. This proximal data set is also coupled with offshore seismic data and a few wells which have penetrated the Messinian salt in its uppermost parts, for producing stratigraphic models and hypotheses related to the distal occurrence of the MSC. These offshore assumptions could only be tested by drilling in the deep Mediterranean Sea. In this work we investigate these fascinating deposits from previously inaccessible domains in the deepest realms of the Mediterranean, and correlate this data with the much more abundant and elaborate findings reported from the marginal and intermediate depositional environments.

Here we provide for the first time high resolution sedimentological, faunal and geochemical data from the massive Messinian evaporite section of the deep Eastern Mediterranean basin. We have analyzed an extensive set of well cuttings while correlating results to well logs and seismic data, and constructed a chronostratigraphic model based on biostratigraphy and astrochronology. We present a detailed account of the pre- and evaporitic Messinian as it occurred in the deep Levant basin, identifying paleo life in the form of diatoms, foraminifera and ostracods within different parts of the section.

We challenge some of the models previously presented that have attempted to explain the ~1.5 km thick salt giant, in terms of timing, composition and oceanographic implications. Questions such as "did the Mediterranean experience dramatic sea-level drops and desiccation during the Messinian?" are re-assessed.

The effect of surface features on natural rainfall-runoff ratios in the hyper arid desert

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In hyper-arid environments, where slopes lack soil and vegetation, runoff generation within the watersheds is mainly dictated by the slopes. These slopes have varied features and heterogeneous runoff characteristics.

Twelve runoff plots of various typical surfaces including bare rock, colluviums and terraces in the Southern Arava and the rift margin were studied. The plots collect runoff from an area of 2.5-5 m². Two plots are one scale larger (30.2-31.5 m²) to study runoff transmission loss due to area enlargement. Nine plots are located within Timna Park on granite, sandstone and sandy-dolomite rock and colluvium as well as on mixed terrace surfaces. Three plots, on bare limestone and colluvium, are located on "Shluhat Shaharut" next to Kibbutz Grofit.

This study combines rainfall-runoff ratio data from 21 diverse rainfall events during more than three rainy seasons (2012-2015) in the Southern Arava, together with analysis of varied surface features of typical slopes in this region, represented by the plots.

Pearson's r test was used to assess the linear correlation between rainfall characteristics (depth, intensity) and runoff (runoff coefficient, runoff threshold, runoff per area unit). Pearson's r test was also used to calculate the correlation between the measurable surface features (surface roughness, stone cover, stoniness and fine material distribution) and runoff yields of the plots. Results show that rock-face plots generate runoff at much higher rates and frequencies than plots with clastic bases. However, in rain events that generate flow on channels from 2nd order or higher, these differences diminish. The best linear correlation found was between rain depth and the runoff volume per area unit. Another good linear correlation found was between rain intensities and the runoff coefficient of the plots.

Surface roughness had the strongest correlation with runoff yields. Negative correlation was found for rock-face plots and positive correlation for plots with clastic bases. For clastic plots, correlations found between other surface features and the runoff yields are not strong enough to explain runoff yields well.

The transmission loss for the enlarged plot areas was found to be higher at the colluvial limestone plots than at the granite rock plots.

An example of applying the results of this study is to map runoff units of different watersheds in the Southern Arava using the rainfall-runoff volume per area correlation that was found in this research.

Using hyperspectral remote sensing in order to characterize the turbidity and salinity parameters of the Dead Sea sinkholes

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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 and spectral change detection that occurred between the years 2014 to 2015. 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' turbidity, 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 we hope it 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.

Study of thermochemical sulfate reduction mechanism using compound specific sulfur isotope analysis

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The term thermochemical sulfate reduction (TSR) refers to the non-biogenic reduction of sulfate to H2S coupled to the oxidation of hydrocarbons to CO2 in hot carbonate petroleum reservoirs (>120 0C). The toxicity and corrosiveness of TSR-generated H2S and CO2 gases lead to greater production costs and environmental risk. Thus, prediction and evaluation of the occurrence and extent of TSR is needed.

Recent works in our group suggested that the δ34S of specific organosulfur compounds (OSCs) can be used in order to estimate TSR occurrence and extent. The aim of this work was to study the S isotopic fractionation associated with the formation of OSCs such as benzothiophene (BT) and dibenzothiophene (DBT) as well as H2S during TSR using pyrolysis experiments.

We conducted controlled pyrolysis experiments at 360 °C using model compounds (n-C16) with CaSO4 or Na2SO4 as oxidizers to simulate TSR at varying time intervals from 10 to 180 hrs.

The observed S-isotopic fractionations between sulfate and BT, DBT, and H2S in experimental simulations of TSR correlate well with the previously suggested multi-stage model of the overall TSR process. Large kinetic isotope fractionations (up to 22.2‰ for BT) occur during the first, uncatalyzed stage of TSR. The fractionations decrease as the H2S concentration increases and the reaction enters the second, catalyzed stage. As the reaction progresses, the 34S values of the OSCs approach that of the associated H2S, suggesting that reduced S species are the main S source for OSC formation during the second, catalyzed stage of TSR. Once all of the oxidizable hydrocarbons have been consumed, sulfate reduction ceases and equilibrium isotope effect then dictates the fractionation between H2S and sulfate.

When CaSO4 is replaced with fully soluble Na2SO4 in the TSR experiments, the rate of sulfate reduction is faster and significant S-isotopic fractionation (12.4‰ to 17‰) between H2S and

source sulfate is observed through the entire reaction period. This supports the notion that $CaSO_4$ dissolution can lead to the apparent lack of fractionation between H_2S and sulfate produced by TSR in nature.

The role of water flow and dispersion on the dissolution of CO_2 in deep saline aquifers

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CO2 geological sequestration is a promising technology for reducing greenhouse gases emissions. This process is based on compression of CO2 to a supercritical phase and injecting it to deep saline-water aquifers. The density of supercritical CO2 is lower than that of the ambient groundwater. The CO2 is therefore expected to accumulate above the water and may leak back up to the atmosphere in case that the sealing layer is not perfectly impermeable. However, when CO2 is dissolved in water it becomes heavier than the CO2-free water. This situation where CO2-free water is overlaid by heavier CO2-rich water, leads to a hydrodynamic instability in which fingers of dense CO2-rich water are formed and propagate downwards, causing CO2-unsaturated water to move upwards. This convection process is desired as it accelerates the dissolution rate.

Previous works have neglected the effect of water flow in the aquifer and assumed it has no effect on the dissolution process. However, it was found that in some of the saline aquifers groundwater flow rate is not zero. Although groundwater fluxes generate hydrodynamic dispersion that may contribute to mixing and enhanced dissolution, our hypothesis is that water flow reduces the hydrodynamic instability, suppresses the formation of fingers and thus reduces dissolution rates. This hypothesis is being tested in the current study by laboratory scale experiments and flow models. The experiments are conducted in a Hele-Shaw flow cell containing glass beads that simulate the aquifer. A mixture of Methanol and Ethylene-Glycol (MEG) is being used as an analogue for the supercritical CO2. Dyed MEG is being inserted from the top of the cell while keeping a constant horizontal background water flow. Experiments are conducted with different horizontal flow rates and using various MEG solutions and glass beads. Pictures of the aquifer are taken using a computer-controlled camera in constant time intervals. Calibration of the color detected signal serves as a tool to measure the distribution of MEG concentration and study the fingers generation, and movement and calculate dissolution rates. Breakthrough curve experiments were conducted to find the dispersion coefficients. The experimental results provide a better understanding of the hydrodynamic instability and the dissolution mechanism and improve our ability to estimate the efficiency and risks associated with CO2 geological sequestration in flowing groundwater environments.

The underground salt layer and sinkholes

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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 salt concentration than 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 to 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 of 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 collapse of the outer layer into these cavities, creating sinkholes.

Do higher sea-cliff retreat rates imply faster sea-cliff retreat?

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Inland retreat of sea cliffs in response to post LGM (last glacial maximum) sea-level rise is an ongoing process that affects coastal environments and communities worldwide. Here, we examine a globally recurring pattern where reported sea-cliff retreat rates since the 20th century often appear to exceed longer-term millennial-scale ('background') rates that rarely exceed ~0.1 m/yr. Focusing on Israel's 30-km-long Mediterranean 'Sharon' sea-cliff as a case study we demonstrate that such apparent increase in rates may also reflect a widely acknowledged sampling bias in geologic rate estimates inferred from observation time windows ('Tobs') shorter than process episodicity. We show that this possible bias leads to an ambiguity in conventional rate estimates obtained by averaging observed retreat distances over Tobs, and that as a result despite ubiquitous and robust observations of cliff retreat since the 20th century (e.g., aerial photographs) recent/current retreat rates for many of the world's episodically retreating sea cliffs remain essentially unknown. To address this present limitation in our ability to detect and quantify recent changes in sea-cliff retreat rates we use airborne LiDAR to measure the continuous wave-driven volumetric erosion of collapsed material from the cliff base as an effective upper-bound constraint for the m/yr rate of episodic retreat of the cliff itself. We find that while conventional retreat rate estimates since the 20th century along the Sharon sea cliff artefactually increase up to several m/yr as an inverse function of Tobs, the LiDAR-constrained retreat rates are not susceptible to this sampling bias, are comparable to the cliff's background retreat rate of 0.03-0.07 m/yr since the mid Holocene and thus indicate no recent acceleration in retreat. This ability to unambiguously constrain sea-cliff retreat rates with annual to decadal-scale observations directly impacts the global-scale push to quantify, better understand and ultimately predict the response of sea cliff erosion and retreat to recent/projected changes in environmental conditions such as sea-level, climate, near-shore ocean dynamics and anthropogenic influences.

A ten million year history of fault activity in Eastern California from U-Pb dating of fault-related opals

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We present a novel methodological approach for direct dating of brittle deformation events over a geological time scale. We use in situ U-Pb SHRIMP-RG (Sensitive High Resolution Ion Microprobe – Reverse Geometry) analyses of opal material in order to constrain the absolute timing of brittle deformation events. The Mojave Desert fault segments within the Eastern California Shear Zone (ECSZ) are ideal faults to investigate the long-term history because of the need for improved constraints on the timing of fault initiation and the observed discrepancy between long-term and short-term estimates for strain accumulation rates. We analyzed fault-related opal samples from 20 different fault exposures within the Camp Rock, Cave Mountain, Manix, and the Cady fault systems. Millimeter size fragments of fault-related opal, occurring as fault coating, filling or fault-breccia cement, were imaged using cathodeluminescence microscopy in order to identify distinct phases of opal associated with specific syntectonic microstructures. Sub-samples within each phase are then targeted with multiple SHRIMP-RG analyses (<50 µm in diameter) to allow the construction of U-Pb isochron and/or Tera-Wasserburg concordia. Temporal constraints on activity of secondary faults from this study provide important observations on fault initiation, longevity and activity. Faults initiated between 12 and 2.5 Ma, suggesting that shearing commenced around 12 Ma as previously proposed. Multiple deformation events, dated within a single structure, demonstrate that faults reactivation period occurs over million-year timescales. In addition, relative probabilities of dated deformation events suggest fault fluctuate in activity over the past 10 Myr, peaking around 1.5 Ma and decreasing since. Additional absolute age control on faults activity, as demonstrated here, will help to determine the driving mechanisms for non-uniform strain rates in the upper crust.

The role of the deep lithosphere in metallogeny

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The single largest influence on the formation and distribution of magmatic ore deposits has been the generation of the Archean subcontinental lithospheric mantle (SCLM: [Begg et al., 2010; Griffin et al., 2013]). The magmas that redistribute metallic elements are derived from the asthenosphere, then traverse and interact to varying degrees with the SCLM, and the crust. The metasomatised lithospheric mantle is a palimpsest, recording multiple fluid events that have affected it since it formed. Interpreting this complex record and tracking specific episodes and processes is a key to reconstructing the nature of the volatile flux from the deep Earth over time. Mantle metasomatism modifies the composition and physical properties of mantle domains [O'Reilly and Griffin, 2012]: density increases and seismic wave speeds decrease; influx of heat-producing elements (K, U, Th) raises the local heat flow; electromagnetic (MT) responses change.

Convergent datasets of Hf-isostope model ages for zircons and Re-Os model ages for mantle sulfides, reinforced by other geochemical and tectonic criteria, indicate that over 70% of the SCLM and its overlying crust (now mostly lower crust) formed at 3.5-3.0 Ga, probably in a global mantle overturn that marked a change in Earth's fundamental geodynamics [Griffin et al., 2014]. This primitive SCLM, the roots of the Archean cratons, was geochemically highly depleted, and subsequently played a major role in crustal metallogeny. Firstly, the buoyancy of this ancient SCLM relative to the asthenosphere, results in the persistence today of low-density, rheologically coherent Archean domains (including relict blobs in ocean basins [O'Reilly et al., 2009]) and commonly, preservation of old crust (the "life-raft" model). Secondly, the enduring, volumetrically dominant Archean lithospheric mantle domains represent a reservoir for metasomatic enrichment over their 3.5 billion year history, creating a metallogenically fertile mantle impregnated with critical elements (including Au, Cu and platinum group elements [Begg et al., 2010]). Thirdly, if the first stabilisation of lithospheric mantle at 3.5 Ga signalled the end of an overturn regime, then this is when long-lived tectonic regimes conducive to mineralising systems (e.g. back-arc basins, passive margins, cratonic boundaries) became available. Fourthly, the formation of Archean cratons provided an lithospheric architectural mantle-scape of regions with contrasting rheology, composition and thickness. These cohesive Archean domains control magma- and fluid pathways around their margins, and may act as both sinks and sources for ore-forming elements, depending on the geodynamic evolutionary stage.

The key role of lithospheric architecture in mineralization can be illustrated by the detailed distribution of diamondiferous kimberlites, which cluster around the edges of lithospheric subdomains within cratons and at their margins. This is relevant to exploration in Israel, where the eruption of gem-bearing volcanic rocks appears to be related to a major lithospheric suture (the Dead Sea Transform) and related faulting.

The Geoscience Olympiad and the promotion of ESE worldwide

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The goal of the International Geoscience Education Organization (IGEO) is to promote Earth Science Education (ESE) in the school level worldwide. The International Earth Science Olympiad (IESO) is considered to be the "flagship" of IGEO in the mission of advancing the quality ESE. The IESO was initiated by South Korea in 2007 and till 2013 it was controlled by the East-Asian countries. As a result the Geoscience Olympiad was only based on traditional multiple choice tests and mainly on memorization skills. In 2013, the IGEO adopted the earth systems approach and the progressive learning and teaching strategies of the Israeli earth sciences high school curriculum. The Israeli approach was first implemented in the Olympiad held in India in 2013 and an individual field based test and two types of scientific investigations by international teams were introduced as an integral part of IESO event. However, there is a long way to go till a significant change of ESE perception and practice will be notice, since many countries find difficulty to accept the new pedagogical approach. The main reason for the negative attitudes is that the vast majority of the leaders and mentors of the delegations are not educators, but university researchers who are not aware and share the IGEO educational objectives. For them the essence of IESO is not pedagogy. Unfortunately, they are not aware of the dual relationship between the quality of teaching and learning in high school and the public image and prestige of the geosciences as a scientific discipline. The image and prestige will influence later the quality and quantity of the students who will turn to study Earth Sciences at the universities.

The ICDP Dead Sea cores and the Dead Sea heat flow

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The amount of heat the earth emits at the surface can be measured and be used to estimate the heat flux of the Earth's interior. The heat flux can help determine the depth of the seismogenic zone, the thickness of the lithosphere, the type of deformation and thus infer on the thermal structure and geological evolution of an area. Being such an important tool in geophysical studies, numerous measurements of heat flow have been made across Israel. During the late 70s measurements of the heat flow around the Dead Sea were conducted by several groups. One group used temperature logging in abandoned oil and water wells while another used a special probe designed for heat flow measurements in lakes. Even though the two groups measured low heat flow values some questions were raised. The measurements conducted by the lake-floor probe were relatively shallow giving way to environmental disturbances. In addition, it is impossible to use the lake-floor probe these days as the Dead Sea is no longer thermically stable and because a thick layer of hard salt is now covering most of the lake bottom making it impossible to penetrate with low tech means. Furthermore, some argue that measurements carried out in abandoned wells display high variation of heat flow values over short distances. Therefore another way of measuring the heat flow of the Dead Sea is required in order to validate the results of past studies. Heat flow obtained by thermal conductivity measurements to great depth combined with downhole temperature logging represents the ideal method to measure heat flow as it does not exhibit any of the drawbacks of the heat flow studies mentioned above. Thus, the ICDP Dead Sea boreholes offer an ideal opportunity. The heat flow of the deep ICDP Dead Sea drill and the western ICDP Dead Sea drill were calculated using measurements of the ICDP Dead Sea cores thermal conductivity together with the logged downhole temperature gradient. The calculated heat flow would help settle the dispute regarding the value of the heat flow around the Dead Sea, shed light on the tectonics of the Dead Sea area and help estimating the geological evolution of the area.

Calcareous nannoplankton from the Upper Cretaceous of the St Lucia formation at Nibela Peninsula, KwaZulu-Natal (South Africa)

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The Upper Cretaceous St Lucia Formation at Nibela Peninsula is generally represented by poorly cemented silty finely grained sandstones with distinct layers of concretions. The beds are rich in invertebrate fossils.
Two sections were described and sampled for calcareous nannoplankton, which offers an older age of the sediments than it has been suggested previously by ammonites and inoceramids.

Section Nibela 1
The lowermost part of the section is referred to the lowest part of the Lower Campanian Zone UC13 due to the presence of Arkhangelskiella cymbiformis, which first occurrence characterizes the lower boundary of the zone. The Lower Campanian Zone UC14 is recognized in the interval from Bed 4 to the middle part of Bed 15; its lower boundary is identified by the first occurrence of Broinsonia parca parca and its upper boundary is defined by the first occurrence of Misceomarginatus pleniporus. Bed 4 and the lower part of Bed 5 belong to Subzone UC14a due to the presence of B. parca parca. The interval from the upper part of Bed 5 to the middle part of Bed 15 belongs to undivided Lower Campanian Subzones UC14b–d due to the presence of Broinsonia parca constricta. The upper part of the section belongs to the Lower Campanian Subzone UC15a, which lower boundary is identified by the first occurrence of M. pleniporus.
Section Nibela 2
The lower part of the section refers to the upper Lower Campanian Subzone UC15b due to the presence of Ceralithoides aculeus, which appearance demarcates the lower boundary of the subzone. The middle and upper parts of the section belong to the upper Lower/lower Upper Campanian Subzone UC15c, which lower boundary is identified by the first occurrence of Ceralithoides sissinghii.

Nd-Sr isotope compositions of suspended particles in floods and stream beds from the Dead Sea watershed

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The Dead Sea is a terminal hypersaline lake that receives, water and fine-grain sediments from a large drainage basin extending from the edge of the Sahara desert to the Mediterranean climate zone. The fine sediments reach the lake mainly through flash-floods and the Jordan River. The chemical and Nd-Sr isotope compositions of fine particles in modern floods reaching the lake and of soils from the region are measured and the values are used to characterize potential sources of fine- detritus in sediment cores. Locations of the samples encompass the various climatic zones within the lake's watershed.

The fine particles of all samples have similar Nd isotope values (εNd=-6 to -8) but define two distinct groups concerning their Sr isotope ratios: (1) 87Sr/86Sr = 0.7080 to 0.7088 (e.g. Nahal Paran that drains the Sinai and southern Negev deserts and Arugot and Darga valley draining the Judea desert); (2) 87Sr/86Sr = 0.7092 to 0.7102 (e.g. Nahal Rachaf and Zeelim and water reservoirs in the Arava valley which drain the loess plateau).

On the Nd-Sr diagram the former group lie between Nilotic and Saharan dust sources. Where, the latter group lie between the fields of the Mountain-top loess and the loess plateau which covers the northern Negev. Samples from the Northern Dead Sea (i.e. Nahal perat) have the least Sr radiogenic values (0.7077-0.7078). Comparing the modern fields with results from the Dead Sea drilling project can help reconstruct paleo rain patterns in the Dead Sea watershed and deduce the changing synoptic conditions through past climate changes.

An immense chaotic body offshore Israel: 3D mapping of primary and secondary boundaries

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Offshore Israel a chaotic zone is evident in 3D seismics (mainly in Yizchak-Gabriella pliocene volume) – an immense body in which seismic reflectors loose coherence and, in places, vanish completely. The chaotic zone seems to have been formed by an east-west trending slide on top of Pliocene units (post-Messinian). However, its unique morphology and characteristics imply that the mechanisms responsible for the chaotic zone are more complex. The disturbed zone is horizontally divided into four main units, according to the characteristics of the constituent reflectors: 1. A completely Chaotic zone explained by collapse in the continental slope, 2. A normal faulting zone upslope, 3. A folding zone downslope, 4. A decay zone – the section becomes thinner and the reflectors are more obvious. The slide boundaries are well defined; In its eastern part the slide is detached by a fault with small throw and a scar, Northward and southward mass transport (sliding) is limited by regional pre-Messinian structures, In its western part the thickness of the disturbed zone decreases constantly until it disappears completely. These boundaries create a conic pattern - boundaries of this type are characteristic for slides. Numerous scar parallel faults are evident east of it. These faults were not sufficiently developed to slide, but represent a weakness surface. The disturbed zone appears in a specific part of the section, which indicates a significant mechanical weakness of this layer. A possible explanation of this weakness may be rapid sedimentation of the section, resulting in a low level of consolidation of the sedimentary column. These findings give way for a better understanding of the disturbed zone geometry, its boundaries and the mechanism of its creation and lead us another step towards evaluating this unique body.

Deep submarine fluid seeps suggested by hydrogeological modeling offshore Northern Israel

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Deep Submarine Groundwater Discharge (DSGD) might promote submarine slope instability and affect sea floor morphology. DSGD occur when groundwater migrate in the subsurface into the basin and seep out to the sea in a relatively large (>5km) distance from shore. In this work, we explore the hydrologic setting in which large scale flow in a confined aquifer generates DSGD, as water recharge into the aquifer on land (e.g. rainfall) and travel along the conductive aquifer deep into the basin area. As a test case, we examine the Judea Group karstic aquifer in northern Israel. We constructed a hydro-geological model of north-west Gallillee and its adjacent offshore region. The first step of the project used wells and seismic surveys to construct a 2D geological model. The 2nd step used the geological model in a Finite Element Flow modeling software (FEFLOW) to create the hydrological model and simulate the flow field under the inferred structure of the Judea group.

The geological model shows that although the Judea group subsides towards the basin east to the shoreline, it then reverses its trend of dip, approaching the seafloor some 15km away from the shore, where the water depth is ~250mbsl. There, submarine canyons - cutting through the continental slope - expose the aquifer to the sea.

Hydrological simulation results, using this geological model, show DSGD out of the exposed regions of the Judea group. Results show that DSGD becomes very focused and strong (with local head gradients exceeding 1.5‰) if the conductivity differences between the Judea group and its surrounding is large (4 orders of magnitude). An intrinsic density-driven convection cell develops within the aquifer near the exposed regions, mixing ground water with seawater to form relatively saline (~98% of seawater) and intense submarine seeps.

These findings may have very important implications for seafloor shaping and canyon formation offshore Israel, fresh water budget in north Israel hydrological system and intrinsic hydrology of the Judea aquifer.

XRF and LA-ICP-MS study of the EBII 'Brown Ware' industry of Gamla

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The 'Brown Ware' industry at Northern Canaanite sites is represented by brown hole-mouthed and necked cooking pots. The appearance of these pots in large numbers in EBII Gamla indicates that this urban settlement was a production and distribution center of the 'Brown Ware'. The current study presents some other types of 'Brown Ware' of EBII Gamla: the brown cooking bowls that were discovered and reported for the first time, and the very rare brown jars. The 'Brown Ware' family was produced in Canaanite workshops at a basaltic provenance, as confirmed by petrographic analysis by the presence of basalt particles in the ceramic material. Indeed, Gamla is located on the Golan Basalt Plateau on which basaltic soil raw material is widespread. The chemical analysis of the ceramic body by using XRF and LA-ICP-MS shows high concentration of SiO2 and Al2O3, lesser concentrations of Fe2O3, small concentration of CaO and typical patterns of several trace elements. This composition of the ceramic is accordance with the utilization of basaltic soil raw material for the production of the 'Brown Ware' family. The results demonstrate that the brown cooking bowls and brown jars were also produced from basaltic soil raw material. The high concentration of iron oxides in the ceramics manufacture from basaltic soil raw material and an oxidation on their surface gives the 'Brown Ware' family their brown color.

The specialization in production of the 'Brown Ware' family, mainly for cooking, seems to be in conjugation with the Northern Canaanite urbanization during the EBII. Indeed, the pots were exported from Gamla to the adjacent regions such as the Kinrot Valley, to the Lower Galilee and the Jezreel Valley. The importance of the 'Brown Ware' family lies on the way they were manufactured from a specific type of noncalcareous clay of basaltic soil raw material, which was specifically designed for cooking and on the fact that they were exported to other southern Levantine regions as part of a flourishing trading network. It can be speculated that the 'Brown Ware' were simply made from this clay as a 'line' of one potter's workshop, regardless their usage, meaning, they were made for serving just like any other vessel. Still, the profile of the brown bowls of Gamla does show that they were made and used for cooking activities, maybe for frying (the shallow bowls) or as kraters (the larger deep bowls).

Physical parameters influencing site response of vertical ground motion

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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 30 meters 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 velocity, 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.

In this study, we test the correlation between the amplification of the vertical component and different profile parameters. We use the existing NGA-West2 ground-motion database in California, and supplement it with additional parameters specifically appropriate for the vertical component of ground motions. We calculate the vertical amplification with respect to a baseline GMPE regressed on surface ground motion recordings in California. We use geotechnical profiles to calculate parameters which we believe may influence the site-response, such as the time-averaged P-wave velocity at different depths. Finally, we use the USGS groundwater database, with water table elevation measurements throughout California, to evaluate the groundwater level at the locations of the ground motion recording stations.

After compiling the required data, a statistical analysis is performed to evaluate the influence of the Vp and groundwater level, alongside other parameters, on the vertical site response.

Customization and adaptation of ShakeMap software for near real time evaluation of seismic intensities and peak ground motions in Israel, including DYFI? Intensity data

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The project was launched for adaptation and implementation of the Shake Map software package, developed by the U.S. Geological Survey (USGS), for earthquakes occurring in Israel. This software generates maps of peak ground motion (PGM) parameters and instrumentally derived shaking intensities, following significant earthquakes.

To be implemented in Israel local conditions, the USGS ShakeMap software was adapted to the Geophysical Institute of Israel (GII) computer platform Linux Ubuntu. During the implementation a number of new computer procedures were designed. The Python's program "Run_shake", written as Linux application to provide a user-friendly interface of ShakeMap for Israel, allows to user generating XML input files and executing calculations for a selected event. The ShakeMap software was modified to generate the map for PSA (Pseudo Spectral Acceleration) at period 0.2 sec additionally to periods 0.3, 1.0 and 3 sec available in the USGS ShakeMap.

The database of 65 strong earthquakes, occurred in Israel and neighboring countries, and recorded by stations of the Israel Seismic and Accelerograph Networks, was collected in the project. Using a new additional program – the PGM module, all acceleration and velocity time series records were processed and all reliable PGM parameters were included into the GII seismological MySQL database that is necessary for implementation, testing and adaptation of the ShakeMap software.

The procedure for site corrections within ShakeMap includes reducing the observed ground motions to a common reference bedrock and then applying site-effect modifications. Amplification factors, adopted by special algorithms, are applied using Vs30 values, which are estimated on the topography basis. For comparison, Vs30 values for operating stations, located within Hashefela and Hasharon regions, were estimated using elaborated for this area 1-D multi-layers soil column models. It has been found that in spite of a very simplified topographic approach to the site condition map, it is correlated satisfactory with the subsurface model-based classification criteria, therefore this approach was utilized for site-effect corrections.

The ShakeMap software, adapted and modified for Israel, was successfully validated by application to some felt local earthquakes, recorded by the ISN, include "Did You Feel It?" (DYFI?) Intensity data of these earthquakes, providing calibration of PGM and intensity estimations, and calculation of appropriate shakemaps.

Paleomagnetic age constraints on ancient slag deposits in Timna, Israel

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Copper slag from smelting sites in the central Timna Valley, specifically Site 34 ("Slaves' Hill") and Site 30a, underwent paleomagnetic intensity experiments in order to date copper smelting activities. The results were compared to available data from well dated sites in the Arabah and beyond, in order to establish age constraints for the slag deposits (slag mounds) of Sites 30a and 34. In this project we show that while the slag mounds found at the unprotected foothill of Site 34 represent a variety of dates (mostly Early Islamic, 650-900 CE), the slag mounds on the hilltops of Site 34 and Site 30a are constrained to the early Iron Age (11th-10th centuries BCE). The correlation between the location of the slag mounds and their dates reflects varying socioeconomic and political dynamics of the region, in which the most prominent pattern is that Iron Age production took place in protected locations. Furthermore, in comparing the new data with previous archaeomagnetic studies from the nearby Site 30, we can assert the existence of simultaneous copper production at Sites 30, 30a, and 34. This gives further support to the claim of intense smelting in the central Timna Valley during the early Iron Age. Finally, this project demonstrates the potential of paleomagnetic experiments in establishing chronologies, and their potency in case studies related to ancient pyrotechnology.

Volcanic host rocks as sources of corundum recovered from Shefa Yamim's multi-commodity alluvial placer, northern Israel

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The Kishon catchment, the core of Shefa Yamim's exploration campaign, is located on an array of NW-SE structural basins cross-cutting the mountainous backbone of Israel, where it drains the Yizre'el (proximal reach) and Zevulun (distal reach) valleys and the intermediate mid-reach corridor. It is topographically and structurally bordered by folds, assigned to the compressional regime of the Late Cretaceous Syrian Arc. Eocene marine sediments filled up the Cretaceous relief, and were later exposed and truncated during the Oligocene regional uplift. Relief on the Oligocene peneplain and a thick Oligo-Miocene section (~1.5km) in the Levant basin offshore Israel and Lebanon hint at a much larger Kishon paleo-catchment (Wald et al., 2015). The current geomorphology is a product of tectonic subsidence, commencing in early Miocene, peaking before the Pliocene and still continuing today.

Two main volcanic components occur in the Kishon catchment, both of significance to the geological model of Shefa Yamim that guides their exploration activities: Mount Carmel Mesozoic pyroclastics and lava flows exposed in fourteen volcanic bodies, two of which drain into the Kishon catchment, and Neogene volcanism, mainly basalts, whose vents and sources surround the valleys, and diminish to the WNW. Both volcanic components host corundum, including sapphire and ruby. Corundum, a relatively common mineral, is linked to alkali basalt terrains globally and its gem varieties of sapphire and ruby are associated with placers derived from such terrains (Guo et al., 1996).

This study defines the provenance and contribution of the proximal-reach Lower Basalt Formation and its derivative syntectonic conglomerates to the Kishon Mid-Reach multi-commodity placer that is dominated by gem and non-gem corundum. Emplaced mainly via normal fault planes, the volume of the Lower Basalt Fm. documents the syntectonic subsidence of Miocene extensional basins and constrains the timing and spatial extent of the volcanism. Its thickness exceeds 600m in at least two locations.

The Kishon River drainage covers some 1122km2 hosting a calculated Lower Basalt Fm. volume of 130km3. The weathered derivatives from these Miocene basalts, notably clays (non-placer minerals) and corundum varieties (potentially placer-forming minerals) have drained into and through the narrow, structurally-confined Mid-Reach of the Kishon Valley where additional trapping from oversize clasts derived from Mt Carmel alluvial fans has promoted placer development (Toledo et al., 2015).

The westernmost structural boundary of the Lower Basalt is Tel Kashish, the gateway to the Kishon Mid-Reach. In this location, both Cretaceous and Neogene volcanics occur, sourced in short reaches draining the eastern Carmel volcanics and the Yizre'el Valley proximal-reach, respectively. In light of these two provenances, Shefa Yamim will further investigate the sources of the corundum, both gem (sapphire and ruby) and non-gem (NGC) varieties, to better define these contributions to the Kishon Mid-Reach multi-commodity placer.

Vertebrate Paleontology in the Miocene-Pleistocene collections of Israel

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The "Levantine corridor" was a major faunal dispersal route from the early Miocene through the Pliocene and Pleistocene, forming a land bridge between Africa and the Eurasian continents. Due to its geographical position the Levant was a natural “traffic hub” for faunal elements of Asian and African origin, which may also include hominins from the early Pleistocene onward. The dispersal events are actually not one event but a more complex process of dispersal pulses and waves, dictated by various variables including the actual climatic conditions, tectonic events and sea level changes.

An up dated survey of the major fossil localities of Israel with their major faunal groups and key species is an ongoing process, requiring combined efforts from research institutions in Israel. Bringing Vertebrate Paleontology back to the major arena of geological research.

The resolution of the faunal exchange inferred from the fossil record depends on the exposure of geological relevant outcrops and the intensity of research. As such fossil-rich and well dated localities refine the large scale perspective maps reconstructing sea levels, land bridges and faunal dispersals routes and their dating.

The hydraulic connection between coastal confined aquifers and the sea: a tidal perspective

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This study attempts to develop a new method to test the connectivity between deep coastal sub-aquifers and the sea, using their response to tidal fluctuations. The Quaternary coastal aquifer in Israel is subdivided into several sub-aquifers, which are separated by confining layers, whereby the upper one is phreatic (unit A) and the deeper ones are confined/semi-confined (units B-D). This separation is evidenced by their different chemical and isotopic compositions as well as their piezometric levels. The hydraulic connection between the confined units and the sea is debatable. It was suggested that the lower sub-aquifers might be blocked to the sea, which is supported by the several observations of old fresh water in the deeper sub-aquifers close to the shoreline. Groundwater level was measured in observation wells at different units and at varying distances from the shoreline. Data of sea level is from the IOLR Hadera MedGloss station. Groundwater of all units show tidal patterns. Nevertheless, the tidal signals are much more prominent in the deeper confined units (C-D), including the low frequency periods (e.g. the spring-neap cycle, Mf-Mm), while in the phreatic and semi-confined units (A-B) signals are more disrupted and irregular. The data was analyzed by the fast Fourier transform (FFT) function in AutoSignal Software. The results indicate that the most dominant frequencies in all datasets are the semi-diurnal tidal components (M2, S2), while the diurnal component (K1) was the next distinct signal recorded. The amplitude of tidal fluctuation increases with depth, which is probably related to its lower storativity.

All water levels time series have been subjected to an extensive Fourier domain filtering and component isolation procedure (Fourier Filtering and Reconstruction). This procedure permits toggle-selected frequency thresholds within the Fourier decomposition and uses an inverse FFT for the reconstruction. The reconstructed data was analyzed by cross-correlation function in MATLAB for determining the time delay between two time series shifted in time relative to one another. The maximum of the cross-correlation function indicates the point in time where the signals are best aligned, i.e. the time delay between seawater level and ground water head fluctuation. The results reveal that the observed groundwater head fluctuations in the deep confined units (C-D), at different distances from the shore line, have either a very small negative phase shift or a positive phase shift by almost one tidal cycle. The results of cross-correlation and time series of groundwater fluctuations indicate that signals at confined units of various depths are in phase. This could suggest that the tidal signals in the confined units are dominated by tidal loading (or

earth tide) rather than by actual seawater intrusion into the aquifer, which should be further studied.

Insights into gypsum precipitation – A Dead Sea-Red Sea brine mixing study

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Gypsum precipitation has major implications for industrial as well as natural and environmental processes. The importance of gypsum formation in these processes has led to research into the kinetics (both nucleation and crystal growth) of gypsum precipitation and the morphology of the formed crystals. The common practice when conducting kinetic experiments is to look at nucleation and crystal growth separately. This simplifies the experiments but causes loss of data which might be required. An example of where this information is critical is in the expected gypsum precipitation during the proposed Red Sea – Dead Sea project. Under this scenario it is assumed that the ratio between nucleation and growth rates will determine the amount of minute crystals that will stay afloat and might cause whitening of the Dead Sea.
The challenge in simultaneous description of nucleation and growth arises from the fact that it is impossible to observe nuclei created during nucleation without disrupting the experiment. A possible way to work around this problem is to look at the entire process by assuming that new crystals are created during nucleation and that crystal growth starts on these initial nuclei. This 'coupling' of the two processes allows modeling precipitation in various systems but requires a projection of the correct number of crystals created.
A proposed model allows to accurately describe the change in sulfate concentration due to gypsum precipitation from Red Sea - Dead Sea mixtures that are close to equilibrium. In order to constrain the model, a method to measure the size distribution of the formed crystals was developed. The crystals are filtered from batch experiments, photographed with a microscope and analyzed with ImageJ software. This procedure allows measuring crystal size and to characterize the morphology (e.g., aspect ratio, circularity) of the crystals.
The newly developed method was applied to mixtures created from different ratios of Red Sea – Dead Sea waters, leading to the following preliminary conclusions: 1. – Both kinetics and crystal morphology are highly dependable on the Dead Sea/Red Sea ratio, 2. – Gypsum formed at high initial supersaturation has a unique morphology regardless of Dead Sea/Red Sea ratio, 3- At a given Dead Sea/Red Sea ratio, higher initial supersaturation leads to smaller gypsum crystals, 4 – Prior to observable change in solution chemistry different crystal faces seem to grow at different rates. As soon as a significant change occurs the formed crystals grow invariantly, 5 - The population of formed crystals has a log-normal distribution.

Gypsum solubility under vonditions relevant to CO_2 geological storage - insights from experimental data

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The solubility of gypsum has been widely studied under various experimental conditions (e.g. temperature, ionic strength and degrees of saturations), but only few studies considered the impact of pressure and CO2 concentration. In the present study, the investigation of gypsum growth has been extended from atmospheric pressure to pressures up to 100 bar and to various molal concentrations of dissolved CO2.

A series of pressurized semi-batch experiments (flow-through experiments with extremely slow flow rate) were conducted in order to establish the solubility of gypsum at high pressures (25, 35, 50, 70, 100 bar) and with various molal concentrations of dissolved CO2 (0.12, 0.3, 0.54). Experiments were performed at 25°C in a high pressure titanium reactor by mixing CaCl2 and NaSO4 solutions, reaching an initial degree of saturation with respect to gypsum of Ω=1.81 and Ω=1.05.

Solubilities attained in the semi-batch experiments match (within a 3% uncertainty) the new PHREEQC ver.3 predictions (Appelo et al., 2014), in which pressure and dissolved CO2 concentrations are two of the new variables. Accordingly, gypsum solubility was found to increase as pressure rises and to decrease as CO2 concentration ascends. In addition, preliminary flow through experiments show that the rates of crystal growth decrease as pressure rises, and increase as a function of CO2 concentration.

Combining radon (^{222}Rn) and fair weather electric field measurements for studying atmospheric electricity and space-weather events

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Radon (^{222}Rn) is considered as a unique trace component due to its properties, in particular as a proxy of temporally varying processes in natural environments. The primary interest in ^{222}Rn is as an eventual indicator and proxy for active mechanical seismogenic and volcanic geodynamic processes. A gamma ray detector (2x2”, SCA) was installed above ground at the Cosmic Ray and Space Weather Center located at Mount Hermon, along side a continuous multi-parametric array, in order to understand geophysical phenomena in the atmosphere. The multi-parametric array consists of a Global Navigation Satellite Systems (GNSS) geodetic receiver (for measuring Precipitable Water Vapor (PWV) and ionospheric Total Electron Content (TEC)), vertical atmospheric electric field (E_z) and current (J_z) and a neutron super monitor (for cosmic ray measurements). Gamma-ray measurements during approximately 200 days indicate variations consisting of diurnal and multi-day signals, assumed to be due to Radon (^{222}Rn) in the local lowermost atmosphere. The diurnal variations show a 24-hour periodicity. In addition, we have captured a strong (K_p=7) geomagnetic storm, which caused ionization changes above the ground and manifested as abrupt jumps introduced into the Radon (^{222}Rn) and E_z measurements. Several other instantaneous jumps observed in our measurements might also be related to severe lightning storm activity during the end of autumn.

Military geosciences–a review of the state-of-art in the western world and an outlook for the 21st century

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The disciplines that examine the reciprocal relations between the spatial and physical characteristics of the surface, and near surface of Earth to military, security and intelligence activities are recognized as 'Military Geography' or 'Military Geology', the latter primarily concerned with the impacts of rock and soil on military operations. These disciplines have recently merged in the western world and are coined Military Geoscience. Military Geoscience is concerned with using the broad scope of the Earth sciences and technical expertise in remote sensing, geo-informatics and geo-physics for military and security purposes. The discipline is an applicable and practical one and requires both general and specific expertise in both military theory and different fields of geoscience.

The areas of interest of Military Geoscience are very broad and relate to offensive, defensive and routine military activities. They encompass geo-strategic to micro-tactic issues, such as developing quantitative environmental models to map the regions and states where conflict will emerge, assessing the specific trafficability of vehicle types per substrate, or analyzing the strata appearing behind Bin Laden clips in order to locate his hideout. The temporal scope of the discipline ranges from studies of the impact of the terrain upon battles of the past to short- and long-term operational planning.

The interest in Military Geoscience in prominent western countries is slowly growing, partly due to the unique and significant environmental impact military activities have upon Earth' surface and the demand of western defense establishments for precise, rapid and low-casualty outcomes. Military geoscientists are becoming more involved in environmental and development activities such as land management of firing zones, and agricultural, water and mineral resource development in controlled lands. Nevertheless, the discipline is recognized as peripheral to central military and academic thinking. This paper reviews the state-of-art of Military Geoscience in western countries and outlines the expected sub-fields of the discipline that will remain important or become even more critical in the 21st century.

Multi-stage growth of a late Pleistocene linear dune dam at the Natufian Ashalim site along the southern fringe of the northwestern Negev Desert dunefield, Israel

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Interactions between aeolian and fluvial processes, known as aeolian-fluvial (A-F) interactions, play a fundamental role in shaping the surface of the Earth especially in arid zones. The blocking of wadis by dunes (dune-damming) is an A-F interaction that records periods of aeolian 'superiority' on fluvial transport power and has had a strong impact on arid landscapes and prehistoric man since the late Quaternary.

The southern fringes of the northwestern Negev dunefield are lined with discontinuous surfaces of light-colored, playa-like, low-energy, fine-grained fluvial deposits (LFFDs). Abundant prehistoric camp sites mainly from the Epipalaeolithic period border the LFFDs. The LFFDs are understood to be reworked loess-like sediment deposited in short-lived shallow water bodies during the late Pleistocene. These developed adjacently upstream of hypothesized dune dams of wadis that drain the Negev highlands. However, no dune dam structures by the LFFDs have been explicitly identified or analyzed. This paper presents for the first time the morphology, stratighraphy and sedimentology of a hypothesized dune dam that hosts recently excavated Epipalaeolithic sites. The studied linear-like dune dam structure extends west-east for several hundred meters, has an asymmetric cross-section and is comprised of two segments. In the west, the structure is 3-5 m high, 80 m wide, with a steep southern slope, and is covered by pebbles. Here, its morphology and orientation resembles the prevailing vegetated linear dunes (VLDs) of the adjacent dunefield. To the south of the structure extends a thick LFFD sequence. In the east the structure flattens and is covered by nebkhas with its southern edge overlapped by LFFD units.

A 120 m long trench dissecting the western segment of the structures revealed a stratigraphy comprised of a thick LFFD base, overlaid by aeolian and fluvially reworked sand, a thin middle LFFD unit, and a crest comprised of LFFDs, fluvial sand and pebbles. Carbonate contents and particle size distributions of the sediments easily discriminate between sand and different LFFD units and surface sediments. Micromorphological analysis of the middle LFFD reveals clay with strial birefringence fabric, sub-angular blocky peds and several cycles of graded bedding, indicating shrinking of saturated clays and sorting in

shallow standing water bodies or very low energy wadis.
The structure seems to be unique archive of several phases/cycles of aeolian and fluvial deposition and erosion that preserved the dune-like morphology. The Harifian and Natufian remains indicate that the structure served as a convenient dwelling site by water bodies that developed to the north and south, probably at different times for short durations. The structure probably accreted during the two main episodes of Negev dune encroachment; around 15 ka, and then around 12 ka (Roskin et al., 2011) when it reached its mature state shortly prior to the Natufian encampment

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Modeling soil moisture content for OSL dating

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Estimation of time averaged soil-moisture content is one of the largest uncertainty sources for calculation of OSL ages. In the current work we utilize tools from the field of soil-physics to predict the annual averaged soil moisture content. We use a one-dimensional unsaturated-flow code to construct a model which calculates the soil-moisture content. The model encompasses site-specific information regarding evaporation, rainfall and soil properties such as the grain size distribution and bulk density.
The model provides the full spatial and temporal distribution of the soil moisture content. It also gives clear uncertainty bounds for the estimated soil-moisture profile which serves as a measure for model reliability. The current approach is applied to calculate the soil-moisture profile at Har-Eitan, a Late-Holocene, open-structure soil section subjected to Mediterranean climate in which hot and dry summers and cool and wet winters generate large variation in the moisture-content. We show that the model can improve soil-moisture estimation, reducing the associated uncertainty and accounting for the variation of soil moisture with depth. These predictions of the model can then be used to better constrain uncertainties in OSL dose rate calculations.

Assessing permafrost formation age by radium isotopes

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Permafrost is defined as the ground at sub−zero temperature during at least two−year period. It is mainly found in the circumpolar region. Atop of the permafrost is the 'active layer', which thaws yearly. Recent thawing of permafrost due to global warming should increase the availability of buried organic carbon to biological processes. This in turn, will probably result in the release of carbon dioxide and other greenhouse gases to the atmosphere, amplifying the greenhouse effect. While the methodology for soil age determination is well established (e.g. OSL), the freezing age of permafrost is often hard to defined, and it is mainly assessed based on geomorphological and landform observations. In this paper, we show that radium isotopes could be used for determining the permafrost formation age. In addition, Ra isotopes can also be used for geochemical characterization of the permafrost ice which can be used to trace the possibility of permafrost thawing.

Permafrost samples were collected from shallow cores (down to 3 m) in two lowland landforms at the Adventdalen valley, central Svalbard, during the late summers of 2014 and 2015. Samples were thawed, and water was immediately separated from solids in order to minimize Ra adsorption onto solids. This was followed by 0.2µm paper filtration. Since Ra isotope analyses require 500-1000 ml of water, depth intervals were relatively wide (20-40 cm), and similar depth intervals from several cores in the same location were combined.

The hypothesis of the current research is that the activity of 226Ra should buildup in the frozen pore space until recoil from the permafrost solids is balanced by its radioactive decay. The 226Ra/224Ra and 226Ra/223Ra ratios are used to account for radium adsorption that might occur during permafrost thawing.

Preliminary results show that 226Ra/224Ra ratios in the permafrost were significantly higher than in the active layer water, which supports the abovementioned hypothesis. In shallow (2-3 m) permafrost profiles, 226Ra/224Ra and 226Ra/223Ra ratios were higher at the topmost permafrost than 1-2 m deeper. This suggests that the deeper permafrost is somewhat younger than the shallower one, which is not in accordance with the common interpretation of aggrading permafrost, and should be further studied. The high permafrost 'signal' (namely: high isotope ratios) at the topmost permafrost may also negate significant permafrost thawing. Preliminary freezing ages were calculated, based on the 226Ra/223Ra ratios in permafrost and the

active layer, and assuming parent nuclide activity ratios of 21.7 (the 238U/235U ratio). The ages derived for the sampled profiles were between 500-3,000 years, in agreement with OSL ages of the sediments. Direct parent nuclide ratios (e.g. 230Th/227Ac) should be studied in order to further constrain the permafrost freezing ages.

Megiddo-Jezreel License Area: Improving subsurface coverage & structural imaging

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The Megiddo-Jezreel license was granted to Zion Oil & Gas, Inc. on December 2013. The company focused its exploration efforts on deep Jurassic and Early Cretaceous targets down to about 4-4.5 Km in the Bet Shean Valley. The seismic acquisition in the area resulted in poor to moderated data due to complex subsurface geology, frequent thickness changes of continental, lacustrine and marine sediments interlayered with numerous volcanic horizons.

Review of the existing seismic data yielded reliable information down to 2-2.5 Km only. To achieve the goal of seismic data improvement, we utilized new tools. These included an accurate survey design with the ArcGIS Collector Application for iPad, and higher quality of acquisition planning with the Tesseral 2D modeling software, by Tetrale Group. The modeling software simulated the subsurface along the east west direction, crossing the target structure. It included assumptions of the seismic velocities and densities, and executed with changing acquisition parameters. The model resulted with sufficient quality of data down to 4.5 Km. The modeling parameters chosen for acquisition were those who produced the best results.

The new seismic lines, acquired during August 2014, were compared with the old data and provided with better results: higher signal to noise ratio, improved coherency and resolution, in particular at depth, with improved deeper data due to longer maximal offset. Using emerging technologies, especially seismic modeling, greatly contribute to seismic survey success, primarily with imaging deep layers and structures in complex areas.

Depositional environments of the Bira and Gesher Formations in the Lower Galilee and Jordan Valley during the Tortonian- Zanclean ages

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During the late Miocene to early Pliocene (Tortonian – Zanclean ages) a fluvial-lacustrine sequence accumulated in the Lower Galilee basin (LG) and the Jordan Valley basin (JV). The sequence lies between the Lower Basalt/Hordos Fm. and the Cover Basalt and comprises the following formations: The Umm Sabune Fm. and the Red Clay Unit; the Bira Fm.; the Gesher Fm., the Fejjas Tuff and a unit of conglomerates, paleosols and pyroclastic rocks. Here, we focus on the depositional environments of the Tortonian Bira Fm. (~10.0 to 7.0 Ma) and the Messinian/Zanclean Gesher Fm. (~ 7 to 5.2-4.6 Ma.) based on lithological and faunal analyses of outcrops and drillholes. Both formations consist mainly of limestones, dolostones and marls in the LG and of mainly evaporites (gypsum and halite) in the JV. The carbonate rocks in the Bira Fm. appear to define three sedimentary cycles, which can be traced throughout the LG basin. Each cycle starts with coarse intraclastic carbonate rocks (calci/dolorudites), and grain size decreases upward until attaining clay size. Each of these sequences is overlain by layers rich in bivalves that are assigned to marine transgressions, and terminates by paleosols development. The Bira Fm. was deposited in a large fresh-brackish-water body that extended over the LG with a constrained connection to the open sea. The three sedimentary cycles were probably associated with a continuous supply of marine water to the Bira lake by ingressions that arrived at its climax during pronounced marine transgressions. These transgressions reached the JV where they deposited halite and gypsum. The Gesher Fm. consists mainly of laminated micritic carbonates, in its lower part, ooidic carbonates in the middle part and nodular carbonates, paleosols and conglomerate in the upper part. Thus, it appears that the transition from the Tortonian (Bira Fm.) to the Messinian (Gesher Fm.) at ~ 7 Ma was accompanied by increasing isolation from the open sea and formation of an inland lacustrine body. Moreover, the transition from the laminated micritic carbonates, to ooides and then to nodular carbonates and soils indicates continuous drying of the region, possibly in step with the MSC (Messinian salinity crisis) in the Mediterranean. A prominent layer with marine shells was found at the upper part of the Gesher Fm. at Nahal Hamud section. The age of this transgression could be after the MSC at the early Zanclean, or before the MSC at ~ 6 Ma. This transgression may be related to the thick sequence of halite in the Zemah-1 borehole and possibly also to that in the Dead Sea basin.

Oxygen isotopic evolution of individual dissolved CO_2 species in a system approaching thermodynamic equilibrium

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In the dissolved inorganic carbon (DIC) system two kinds of oxygen isotopic equilibria can be distinguished: an 'external' thermodynamic equilibrium between the DIC and water, and an 'internal' equilibrium among the different DIC species themselves (CO2(aq), H2CO3, HCO3-¬ and CO32-). The external oxygen equilibrium has been well studied. Equilibrium fractionations between the individual DIC species and water have been constrained, and from their relations stem the internal equilibrium fractionations among the DIC species themselves. The time required to achieve an external equilibrium was evaluated both theoretically and experimentally, and found to be on orders of minutes to weeks, depending mainly on solution pH. The isotopic evolution of the total DIC during that time has also been investigated. However, to date, the isotopic evolution of the individual DIC species in a system approaching external equilibrium is not known, nor the time required to achieve the internal equilibrium, which may be different than the time required to achieve the external equilibrium. In this work we address these issues by bridging theoretical gaps in the study of kinetic oxygen isotope effects in the DIC system.

New findings on the 2007 BenNun - Shaalabim earthquake and its relation to the Modiin fault

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In 2007 a 4.2 Ml Magnitude earthquake had occurred near Ben Nun village, with its epicenter located at a depth of <11 km. Since the earthquake occurred in a “non seismogenic zone” (Shamir, 2001), where no previous earthquakes have been reported, further investigations where conducted by the GSI. Following a seismic line acquired east of the epicenter using a vibroseis (in 2008) an east dipping 1.5 km wide fault zone was revealed. Based on subsurface mapping by Fleischer and Gafsu (2003) and an outcrop near the city of Modiin (Sneh et al., 1999), the wide fault zone was interpreted as part of the southward continuation of the NE-SW trending Modiin fault (Shamir et. al, 2009). Taking these findings into account it was thought that the epicenter is located on the southward prolongation of the Modiin fault. Acquisition of a high resolution seismic line (in 2010 using an accelerated weight drop) further constrained the upward prolongation of the fault zone in the shallow subsurface (Medvedev and Marig, 2011). While booth lines were acquired north to the epicenter, GII has recently acquired a new high resolution seismic line ~0.5 km south west of the epicenter to further constrain the fault plane azimuth.

Results from this survey were combined with interpretation of three additional seismic lines from different vintages and resolution, and reveal that the Modiin fault plane extend southward, and dips westward at the deep subsurface. These new findings challenge the interpretation that the epicenter was located on the Modiin fault. As no other fault plane is observed east of the Modiin fault, nearby the location of the epicenter, and as the epicenter occurred in the crystalline basement (>11 km depth) further investigation is required to assess whether the 2007 earthquake occurred on a fault plane extending to the upper (~2 km) sedimentary section.

The enigma of the Jonah high in the middle of the Levant Basin and its significance to the history of rifting

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Recent giant gas discoveries within deeply buried structural highs in the middle of the Levant basin have attracted the attention of the industrial and academic communities striving to understand the origin of such structures, their relations to the tectonic history of the basin, and their evolution through time. Here we focus on the Jonah high, which is one of the largest structures in the basin and is particularly enigmatic in its geometry, dimensions and location compared to nearby structures. It is buried under more than 3 km of Late Tertiary sediments, and is associated with one of the largest magnetic anomalies in the basin, though no significant gravity anomaly is observed. Previous studies raised several possibilities explaining its origin: an ancient horst related to the early stage of basin formation (Late Paleozoic or early Mesozoic); a Syrian Arc fold (Late Cretaceous to Neogene); a giant volcanic seamount; and an intrusive magmatic body. A reconstruction of the evolution of this structure is proposed here based on newly produced pre-stack depth migration of five selected seismic reflection lines crossing the Jonah high combined with a basin-wide interpretation of more than 500 2-D time-migrated lines. We suggest that the Jonah high is a horst bounded by grabens, most probably formed during continental breakup related to the Neo-Tethys formation. However, unlike other extensional structures that were reactivated and inverted during the Syrian Arc deformation, the Jonah high was never reactivated. Rather, it formed a prominent seamount that persisted for 120-140 million years until the Early Miocene, when it was finally buried. In a wider perspective the Jonah horst is similar to the Eratosthenes seamount, a fragment of continental crust between the Levant and Herodotus basins.

An early Holocene pulse of export production in the Red Sea

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The physical and geochemical characteristics of the Red Sea are modulated by water exchange across the narrow Bab-el-Mandeb strait and are consequently highly sensitive to Quaternary global climate and sea level changes. In addition, the location of the Red Sea in the subtropical desert belt exposes it to the impact of tropical monsoon systems, which may be associated with a change in primary and export production along the Red Sea surface waters. Thus, the Red Sea oceanographic configuration provides a key to understanding the connection between climate change and the carbon cycle in the atmosphere and in oceans.

Here, we examine the history of the Red Sea in terms of its export production record. This work focuses on two marine sediment cores, KL23 and KL11 located in the north and center of the Red Sea, respectively, and an additional sediment core, KL15, located outside the Red Sea in the Gulf of Aden. Each core is sampled at approximately 1 ka temporal resolution and measured for major and minor elemental abundances.

Preliminary results from the two cores over the last 70 ka reveal an abrupt increase in the concentrations and Al-normalized ratios of elements associated with water column primary and export production (e.g., Mn/Al, Ba/Al, U, Fe/Al, Co/Al, Ni/Al, Cu/Al, Mo, Cd, V/Al, Cr/Al) during the early and middle Holocene, ca. 11.7-3.6 ka. By contrast, the Gulf of Aden record displays an overall enrichment in elements considered to be nutrients or micronutrients (e.g., Ni/Al, Cd, Cr/Al), but otherwise shows far less pronounced shifts in elemental trends across the last deglacial and Holocene.

A south to north gradient of peaks in Mn/Al, U, Mo and Cd concentrations, suggests the occurrence of an abrupt and time-limited increase in organic-rich deposits, which was limited to the Red Sea (i.e., not observed in the Gulf of Aden) and developed from south to north. We propose that this event was triggered first by the deglacial sealevel rise that resulted in the influx of relatively nutrient-rich seawater into the hypersaline glacial Red Sea, resulting in the development of water column stratification and bottom sediment anoxia. The observed increase in elemental abundances is much more gradual relative to their decrease back to baseline values, reflecting a late penetration of oxygen to the sediments and a top-to-bottom "burn-down" of the signal.

These observed elemental peaks are coeval with an intensification of tropical monsoon activity (i.e., the "African humid period"), which is shown to have triggered an increase in export production in the Red Sea. This conclusion however, should also be considered in the context of signal preservation and over-print due to changes in redox conditions in the water column and sediments.

Pockmark asymmetry and seafloor currents - case study from Santos basin, offshore Brazil

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Pockmarks form by gas/fluid expulsion into the ocean. Ideally, they are circular at the seafloor and symmetrical in profile. Elliptical pockmarks are associated with seafloor currents while asymmetric ones with sedimentation patterns. We examine these associations through morphological analysis of multibeam data collected across the Santos continental slope, offshore Brazil (353-865 m). From 984 pockmarks, 78% are elliptical and asymmetric. Geometric criteria divide the pockmarks into three depth ranges that correlate with a transition between two currents: Brazil Current transfers Tropical Water and South Atlantic Central Water southwestwards; below, the Intermediate Western Boundary Current transfers Antarctic Intermediate Water northeastwards. We suggest that seafloor currents velocity and persistence dictate pockmark ellipticity, orientation and profile asymmetry. Fast currents (>20 cm/sec) are capable of maintaining pockmark flank steepness close to the angle of repose. These morphological expressions present direct evidence for an edge effect of the South Atlantic Subtropical Gyre.

Environmental changes in the southern Tethys productivity belt: a multi-isotope study of the giant phosphorite deposition

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The Santonian to Maastrichtian age (85-65 Ma) phosphates in Israel are part of an extremely large Cretaceous to Eocene phosphorite deposition belt that stretches from Turkey to Morocco.
Previous studies suggested that phosphorite deposits occur in two different facies: pristine phosphorite deposits that are attributed to high productivity and sedimentation rates in suboxic to anoxic conditions, and reworked phosphorites (the economic facies) deposited under oxidized conditions at low sedimentation rates in high-energy events accompanied by bioturbation. Although important studies have been made on the deposition conditions of the Middle East phosphorites and their enclosing rocks, several aspects of the the environmental conditions remain unclear and can be explored with nitrogen isotopes (δ15Norg), molybdenum isotopes (δ98/95Mo), redox sensitive trace elements (RSTE) and rare earth elements (REE) content. Preliminary work in this study was made on samples collected from the Zin valley quarry at Zin 3A and Yorkeam sections. Samples were taken from different phosphorite layers representing alternation between pristine and reworked phosphorite. Our results show that pristine phosphorites are enriched in most elements compared to reworked phosphorites, with the exception of elements that are known to be associated with carbonate fluorapatites (as shown in previous studies). The total organic carbon (TOC) contents in Zin 3A section shows small variations(0.4-2.4%) between the facies, while Yorkeam section displays enrichment in TOC in the pristine phosphorites (10-12%) compared to reworked phosphorite (1-2%). Also, many RSTE variations are positively correlated with TOC in Yorkeam bitumen section, but not in Zin 3A. The δ15Norg results on Zin 3A section show small variations of ~1.2‰ (4.4‰ to 5.6‰), without a clear difference between pristine and reworked phosphorites, similar to the results of previous study 1. In contrast, Yorkeam section shows a clear difference between the two phosphorite facies with a shift from δ15Norg values of 5-7‰ in the reworked phosphorite to 0.75-2.4‰ in pristine phosphorite. δ98/95Mo values of four couples of pristine-reworked phosphorites (two from Yorkeam and two from Zin 3A) were measured at ETHZ after column chemistry at the GSI. All values are positive, ranging from 1.06 to 1.77 ‰. In all four couples the reworked phosphorites are enriched relative to the pristine phosphorites, which is the opposite of a trend reported in a previous study 2. The differences in δ15Norg and RSTE behavior between Zin 3A and Yorkeam

sections may result from in situ oxygenation of the OM that took place at Zin 3A section during deposition or shortly afterwards.

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Isotopic evidence for the origin of DMS and DMSP compounds in a warm-monomictic freshwater lake

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The volatile methylated sulfur compound, dimethylsulfide (DMS), plays a major role in the global sulfur cycle by transferring sulfur from aquatic environments to the atmosphere. The main precursor of DMS in saline environments is dimethylsulfoniopropionate (DMSP), a common osmolyte in algae. The goal of this study was to assess the formation pathways of DMS in the water column and sediments of a monomictic freshwater lake based on seasonal profiles of the concentrations and isotopic signatures of DMS and DMSP. Profiles of DMS in the epilimnion during March and June 2014 showed sulfur isotope (δ34S) values of +15.8±2.0‰, which were enriched by up to 4.8‰ compared with DMSP δ34S values in the epilimnion at that time. During the stratified period, the δ34S values of DMS in the hypolimnion decreased to -7.0‰, close to the δ34S values of coexisting H2S derived from dissimilatory sulfate reduction in the reduced bottom water and sediments. This indicates that H2S was methylated by unknown microbial processes to form DMS. In the hypolimnion during stratified period DMSP was significantly 34S enriched relative to DMS reflecting its different S source, which was mostly from sulfate assimilation. The present study provides isotopic evidence for multiple sources of DMS in stratified water bodies and complex DMSP/DMS dynamics that is linked to the various biogeochemical processes within the sulfur cycle.

Reconciling retreat rates of vertical vs. non-vertical knickpoints, and a potential link to bedrock channel concavity

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Oversteepend channel segments (knickpoints) move up-channel as they communicate relative changes in base level (in response to tectonic or climatic forcing) to the upper reaches of channel networks. For a non-vertical knickpoint that moves up a steady-state channel (a channel where the rate of erosion equals the rate of bases level change), the knickpoint velocity (v), can be cast as $v \propto A^{\theta}$. This expression is derived from the commonly used Stream-Power law, where A is drainage area, and θ, the channel concavity, is measured from the channel profile. However, the assumptions that underlie this formulation are not valid for vertical knickpoints. Hence, for vertical knickpoints this process is simulated with a similar functional form where the exponent, now termed p, is determined through an iterative optimization procedure that attempts to minimize the misfit between simulated and observed knickpoint locations. It is not clear, however, if the velocity of a vertical knickpoint depends on the processes that shape the adjacent non-vertical channel segments such that $p \simeq \theta$, or whether these processes are independent (i.e., $p \neq \theta$). The later implies that when vertical knickpoints are formed, the stream power law is incapable of predicting landscape response to changes in base level.

A major hurdle in testing whether $p \simeq \theta$, is that p is traditionally reported without a measure of uncertainty such that it is not clear whether θ and p are similar within error. This study presents methods to evaluate the error in p and applies these methods to analyze channel networks with vertical knickpoints across the world. The calculated p values and their range are very similar to the magnitude and range of θ. This suggests that retreat of vertical knickpoints is often enslaved to incision processes in adjacent, non vertical channel segments, such that knickpoint retreat predictions based on the Stream-Power law are probably valid in the context of vertical knickpoints. Further analysis is needed to support these preliminary results.

Oligocene to late Miocene erosional and depositional processes in the southeastern part of the Levant basin, Offshore Israel

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Tectonic and eustatic changes that were initiated during the Early Oligocene resulted with the development of three major submarine canyons (Afiq, El-Arish and Ashdod) in the southeastern margin of the Levant basin. This study focuses on the evolution of the Oligo-Miocene canyons, prior to the deposition of the Messinian Salt. Integration of 2D and 3D seismic data with borehole data allows interpreting ten seismic units within the Oligo-Miocene succession that are associated with canyon incision and in-fill. Volume and surface seismic attributes were used to identify and map channel systems and fan complexes within the Oligo-Miocene canyon-fill. Our analysis shows that submarine erosion was intermittently active in different intensity and location during the Oligocene to Late Miocene time span. In the Early Oligocene, the Afiq canyon was less developed then the El-Arish and Ashdod canyons. Falling sea level in the Mid-Late Oligocene is associated with lowstand conditions and development of a regional sequence boundary, followed by forced regression and deposition of prograding clinoforms. This lowstand package is topped by a transgressive surface. In the Early Miocene, incision in the Afiq canyon was more intense (in comparison to earlier incision events). In the Mid Miocene, this erosion was further intensified, cutting deeper and partly removing older incisions surfaces. In the Late Miocene the incision in the Afiq canyon, as reflected by the base Messinian “N” horizon, was relatively minor despite the fact that relative see-level drop was likely higher than in earlier periods.

It is suggested that Oligo-Miocene canyon incision and deposition episodes on the Levant slope were controlled by three main factors: (1) regional tectonic uplift, (2) eustatic processes, and (3) vertical motions on three structural features in the canyon pathway. Significant amount of siliciclastic material was transported during this time from the southeastern Levant shelf into the basin through the Afiq-El Arish-Ashdod canyon system. Overall, canyon deposition shows progradation of facies from the proximal canyon in the southeast to the distal part in the northwest. Deep-marine channel and fan systems that accumulated in unconfined setting in the distal part of these canyons, show braided and meandering morphologies, trend mostly in a northwest direction and likely form stratigraphic traps for biogenic gas.

Provenancing the James Ossuary: methods, results and implications

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The James ossuary (burial bone box) was unveiled to the public on Oct. 21, 2002 and rapidly made cover stories in most major international journals. Without commenting on the legal and professional debate regarding the authenticity of the second half of the inscription on the ossuary "James son of Joseph brother of Jesus" it is of enormous importance to determine whether this unprovenanced ossuary belongs to the Talpiot tomb (TT). This was excavated in 1980 and contains ossuaries with the inscribed names of the immediate family of Jesus. If shown to be true such a rationale would immensely strengthen the argument that the TT is indeed the tomb of Jesus of Nazareth. When discovered the blocking stone into the tomb was missing and ten ossuaries (six inscribed) were found intact in their kokhim covered by unstratified soil to a depth of over 1.5 meters. We have already shown that in consequence of an earthquake-linked tectonic event in 363 AD rock slides were generated and the Talpiot tomb was flooded with soil. Unlike in other tombs where geochemical change is continuous, the TT, like Pompey buried in ash, became a time capsule thereafter preserving its own, unique chemical milieu.

Our research focuses on chemical changes which affected the chalk of the TT, the James and a number of random ossuaries including on materials which invaded their interior. Chemical analyses complemented with statistical data utilizing some 23 major and minor elements clearly show that 1. The Talpiot tomb and its ossuaries possess a unique chemical signature which differs significantly from that of all other tombs sampled 2. The chemical signature of the James ossuary, based on the full range of chemical data, is similarly unique and notably identical to that of the TT ossuaries. If so, the James spent most of its ca. 1800 year history inside the Talpiot tomb, and 3. Even if only the first segment of the James inscription is authentic, the Talpiot tomb must, without any reasonable doubt, be the tomb of the family of Jesus of Nazareth.

Strength And Elasticity Of Organic-Rich Chalk

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We investigate the rock physics of immature organic-rich chalk located at the Shefela basin, central Israel, focused here on its unique rock mechanics. The Late Cretaceous organic-rich chalk of the Ghareb and Mishash formations is characterized by high porosity, low permeability, slow P and S waves velocities and low elastic stiffnesses. Total organic carbon (TOC) is as high as 20%, mostly associated with immature type IIs kerogen. We tested the Brazilian tensile strength and the triaxial compressive strength of air-dried chalk specimens, taken from ten different intervals within the 330-610 m depth section in the Zoharim well. Porosity and density were measured using oven-dried core plugs, and TOC (which indicates kerogen content) was measured on core fragments. We observe that both compressive strength and tensile strength decrease linearly with increasing porosity, and are unaffected by kerogen content. Unlike the compressive strength, static Young's modulus of the chalk appears to be effected by kerogen content. A porosity-equivalent volume is used: $\phi_{eq}=\phi+c_k f_k$, where ϕ is the measured porosity, f_k is kerogen volume and c_k is a dimensionless coefficient defined here for the first time. The c_k coefficient theoretically ranges from 0 (no influence on Young's modulus) to 1 (kerogen is compliant as the dry pores). This range realistically is narrower and believed to depend upon pore-geometry stiffness, kerogen type, maturity and shape. Based on our results and data by Bisnovat et al. (2015), we obtain a great match between Young's modulus and ϕ_{eq} using a power-law regression and c_k=0.3. We also find that tensile strength of air-dried chalk is transversely isotropic, being ~1.5 times greater parallel to bedding than perpendicular to bedding, whereas the anisotropy stems from dense lamination.

East Mediterranean sea levels in the last 3,000 years; the combined Israeli and Greek data

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The last 3,000 years of relative sea level (RSL) in the East Mediterranean are derived mainly from archaeological indications, but also bio-construction indicators (Dendropoma petraeum reefs at the edge of the abrasion platform along the Israeli coast). The current study challenges the assumption that RSL trends observed along the coast of Israel would also be observed in other East Mediterranean sites like Greece, so that better evaluations can be made of local and regional driving mechanisms. The process is comprised of three questions: 1) Which types of archaeological and biological sea-level indicators in Greece and Israel have the highest level of reliability for RSL evaluation and what degree of error do these observations have? 2) What are the overall trends of sea-level change in Greece and Israel during the last 3,000 years? 3) What regional trends can be identified from the combined Greek and Israeli data?

In order to answer the above questions, three objectives are pursued: 1) Identify archaeological and biological RSL indicators from the last 3,000 years in Israel and Greece, including already published indicators. 2) Assess the reliability of indicators using a consistent scoring system, correction for isostatic and tectonic effects, more precise measurements from indicators, and exploration of new methods to determine the chronology of archaeological indicators in Israel. 3) Use the assembled data to create a sea-level reconstruction for Greece, and combine the data with synthesized reconstructions from Israel for an analysis of matching trends.

The survey collected nearly 140 archaeological indicators from Israel and about 120 from Greece (excluding those outside the project's chronological scope). Of the Israeli indicators, some 120 were deemed reliable enough for reconstructions, whereas in Greece only 40 were, and not all of these from tectonically stable areas. The Israeli data includes 31 dates obtained from Dendropoma reefs in Israel. The higher reliability of the Israeli dataset may stem from a smaller coastline and more focused SL research over the past few decades. In Greece, many measurements were taken before precise surveying methods were available, and published without sufficient metadata.

The two regional datasets reveal chronological gaps and disparities: Israel has a strong set of many indicators from the Roman Period (~2000BP) to present, but fewer from 3000-2000BP, while Greek indicators are strongly clustered in the Classical to Hellenistic Periods (2500-2000BP).

Results however suggest some correspondence and support previous Israeli conclusions suggesting somewhat lower levels around 2500BP and in the first half of the last Millennium: The Crusader period in Israel (11th to 13th century AD) and the Venetian period in Greece (12th to 15th century AD). Near-present, stable levels, with indications for slightly higher levels in late Roman/Byzantine time, are indicated during most other periods.

Integrated petrography and chemical analysis of ceramics: application to study of the trade relations of an Iron Age Pillared Building at Tel-Hadar

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An Iron Age large Pillared Building from the 11th century BC was excavated at Tel-Hadar, on the shore of the Sea of Galilee. Storage rooms, granary rooms and a columned hall were excavated in the ground floor of the building. Many storage and tableware vessels and some cooking pots were found in the storage rooms. Therefore, it was imported to study the functioning and the trade relations of the Pillared Building. In the present study we applied integrated petrography and chemical analysis by XRF and LA-ICP-MS in identification of the composition and the proveniences of the ceramics. Petrography method is succeeding in identification of the coarse particles within the ceramic material but imperfect in examination of the composition of the ceramic matrix. Therefore, we support the petrography results by the chemical analysis. The investigated ceramics were divided into nine groups. Groups 1–3 consists of cooking pots that were imported to Tel-Hadar from Golan and from Galilee. Tableware vessels of Group 4 are of local production. Imported storage jars of Group 5 were probably brought as containers for the traded goods. Pottery of Groups 6–8 was imported to Tel-Hadar from the Phoenician shore. These vessels are burnished or color-slipped and part of them was decorated with brown–red bands. A 'Greek' bowl of Group 9 was possibly imported from a Mediterranean island. This pottery is fine and thinner and decorated inside with a red cross.

The various petrographic groups of the ceramics and the concentration patterns of the major and trace elements observed by the XRF and LA-ICP-MS methods reflect the proveniences of the ceramics and thus the trade connections of the pillared building of Tel-Hadar with the surrounding region. The pottery was manufactured in different locations and imported to Tel-Hadar. The analyses reveal that some of the ceramics were manufactured in the vicinity of the site while others brought from the Golan, Jordan Valley, Galilee, Western Galilee–Lebanon and the Phoenician shore. Thus, the movement of goods seems to have covered a large area. The many storage and tableware vessels found in the storage rooms of the Pillared Building and their various provenances indicate that the site was functioned as a trading post. It seems that columned hall of the Pillared Building served for marketing. The large granary rooms of the Pillared Building also in accordance with the functioning of this structure for trading.

The influence of volcanic activity on the thermal history of the Golan Height sedimentary basin

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This study examines the influence of relatively young volcanic activity on the thermal history of the country rocks of the Golan Heights sedimentary basin using apatite (U-Th)/He thermochronology (AHe). The apatite minerals utilized are derived from two different sources: magmatic apatite from basic intrusions, and sedimentary, non-detrital apatite (biogenic?). The latter phosphate-associated apatite is often considered unsuited for AHe thermochronometry but was relatively little explored in the past.

Scanning Electron Microscopy (SEM) analysis of sedimentary apatite grains reveals intriguing structures consisting of packed aggregates of micro-scale crystallites. To explore the retentivity of these grains, two sets of sedimentary samples from Senonian rocks were analyzed: One set was collected adjacent to young Plio-Pleistocene volcanic necks and the other away from any known thermal perturbation. Both sets of samples experienced limited burial.

Our initial results show surprisingly similar AHe ages in both sets of samples (< ~4 Ma). This indicates that the sedimentary apatite analyzed must have experienced significant helium loss, even under temperatures as low as ~30°C, most probably due to their small crystallites size. On the other hand, it demonstrates that considerable volumes of helium may be retained in sedimentary apatite grains. Future characterization of the size distribution of multi diffusion domains in each grain will enable to constrain the conditions under which such grains can be used as thermochronometers.

AHe analysis on apatite grains from magmatic origin was more straightforward due to their single and relatively large diffusion domain. 13 borehole-derived apatite grains from a single basic intrusion to Eocene rocks (470 m depth) at the southern part of the Golan Heights yielded an AHe age of 4.9±0.4 Ma - identical to the age of the Cover Basalt formation. Inverse thermal modeling of these ages requires rapid cooling to temperatures lower than 30oC at 4-5 Ma and suggests normal (<25°C/km) paleo-thermal gradients over most of this period. However, measured borehole temperatures apparently indicate a higher current geothermal gradient and a present day temperature of around 40°C at 0.5 km. This can be reconciled with the thermochronometric data only if the abnormal thermal regime is due to a young thermal perturbation during the last < 250 ka.

We suggest a combined effect of late Pleistocene volcanic activity in the northern part of the Golan Heights and groundwater flow patterns as potential sources for such a thermal

perturbation.

Further exploration of both thermochorometers is expected to promote our understanding of the thermal evolution of the Golan Heights and its sedimentary basin.

Sinkhole-related subsidence along the Dead Sea and its response to flash floods: Insights from high resolution InSAR

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Sinkholes and sinkhole-related subsidence constitute major geo-hazards along the Dead Sea shores challenging both existing infrastructure and future development plans. Sinkhole generation is attributed to the dissolution of a subsurface salt layer by under-saturated groundwater. High-resolution (COSMO SkyMed, 3x3 m per pixel, λ=3.1 cm) interferometric synthetic aperture radar (InSAR) was applied in order to quantify the effect of flood water on subsidence in the vicinity of sinkholes and explore the spatial and temporal variability in subsidence patterns along the western shore of the Dead Sea. Subsidence rates and volumes during the past 3 years (2012-2015) were quantified in 21 sinkhole sites along the channels and alluvial fans of Darga, Hazazon, Arugot, Hever, Zeelim and Rahaf streams. For each site, a time series of interferogram-derived subsidence was constructed, bracketing major flood events and intra-flood periods. Subsidence rates and temporal shifts in the spatial distribution of subsidence were quantified and compared. Three different modes of response to floods were observed: immediate, gradual and no response. In sinkhole sites that are located in active channels, subsidence rates and volumes increase dramatically by a factor of up to 20 immediately after floods and decay quasi-exponentially over periods of ~150 days. Gradual response was observed in sites which are adjacent to active channels with sinkholes. In these sites, subsidence rates increase gradually during the winter, spring and early summer and decay gradually until the following winter. Sites in which floodwater does not drain into sinkholes do not show any flood-related subsidence. In all the sites which responded to floods a significant increase in the subsidence area (by a factor of up to 7) was observed following the floods.

The major mechanism for flood-dependent subsidence acceleration is increase in the dissolution rate of the subsurface salt layer immediately after flood events, due to rapid drainage of large volumes of under-saturated water directly into the subsurface salt layer through existing and newly formed in-channel sinkholes.

InSAR-derived site-specific subsidence rates reach a maximum of 2.5 mm/day and can accumulate in specific sites to ~50 cm/yr. Subsidence volumes reach values as high as 28 m3/day and the cumulative estimated subsidence volume in the 21 examined sites exceeds 37000 m3/yr. Regardless of the site response to floods, dramatic increase in subsidence rates was observed over a decadal time-scale and an annual increase in the cumulative subsidence was observed in most of the study sites across the 3-year study period. In addition, several sites display eastward migration of the subsidence zone at rates of 10-100 m/yr.

Methane bubble propagation within muddy aquatic sediments under different ambient methane concentration profiles

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Understanding of mechanics of bubble propagation within aquatic sediment is crucial for estimation of the amount of methane reaching the sediment-water interface and being released into the atmosphere. Previous models show that bubbles propagation within fine-grained muddy aquatic sediments can be described using principles of linear elastic fracture mechanics, while initial rise of the bubble starts once its longest axis reaches a critical length, determined in turn by the fracture toughness of the sediments. Mass transfer between the bubble rising with high velocity and the surrounding sediments was ignored in the preceding studies. In this paper we show that under the variable source strength profile, associated with bio-chemical processes of methane production and consumption within the sediment, as it accurse in nature, changes in the dissolved methane concentrations strongly affect bubble growth and rise, sometimes leading to its retardation below sediment-water interface. Therefore, mass transfer between the rising bubble and its surrounding can't be ignored.

Optically stimulated luminescence (OSL) dating and ancient mining technologies of Timna valley, Israel: New insights from the central Timna valley project phase I

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Timna Valley, Israel was an important source of copper ore in antiquity, and as such served as the location for the pioneering research into the archaeometallurgy and mining archaeology of the ancient near east. In this study we addressed a fundamental issue in mining archaeology, the lack of dateable material (artifacts or organic remains). As part of the Central Timna Valley (CTV) Project Phase I, we systematically investigated the two basic types of mines identified in the Timna Valley by the Arava Expedition of Beno Rothenberg: open-pit (placer) mines (represented by Merkavot 1 of the CTV) and the 'plate-like' shaft mines (represented by Merkavot 2 of the CTV). The results of our excavations confirm Rothenberg's typology and provide new insights regarding mining technology and post-depositional processes, including the important observations of reuse of mining technologies in later periods and deliberate filling of the 'plate-like' shaft mines by the miners as part of the mining process. Furthermore, to address the long-standing question regarding the chronology of the mines, we applied Optically Stimulated Luminescence (OSL) dating to the fine quartz grains of the mine fills and tailings. Together with preliminary results of previous research in the Faynan copper ore district (Ben-Yosef et al. 2014), we demonstrate the potential of this method to provide age constraints on ancient mining activities, and discuss the evolution of mining technologies in the region.

Geodynamics of the Radon system at the Inter-University-Institute (IUI) site, Elat

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A strong radon anomaly occurs at IUI, located on the shore of Elat and situated next the western boundary fault of the Elat sector of the Gulf of Aqaba. Radon at IUI shows systematic variations composed of periodic Daily Radon (DR) and Annual Radon (AR) signals, and of non-periodic Multi Day (MD) signals. Exceptionally high levels of radon and very large temporal variations occur in seawater of the shore gravel, at a depths 2 and 3 meters. Gamma spectrometry in the hole confirms that the detected variation is due to radon in the seawater. Similar variations occur in the open sea at 3 meters below sea level and at sea bottom in a water depth of 30 meters. The radon level in the seawater is not supported by radium in the water, indicating a sub seawater influx. In addition, a peculiar high anomaly of radon variation is observed in lowermost atmosphere above the IUI facility. The patterns of the variation of the DR and MD signals in the sub-shore seawater, in the seawater and in the lowermost atmosphere have similar characteristics. Spectral analysis shows that the diurnal frequency band is dominated by constituents indicative of gravity-tidal influence (indicator - M2 constituent of 1.93 CPD). This feature is in sharp contrast with the extensive experience on the DR signal at on-land geological sites and in simulation experiments using the Enhanced Confined Mode (ECM) configuration, all of which lack the M2 component. At this stage it is not known whether the diurnal tidal forcing of the radon at IUI is due to the effect of change in the sea level, sea tide forcing of the sub-sea system or local solid earth tide. As far as known a gravity component cannot be generated in radon in air. The observations at IUI are the first of radon signals at the interface of marine, shore and atmospheric environments.

Unravelling the controls and especially the dynamics of the unique radon system at IUI relate to understanding of: a) The nature of the large radon flux along the major western active boundary fault of the Elat deep, indicative of an unexplored geodynamic potential; b) Clarifying the nature of the tidal components in the DR signal is central to the understanding of the processes involved – sea level, sea tide, or solid earth tide; This will help constrain the driver(s) of other radon signals which may be reflecting geodynamic transients (MD signals); C) Comparison with signal patterns in the on-land geological environment and experimental simulations should contribute to the understanding of the overall frame governing the variation of radon; D) Setting the ground for extending research of radon at sea bottom locations in the Gulf of Aqaba.

Numerical thermomechanical model for prediction of future tectonic developments in Levant and Phoenician Basins

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Prediction of the geodynamic evolution of the Eastern Mediterranean is complex. This is due to the variable nature and rheology of interacting lithospheres and the sparse data regarding 3D slab geometry and related mantle flow. In order to predict the temporal evolution of this dynamics, the present-day kinematics was considered. In this study, the Levant and Phoenician basins were examined, where a long-lived subduction zone has been active since the Mesozoic. In this region, tomographic models showing low-velocity anomaly beneath Anatolia indicate that the Tethyan active margin is notably characterized by successive subductions of oceanic and continental ribbons, slab retreat episodes and possible slab tearing processes. Using high-resolution 3D thermo-mechanical numerical modeling, a complex model of the Eratosthenes-Cyprus collision zone and its adjacent slabs was produced and used to infer the prospect of possible future developments. Numerical experiments were performed using the I3ELVIS code, considering non-newtonian visco-plastic rheologies. Partial melting and melt extraction processes were integrated as well as fluid and melt transport mechanism. The initiation of a new subduction zone along the boundaries of the basins was observed, which absorbs the strain of the collision zone. Lack of internal deformation of the slabs and a great dependence upon the angle of subduction along the Cyprian arc was found. Final results of this study will determine the relations between possible mechanisms for the release of collision-related strain such as subduction initiation, subduction trench advancement and erosion of the colliding plate to resume subduction.

Geochemical and hydrological processes in the coastal area of the Dead Sea, Einot Tzukim area – preliminary observations

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The Dead Sea (DS) area is actively undergoing changes due to its rapidly decreasing water level. The land surface, which was previously covered by DS brine is now exposed to geochemical and hydrological processes that include: (a) the creation of a new coastal aquifer; (b) a decrease in groundwater level; (c), changes in the fresh-saline water interface; (d) rapid flushing of the original DS brine by relatively fresh groundwater; and (e) salts accumulation in the upper part of the sediment profile. The purpose of this research is to understand and estimate the rates of these processes.

Boreholes were drilled to depths of up to 3 m at the vadose zone at distances of up to 1 km from the current shoreline (at the shorelines of 1991, 1999, 2008). At the 1999 shoreline we drilled both in winter and summer to observe the seasonal effect on the sediment profile. In-situ sediment temperature was recorded and samples were taken for moisture content measurements and chemical and isotopic analysis, at high resolution.

Water extraction was performed by two methods: (a) directly with a 25 ton hydraulic press; and (b) by adding 30 gr DI water to 5 gr sediment sample and then spinning in a centrifuge. The pore water composition at 3 m depth at the 2008 and 1999 shorelines were similar to the present day DS brine. The concentration of relatively conservative ions rises from 1m depth to the surface (e.g Mg^{2+} rise from 3.8 eq/L to 7.5 eq/L; compare to 3.6 eq/L the DS) as a result of evaporation. On the other hand, Na^+ ion decreases as a result of halite precipitation. In the western most borehole, 990 meters from the current DS shoreline, low ions concentration are found, similar to concentrations at Einot Tzukim springs. This was expected since this borehole is closest to the springs. We also observed negative values (-5.5‰) of $\delta^{18}O$ at the bottom of this borehole (similar to the fresh water springs in the area), and a maximum of $\delta^{18}O$ (+0.6‰) at a depth of 0.55 meters, which is the depth of the evaporation front. The zone of this front is where steady-state between two processes is achieved: evaporation and exchange with ambient atmospheric vapor. The isotopic profile obtained in boreholes at shoreline 1999 and 2008 shows positive values on the lower part of the profile, which are similar to DS, and extremely negative values (-17‰) on the uppermost part of the profile. These extreme negative values are explained

by re-equilibration with vapor. To test this explanation, a vapor adsorption experiment was conducted. In the experiment, sediments were dried in an oven for a period of 48 h after which they were exposed to the atmosphere on the D S shore. Within two weeks, the δ18O values of the pore water approach -17‰, indicating that vapor absorption is indeed the main process controlling the observed δ18O values.

Decade-long imprint of sewage sludge on live benthic foraminiferal assemblages off the Mediterranean coast of Israel

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The largest point source of nutrient introduction into the ultra-oligotrophic Israeli shoreline is the sewage sludge outlet of the Shafdan Wastewater Treatment Plant, at ca. 36 m water depth off Palmachim. A detailed study in the years 2003-04 tracked the response of live benthic foraminiferal assemblages to organic overload input, dispersion of the sludge and aeration of the sea floor, at sub-seasonal time-scales. By revisiting this site ~10 years later, the longer term environmental impact can be assessed.

Numbers of live foraminifera were depleted by an order of magnitude, although seasonal patterns remain. The abundance of the most dominant species, A. tepida, decreased dramatically. However, numerous new species were present. The year of 2012 was comparatively stormy with a strong current regime all year, and this aeration was reflected in much lower TOC and Chl a concentrations compared to 2003-4.

The reduced foraminiferal abundance demonstrates cumulative long-term damage attributable to the ongoing discharge of sewage sludge. On the other hand, improvement in all diversity measures is a strong signal for recovery potential in the outlet area.

Selective responses of benthic foraminifera to thermal pollution

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Predictions of future climate and recent observations point towards a trend of rising temperatures in the Middle East region. The temperature rise propagates into the marine environment, with shallow, coastal ecosystems being most affected. An ideal model system to study the effect of increased temperatures in coastal ecosystems is presented by benthic foraminifera. The persistent of thermohaline pollution at a site along the northern coast of Israel, attributed to a power and desalination plant, is used as a natural laboratory to evaluate the effects of rising temperature and salinity on benthic foraminifera living in shallow hard bottom habitats.
Biomonitoring of the disturbed area and a control station shows that elevated temperature is a more significant stressor than salinity. The deleterious effect of extreme temperatures is indicated by decrease in numerical abundances and reduced species richness, eventually leading to substantial changes in community composition. Critical temperature thresholds were observed at 30˚C and 35˚C, the latter observed by the most thermally tolerant species Pararotalia calcariformata, the only symbiont bearing species observed within the heated area. Common species of the shallow hard bottom habitats are almost absent from the most extreme site indicating that they presently live very close to their upper temperature threshold, and that excess warming will likely impede their future survival in the Eastern Mediterranean. Several of these species are either proven or suspected to be tropical Lessepsian. Thus, considering present models of expected north-western future expansion of Lessepsian species in the Mediterranean, our study show that it is important to consider excess warming as a major stressor that will limit their distribution.

Developing the resource characteristics of the Kishon mid-reach multi-commodity alluvial placer: Recent progress in

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Although Shefa Yamim's exploration programme for "precious stones" in northern Israel had an unconventional beginning, the results from the systematic prospecting campaigns in the Kishon catchment and on Mount Carmel led to a "Source to Sink" geological model that guides their current and future exploration activities (Toledo et al., 2014).

The highest priority exploration target identified in Shefa Yamim's "Source to Sink" model is the 4.5km long, Kishon Valley Mid-Reach, transient fluvial placer hosted in accessible palaeo-Kishon basal gravels preserved in low terraces flanking the modern course between Tel Kashish and Jalame Junction (Toledo et al., 2015). This multi-commodity placer contains the target mineral assemblage (TMA) of diamond (D), moissanite (M) and the corundum gem varieties (C) of sapphire and ruby (the DMC suite) and the heavy industrial minerals (the HIM suite) of non-gem corundum (NGC), zircon, rutile, ilmenite and garnet (Toledo et al., 2015). We report here the progress on advancing this placer from an exploration target towards a resource that has a minimum inferred category of confidence (sensu SAMREC Code, 2009).

From the mapping and drilling campaigns to date (133 holes, 313m), two high-interest zones have been modelled volumetrically using ArcGIS, Voxler®4, Strater®4 and Surfer®12 software. Zone 1 covers an area of some 140,000m2 hosting 240,000m3 of basal gravels with an overburden volume of 360,000m3.
Zone 2 spans an area of 365,000m2 containing some 514,000m3 of basal gravels with an overburden volume of 350,000m3.
Following the earlier small-scale trenching exercises (20 excavations), four discrete bulk sample trenches in Zone 1 were excavated to give 400-600 tonnes of basal gravels per sample that are processed at the Shefa Yamim treatment facility in Akko (bottom screen size is 1mm). To date, only Sample 1124 has been completed, yielding 1,431.59 carats of TMA (excluding diamond which was not found) from 400 tonnes of basal gravels to give an overall grade of 358 carats per hundred tonnes (cpht). The HIM suite made up 98% of the total carats and the gem DMC suite 2%. The HIM

suite comprised NGC (69%; maximum size = 23.4 carats), garnet (24%; maximum size = 8.19 carats), ilmenite (4%), zircon (0.2%) and rutile (0.1%). The DMC suite was dominated by sapphire (85%; maximum stone = 3.33 carats), followed by moissanit (12%; maximum length 4.14 mm) and ruby (3%).

The results from Sample 1124 will be combined with those from the remaining three bulk samples (1174, 1175 and 1125) to develop an estimate of the resource potential of Zone 1 in the Kishon Mid-Reach multi-commodity alluvial placer.

The first deployment of sediment traps in the Gulf of Aqaba: a new time series of export production and biogeochemical cycling of marine particulates

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Export production, or the flux of particulate organic carbon produced by plankton in the upper ocean that escapes to deeper waters, is an important component of the global carbon cycle and a primary source of nutrients for biological communities in the deep ocean. Knowledge of real time dynamics between dust input, primary production, and export production in deep oligotrophic waters is extremely poor, and suffers from very limited real-time observational support, especially in the context of the direct response and lag time between nutrient supply (e.g., dust), the oceanic biogeochemical response and the signal transfer from the water to sedimentary record. Here, we report on the first direct measurment of bulk and export production fluxes in the Gulf of Aqaba (GOA), north Red Sea, based on a new deployment of sediment traps. A vertical mooring mounted with 5 sediment trap stations (KC Denmark Inc.) at approximately equal intervals between 120 and 570 meters (at a ~600 m water depth), was deployed at January 2014 and sampled at a monthly resolution. Additionally, a time series sediment trap (PARFLUX-II, McLane Labs Inc.), containing 21 automatically rotating sampling bottles has collected daily to bi-daily resolution samples at a water depth of ~400 m since April 2014. This coupled configuration allows for a unique collection of marine particles, whereby the annual and seasonal patterns can be evaluated in the context of discrete events such as abrupt dust storms, floods and biological blooms. These short events are otherwise undocumented in the GOA marine environment, nor in other comparable marine environments.

In this talk we will describe the logistical and technical details of the campaign, present preliminary results and discuss their application in the context of improving our understanding of the interplay between terrigenous fluxes, marine biogeochemical cycles, and the interpretation of the paleo-record.

A 470 year record of anthropogenic activity in the Gulf of Aqaba from Pb isotopes in marine sediments

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Human activity during modern times has induced a significant increase in the concentrations of metals in atmospheric dust, the oceans, surface sediments and freshwater bodies. The onset of the industrial revolution during the 19th century is reflectd in many geological archives by a significant increase in the the content of trace metals and a shift in their isotopic composition. In particular, lead (Pb) concentrations and isotopes are robust tracers of industrial activity that involves fossil fuel burining. Yet the impact of global use of fossil fuels is not necessarily synchronous world wide, particularily in distant regions where little or no indsutries existed until several tens of years ago.

Here, we present a study of anthropogenic contamination from a sediment core in the Gulf of Aqaba, (GOA) north Red Sea. The ~40 cm thick core provides a continuous record at a decadal–timescale resolution of anthropogenic contamination of the GOA over the last ~470 years. Pb concentrations display a gradual increase from their pre-19th century values (~18 ppm) through the 19th and 20th centuries to their modern values ca. 25 ppm. This increase however is only partially related to anthropogenic fossil fuel contamination, because of a corresponding shift in the mineralogy of the sediments from a carbonate- to a clay- dominated lithology, reflecting an overall shift in the climatic-oceanographic configuration of the Gulf of Aqaba. Indeed, the Pb isotopic composition remains within the range of natural values up until approximately 1950, when industrial activity became significant with the building of the ports of Eilat and Aqaba. These, together with the subsequent building of a commercial oil pipeline in Eilat and extensive industrial development, resulted in an abrupt change in 206Pb/204Pb, 207Pb/204Pb, and 208Pb/204Pb ca. 1950, from baseline values of ~19.5, 15.7, and 39.15, respectively, that continued until a temporal minima was reached ca. 1990, when Israel transferred to using unleaded gas.

Thus, human activities are clearly recorded in the geological archives of the GOA, and can be quantified in terms of timing and magnitude, based on Pb concentrations and isotopic compositions. These preliminary results suggest that further investigation of the impact of human activities in the fragile ecosystem of the GOA (e.g., coral reefs) should be performed in atmospheric dust, seawater, sediments and the biosystem.

Thermal evolution of the Negev (Red Sea rift margin) during the last 150 Ma: low-temperature thermochronology of deep boreholes and igneous outcrops

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Lying at the margin of the Red Sea rift and the Dead Sea transform and at the locus of intense Late Cretaceous regional folding - the exhumation, uplift and cooling record of the Negev (southern Israel) may hold answers to the timing, rates and mechanisms of major tectonic events including the closure of the neo-Tethys ocean and the associated evolution of the Syrian Arc fold structures, continental rifting along the Red Sea, regional Oligo-Miocene denudation phase and the development of the Dead Sea transform.

We utilize low-temperature thermochronology to examine the cooling history of the Negev during the last ~150 Ma as reflected in apatite (U-Th)/He (AHe) ages of 63 samples collected from deep boreholes and Early Cretaceous igneous outcrops. Since the maximum exhumation depth across the Negev during the last 150 Ma rarely exceeds ~1.5 km, the apatite He system is an ideal thermochronometer for this setting.

Samples from 6 deep boreholes reaching depths of up to ~3.5 km and penetrating a Neoproterozoic stratigraphic sequence (Zenifim Formation) at their base were dated. Apatite (U-Th)/He ages (~200 dated grains) decrease from ~105 Ma for igneous outcrops within Makhtesh Ramon to <3 Ma at a depth of 3-3.5 km where current borehole temperatures are ~80-95°C. Previously published apatite fission track (AFT) ages from the same boreholes decrease from ~122 Ma to ~32 Ma. All the fission track ages are older than the corresponding apatite (U-Th)/He ages. The AHe ages of lower Cretaceous intrusions in the Ramon area are similar to their AFT and emplacement ages suggesting rapid post emplacement cooling and a limited total overburden ever since.

Simultaneous inverse thermal modeling of Ramon 1 borehole AHe and AFT multi-sample age profile delineates peak burial temperatures at ~130 Ma followed by cooling of >60°C ever since. These results constrain the paleo-thermal gradients to >30°C/km at 135-120 Ma, and <25°C/km over the last ~40 Ma. Over the entire ~130 Ma period thermal gradients have decreased by >10 °C/km. In addition, the deepest samples (currently held at 70-96°C) seem to require moderate heating over the last several Ma.

The observed t-T paths can be attributed to a lower Cretaceous crustal scale-thermal perturbation associated with magmatic activity which might be related to the Levant-Darfur hotspot, followed by thermal relaxation over a ~10-30 Ma long period. Surprisingly, the effects of intra-continental deformation associated with growth of monoclines (Syrian Arc folds system) and the regional Oligo-Miocene denudation phase are less prominent.

A wetland that became a desert: Dynamic depositional environments in the southern Kalahari

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The ca. 140 Ma vast Kalahari basin is characterized by uplifted margins, terrestrial sedimentation within a semi endorheic basin, subdued morphology and relatively interpretable stratigraphy. This cratonic basin has been subjected to prolonged period of subsidence affecting its sedimentary fill by changing 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.

Inquiry into southern Kalahari Group succession in Mamatwan reveals three main depositional environments; a bottom lacustrine, low-energy water body, a middle fluvial, high-energy environment and an upper aeolian sandy unit. With exception of the surface sand, the section is cemented with calcretes that were U-series dated to the mid-Pleistocene. The entire section, which was deposited within the Quaternary, records significant environmental and depositional changes.

The fully exposed section (55 m) of the Kalahari Group at Mamatwan mine was analysed for its elemental composition. Redox sensitive indicators imply that alternating oxidizing and reducing conditions occurred in the water body, suggesting deposition in distal-end alluvial fan surroundings. Fine sediments fraction throughout the section mainly assembled from ferromagnesian minerals sourced at a mafic province. The upper third part of the section consist of a more aluminosilicate minerals, concentrated mainly in the coarse fraction and point to a more felsic source supply, perhaps as response to enhanced aeolian transport.

Results indicate that a significantly less arid than presently environment existed during early to mid-Pleistocene in the southern Kalahari, contemporaneous with hominines developing and expanding.

Hydrological – geochemical processes in the En Qedem hydrothermal-saline springs, western Dead Sea

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The En Qedem (EQ) hydrothermal saline spring system that emerge on the west shore of the Dead Sea (DS), affect the composition of the near shore groundwater and the DS. The solution comprising a Ca-chloride brine is characterized by half of the DS salinity (<190 g·L-1 compared to 340 g·L-1), and maximum temperatures of 46°C, discharge from the alluvial aquifer along the western DS shore. Assuming a geothermal gradient of 19°C/km, the EQ solution ascends rapidly from a depth of at least 950 m.

The discharge of numerous springs from the EQ system has been measured annually since 2005 by the Hydrological Service. The measurements show that the springs migrate eastward together with the coastline as the DS level declines. The discharge rate of the EQ spring system over the years is 8-13 MCM·y-1 with rather small fluctuations and no obvious correlation with the annual rate of DS level decline. Some correlation that required verification was found with the amount of annual rain in the Judea Mountains.

The chemical composition of EQ brine remained almost constant during the last 40 years, suggesting that EQ brine is derived from a very large aquifer. Apparently the EQ brines do not mix with other groundwaters except at very shallow depths, where they may mix with fresh groundwater (En Gedi) or DS brine. Previous work suggested that EQ brines are relics of a large surface water reservoir, possibly the epilimnion of last glacial Lake Lisan that infiltrated the geological section during high stands (~ 30-18 ka BP).

The EQ brines are slightly undersaturated with respect to halite and gypsum. In few cases the brine's Na/Cl and SO4/Ca ionic ratios indicate that halite and gypsum dissolved in the subsurface.

The Holocene sedimentary section exposed at the EQ shores show rather unique concentric bodies comprising gypsum and aragonite laminae alterations that are not common in other exposed section of the Holocene Ze'elim Fm. These deposits, which are not known to be produced today, cannot be explained by simple mixing between the modern DS and the contemporary spring composition. The mechanism and environment of deposition of these concentric bodies, as well as of the thick gypsum sections that were preliminary studied before, and their relationship to regional paleo-hydrology are open questions that will be studied in this research

Looking for buried treasures – detection of ancient underground mine galleries with seismic methods

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Timna valley in southern Israel was an important source of copper in antiquity, with evidence of mining activity as early as the 5th millennium BCE. The most common mines in the valley were vertical shafts and galleries (tunnels) dug into the copper bearing layer of the Lower Cretaceous sandstone. The ancient miners dug shafts to reach the ore, and these are now visible as circular shallow depressions embedded in the desert pavement ("plates"). Thousands of such depressions are located along the circumference of the Timna Valley, representing prospection and mining activity: only in cases a shaft reached ore, a system of galleries was developed, following the veins of copper minerals. As the galleries are hidden underground, it is impossible to estimate the depth of the galleries and their structure, as well as the ratio between prospection (=failed) and mining (=successful) shafts. This information is important for evaluating the amount of copper produced, the productivity of the mining activity, technological aspects of constructing a mine, and other factors related to ancient exploitation of copper in the region.

In an attempt to better understand the underground system of mining galleries, we conducted several shallow seismic lines in two main localities (near the "Merkavot" Site). Our aim was to locate the existence of connecting galleries between shafts (= surface depressions). We assume that any open or even partially filled gallery would create a source of diffracted seismic energy. We therefore used a method called "diffraction imaging", which is based on integrating seismic energy along constant velocity paths to generate a diffracted energy image. In one site the image revealed a strong underground diffraction source 7-8m below the surface, and this source may be an open gallery connecting between two filled shafts. If this observation is verified in future excavation, the method presented here could be used to better understand ancient copper exploitation in Timna and beyond.

Coseismic horizontal slip revealed by sheared clastic dikes in the Dead Sea basin

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Despite the hazard caused by near-surface destructive horizontal displacements during earthquakes, field evidence for coseismic slip along horizontal discontinuities is exceptionally rare, mainly due to the lack of adequate exposure and markers. However, within the seismically active Dead Sea basin, the Late Pleistocene Lisan Formation contains vertical clastic dikes at maximum depth of 15 m that are sheared laterally and thereby provide unique profiles of such horizontal displacement. In order to investigate how coseismic horizontal shearing is distributed near the surface, we document a ~1 m thick brittle shear zone, comprising up to eleven slip surfaces that can be traced for tens of meters in the Lisan Formation. Displacements along individual slip surfaces are up to 0.5 m and the total displacement across the shear zone is up to 2 m. Displacement profiles and gradients indicate that the brittle shear zone formed by simple shear, and deformation was associated with slip partitioning and transfer between primary and secondary slip surfaces. Evidence for concurrent displacement along slip surfaces during a single event indicates that the brittle shear zone was formed during a coseismic event post 30 ka. We consider the mechanical effect of seismic-wave related transient stress, which when added to the initial static effective stress, may result in concurrent horizontal shear failure along detrital-rich layers in the Lisan Formation. The exceptional quality of exposures and markers enables us to document for the first time, the details of near-surface horizontal shearing, and indicates that displacement along horizontal bedding planes is a viable mechanism to absorb coseismic deformation in well-bedded near surface strata.

Rock slopes in hyper-arid regions – how do they erode? New insights supported by LIDAR spatial analyses

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Tectonic and climatic stable environments, along with slow chemical and physical processes, are expected to contribute to stable landscapes in hyper-arid areas. Yet, evidence show that in such environments, which are also characterized by sparse vegetation, rock slopes are undergoing large magnitude erosional processes. While transport-limited processes have been proposed as the driving mechanism for rock-slope evolution, under the existing stratigraphic column, their contribution could not explain dynamics that such entities undergo in these environments. We identify weathering processes as the main contributor to rock slope instability, and propose a new model describing the evolution as consequence of transport and weathering cycles. We also explain the morphologies and spatial distribution of weathering forms which vary dramatically even on a single slope and on an individual lithology.

Our model is complemented by quantitative slope-scale analysis of high-resolution 3-D laser-scanning data. The derived observations allow us to contradict common assumptions that link environmental parameters (e.g., slope aspect or valley type) and reveal the actual factors governing spatial appearance of both micro and macro weathering features.

Technological innovations and socio-political dynamics in the Timna Valley during times of large scale copper production (ca. 3000 BP)

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The first stage of the Central Timna Valley (CTV) Project, directed by Dr. Erez Ben-Yosef, focuses on the main copper smelting sites of Timna. As demonstrated recently, most of these sites should be dated to the Iron Age (Ben-Yosef et al., 2012, contra Rothenberg's Late Bronze Age chronology); however, earlier, New Kingdom Egyptian interest in local copper exploitation is clearly attested mainly by the Egyptian temple at Timna. This research attempts to identify and characterize the copper smelting technologies of the ''missing'' Late-Bronze Age (14th-12th c. BCE), and to link it with the technologies of the consecutive Iron Age (11th-9th c. B.C.E). With the use of high precision 14C dating, we were able to date some smelting contexts in the Timna Valley to the Late-Bronze Age. This was followed by chemical analyses of slag (using ICP-MS and EDS), and the reconstruction of technological aspects (e.g. efficiency, standardization, fluxing materials and more). By comparing Late Bronze to Iron Age technologies, we are able to identify technological evolution between the periods and gain several important insights on the socio-political dynamics of the societies at the southern Arabah before, during and following the transition between the Late Bronze and Iron Ages.

Investigation of the ground-motion variability associated with site response for sites with VS30 over 500 m/s

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Understanding and reducing uncertainties in ground-motion prediction are high priorities for seismic-hazard analysis. This project examines φs2s, the variability in synthetic ground motions at rock sites caused by the variability in randomly generated velocity profiles of the geological column from 5 km depth to the surface. Only sites with VS30 (the time averaged shear wave velocity of the upper 30 meters of the geological profile) of 500 m/s or higher are considered, and linearity is assumed.

These synthetic estimates of the mean value of φs2s are a complicated but understandable function of magnitude, period, and VS30. The distribution of modeled residual response spectral amplitudes at several oscillator periods is not lognormal, but the deviations are in the central part of the distribution, in which the effect on probabilistic seismic-hazard analysis may not be very large. Adding another constraint to the velocity profile, namely that the shear-wave velocity of the uppermost layer should be at least 70% of VS30, greatly reduces the uncertainty at high frequencies. We tentatively identify sites with this property as non-resonant rock, because it excludes sites with a strong resonance in a thin shallow layer. The reduction in uncertainty that this allows might reduce or eliminate the contradiction between the U.S. National Seismic Hazard Map and precarious rocks in southern California.

Empirical estimate of resonance frequency of the Dead Sea basin - a pilot experiment

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In this pilot research we analyzed observed ground motions in the Dead Sea Basin (DSB) from teleseismic earthquakes with magnitude larger than 6.5 at distances of 4,500-16,000 km. The data were obtained by Dead Sea Integrated Researches (DESIRE) project that aimed in studying the Dead Sea basin (DSB) and its outskirts, and DESERT2000 project aimed in studying the Dead Sea Fault. We selected 21 teleseismic events from DESIRE project and 18 teleseismic events from DESERT2000. These events are used as "input" to DSB.
We used two methods for determination of fundamental resonant frequencies of DSB: 1) ratio between the Fourier spectra of seismograms recorded on site and the spectra of seismograms recorded at a reference site; 2) horizontal-to-vertical S-wave spectral ratio. All teleseisms exhibit clear peaks at fundamental frequencies in the stations located in the Dead Sea basin. We identified three segments with fundamental frequencies: first segment with length of 16 km and 0.1 Hz, second segment with length of 9 km and 0.2 Hz, and third segment with length of 20 km and 0.1 Hz, all with amplification factors of 2 to 5. Ten reference stations have been installed on rock, at distances of 2-10 km away from the basin. These stations recorded vibrations in the range of 0.1-0.5 Hz, generated in the Dead Sea basin. We did not find locally-induced surface waves causing lengthening of the significant shaking duration and strong low-frequency amplification. The absence of basin effect can be explained by the large linear dimensions of DSB, its shape, and the relatively high velocity of shear waves that varies with depth from 800 m/sec to 3200 m/sec. These parameters do not support the excitation of basin-edge induced waves.
A stochastic optimization algorithm is applied to calculate the velocity of layers, yielding 1-D transfer function to optimally match the observed H/V curves considering all resonance peaks.

Messinian incision in the Be'er Sheva Canyon- A new route through the Hazerim channel

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The ~1000 m apparent Messinian incision into the Afiq submarine canyon across the coastal plain of Israel contradicts the lack of any contemporaneous incision in the eastern inland part of this canyon in the Be'er Sheva valley. This enigma remained an open question since the first studies in this valley about 50 years ago. We studied old and new drill holes distributed between Aro'er area in the east and the coastal plain in the west. Synthesis of subsurface data with new nanoplankton analysis discovered a subsurface buried Messinian channel extended as east as Nevatim area, and filled by marine sandy Pliocene sediments.

Between Nevatim and Be'er Sheva, the route of this Messinian channel follows the southern margins of the buried Middle Miocene canyon. However, east to Be'er Sheva it diverts to the south-west and incises into the rocks of the Early Eocene Adulam Fm. that builds the landscape south of the Be'er Sheva City. Near Hazerim this valley turns to the north, where it follows a branch of the older canyon (the Hazerim Channel), and then joins with the main route of the older canyon west of Be'er Sheva. The depth of the Messinian channel within the Late Miocene sediment increases from 60 m near Nevatim to more than 70 m near Hazerim.

The new valley between Be'er Sheva and Hazerim is presently occupied by Nahal (ephemeral stream) Be'er Sheva, but it does not follow the Hazerim channel and continues to the SW toward Nahal Besor.

The Messinian canyon and the relief that its tributaries formed throughout the Be'er Sheva valley were flooded by the Zanclean (Early Pliocene) transgression, which created an estuary that extended to the east of Nevatim. The Messinian relief in the Be'er Sheva Valley was completely buried under the extensive cover of the Pliocene sandy Pleshet Fm.

The Pelagonian terrane in Greece: a piece of peri-Gondwanan mosaic of the Eastern Mediterranean and a new piece of information about the geological evolution of Avalonia

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The North-East Mediterranean region is a crustal mosaic comprised of proximal (Cadomian) and exotic (Avalonian) peri-Gondwanan terranes that were accreted to the European margin and repeatedly reshaped during several orogenic events, including Caledonian, Variscan and Alpine. The Pelagonian terrane in Greece is the peri-Gondwanan terrane of the Avalonian affinity: the properties of its >700 Ma-aged "Proto-Pelagonian" basement are attesting its peri-Amazonian origin.

Here we report the data obtained on the Late Ediacaran to Early Mesozoic Pelagonian rock section, using U-Pb-Hf isotope geochemistry, and supported by structural and lithological observations. These data helps (1) to discriminate between similarly looking stratigraphic layers, to compare them with their Avalonian correlatives and clarify the tectono-stratigraphic structure of the Pelagonian basement, and (2) following the manner that the provenance changed in time with, to gain the valuable insights regarding a trajectory of this terrane made from its original location towards the current position and restore its geological history.

The new data show that the Late Ediacaran Pelagonian metasedimentary sequence yields mainly magmatic ages between 750-560 Ma with Hf-TDM ages of 1.0-1.4 Ga, indicating the detrital transport exclusively from the insular at that time, Avalonian microcontinent. This data are well correlated with the correspondent Avalonian sequences from the Atlantic Canada and British Midlands. According to the previous studies, Avalonia approached the North African periphery of Gondwana at the Middle Cambrian for a short (ca. 30 Ma) stopover, recorded by a detrital influx of the North African affinity. Tectonic slivering of the Avalonian microcontinent began even earlier; transtensional movements distributed Avalonian sliver-terranes along the Gondwanan margin.

It is generally suggested that Avalonian terranes were detached from Gondwana by the Rheic Ocean opening in the Early Ordovician, orthogonally moved across the Iapetus Ocean and accreted to the European margin in course of the Caledonian orogeny, while the Cadomian terranes have detached and accreted later, during the Variscan convergence. Despite this, in the

Eastern Mediterranean the Caledonian ages were reported mainly from the Cadomian-type terranes. It may indicate that some Cadomian-type terranes included in the continental ribbon that collided on the Caledonian front. The tectonic position of the Pelagonian terrane, tectonically emplaced in between the Cadomian-type terranes, indirectly supports this idea. However, the post-Caledonian Pelagonian strata displays no Caledonian zircon ages, but the gap between 520 and 350 Ma. This data suggest that the Pelagonian terrane wasn't involved into the Caledonian orogeny, but had remained adjacent to Gondwana or insular within the Rheic Ocean until the Variscan convergence. The voluminous Variscan granites from the Pelagonian record the typical for the Avalonian crust εHf values, indicating the upper-plate position for the Pelagonian terrane at that time.