Abstracts

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Kfar Blum

חוברת תקצירים

Abstracts

עורך: שלומי ויינר

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החברה הגיאולוגית הישראלית מודה למוסדות ולגופים הבאים על תמיכתם ותרומתם לכנס השנתי בכפר בלום 2019:

- משרד האנרגיה
- המכון למדעי כדור הארץ, האוניברסיטה העברית
- בית הספר למדעי הים ע"ש ליאון צ'רני, אוניברסיטת חיפה
- המכון הגיאולוגי לישראל
- המחלקה למדעי הגיאולוגיה והסביבה, אוניברסיטת בן גוריון בנגב
- המחלקה לגיאופיזיקה ומדעים אטמוספריים ופלנטריים, אוניברסיטת תל-אביב
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- המכון הגיאופיסי לישראל

חברי ועד החברה הגיאולוגית הישראלית לשנת 2018-2019

זהר גבירצמן - נשיא

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A probe from the North Gondwana lower crust: Neoproterozoic sediment subduction and Syn-Variscan magmatism and metamorphism documented by zircons in mafic granulite xenoliths from the Lower Galilee

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The basement of North Gondwana and its transition towards the Peri-Gondwana Cadomian domain in Israel is sealed by a thick sedimentary cover and inaccessible. To study the geologic and thermal history of the lower crust of the North Gondwana edge we examined the U-Pb-Hf systematics in zircons from mafic granulite xenoliths, brought to the surface by the Pliocene Cover basalt in Qarnei Hittin (Lower Galilee). The xenoliths are composed of plagioclase + orthopyroxene + clinopyroxene ± amphibole ± garnet ± spinel. Zircon age populations vary between xenolith samples, yet display distinct concentrations at 400-1200 Ma, 170-350 Ma, and 3.6-4.2 Ma, demonstrating the lower crust preserves a prolonged thermal and igneous history. Zircons aged 400-550 Ma are shown to be the result of Pb loss, yet the wide scatter of zircon grains aged 550-1200 Ma, alongside their diverse $\varepsilon Hf_{(t)}$ values (-25 - +10), is an extraordinary evidence for the accretion of Neoproterozoic sediments into the North Gondwana lower crust. The U-Pb-Hf signature of these zircons resembles Cadomian sediments of the Tauride block to the north, indicating southward (present coordinates) subduction under North Gondwana and possible accretion of fore-arc sediments to the lower crust through relamination in the latest Neoproterozoic. One xenolith sample contained only metamorphic-shaped zircons aged 170-350 Ma with positive εHf values and Hf-T_{DM} of 0.85 Ga interpreted to reflect Paleozoic recycling of the Neoproterozoic juvenile Arabian basement, which we consider to form a major component of the lower crust in the region. An overwhelming cluster of Carboniferous zircons concentrating at 305 Ma with exclusively negative εHf values around -6, was retrieved from three xenoliths. Some of these zircons portrayed igneous textures and shape, an evidence for late Carboniferous magmatism affecting the lower crust. The Paleozoic age-Hf composition in our xenoliths is therefore interpreted to result from syn-Variscan recycling of Neoproterozoic sediments in the lower crust, and some degree of melting in an anorogenic environment. Rather than with horizontal plate motions and (Variscan) orogeny, the Carboniferous zircon ages in the xenoliths coincide with significant vertical movements that created continental-scale unconformities and broad (~1000 km) basin-and swell structures known to develop over the entire north Gondwana margin at that time. The Carboniferous-aged zircons in northern Israel lower crustal xenoliths are therefore a unique gauge of the thermal perturbation that accompanied the large-scale mantle dynamics below the then-passive North African

margin of Gondwana, while Variscan orogenic accretion occurred on the Eurasian margin. This North Israel granulite xenolith suite tracks the record of a protracted history of the North Gondwana lower crust from the late Neoproterozoic through to the Pliocene.

Latest Neoproterozoic (ca. 550 Ma) mafic magmatism on the North ANS periphery: New apatite U-Pb constraints from intrusions within the Zenifim Formation (subsurface Israel)

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The Zenifim Formation is a late Neoproterozoic arkose-dominated clastic wedge that overlies the northern outskirts of the Arabian-Nubian Shield (ANS) and topped by the Cambro-Ordovician North Gondwana sandstone package. It is known from several boreholes in Israel and adjacent regions, and is correlated with a number of equivalent exposed outcrops overlying the ANS basement. The deposition of the Zenifim formation is bracketed between the termination of plutonic alkaline magmatism in the North ANS at ca. 580 Ma, and the onset of Cambrian sandstone deposition. Zenifim Formation was affected neither by metamorphism nor by deformation, but is intruded by a number of basic-intermediate igneous bodies that are either confined within the Zenifim section or are truncated by the formation top. Many earlier studies have reported ages of ca. 550-530 Ma from igneous rocks in the North ANS and its vicinity, mostly using the Rb-Sr, K-Ar and Ar-Ar methods. Recent studies using the zircon U-Pb method have limited the magmatism in the North ANS to ca. 580 Ma. Being situated within latest Neoproterozoic sediments, the Zenifim intrusions have the stratigraphic potential to represent a latest Neoproterozoic igneous phase that is mostly unfamiliar in the area. We sampled core fragments from a number of intrusions within the Zenifim Formation and dated samples that contained apatite and/or zircon. Apatite [$Ca_5(PO_4)_3(F,Cl,OH)$] is a U bearing mineral, a common accesory phase in many magmatic rocks. Unlike zircon that is both high in U and low in non-radiogenic (common) Pb, apatite can incorporate a significant amount of common Pb and cannot easily be dated using a single analytical spot on a grain. While zircon is a robust and easily dateable mineral, many rocks either contain only xenocrystic zircons or no zircons at all. Especially in zircon absent igneous rocks, a number of co-genetic apatites can form an isochron on a Terra-Waserburg diagram (given variation in U concentration and common Pb in the analyzed grains) in which the lower intercept will represent the crystallization age, and the upper intercept the composition of common Pb. Apatites from a quartz-porphiry Rhyolite at the base of Makhtesh Qatan-2 borehole produced a U-Pb age of 604±12 Ma, coinciding in age with the concentration of youngest zircons from the same intrusion dated at 598±5 Ma. Apatites from mafic intrusions in the Makhtesh Qatan-2 and Hameishar-1 boreholes produced U-Pb isochron ages of 557±12 and 545±21 Ma respectively. These results define two distinct phases of magmatism within the Zenifim Formation: an early ca.600 Ma phase – probably

related to the widespread post-orogenic ANS plutonic magmatism, and a late ca. 550 Ma phase that coincides with Cadomian magmatism known in the adjacent peri-Gondwana domain.

Mapping Israel's Western Paleo-Shorelines From 3D Seismic Data

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Global glaciation resulted in a sea level drop of ~120m, and westward migration of a few kilometers of Israel's western shoreline twice during the last 140 kyr: at around 140 ka (MIS6), and at 26 ka (MIS2), the last glacial maximum. The sea level changed little for millennia, until deglaciation caused an abrupt rise.

The location of Israel's western shoreline during the last glacial period had been inferred by fitting the global sea-level curve to Mediterranean bathymetry, assuming it has not changed and neglecting flexural isostacy. Accounting for sediments deposited since then, the shoreline is actually buried; direct evidence for its location has not yet, been produced.

In this research we interpret high resolution 3D seismic surveys (in time and depth) and high resolution 2D sparker surveys located west of Israel's western shoreline from Atlit to Tel Aviv in order to map the paleo-contour from the glacial periods. The paleo-contour traverses pinch-out points per the stratigraphic sequence. A paleo-contour found in this manner is likely from one of the glacial peaks and located 14-16 km west of the modern shoreline. This paleo-contour is determined at a depth of ~130m bsl, is buried under up to 45m of sediment (up to 100m water depth), and is compatible with the eustatic sea level of the last glacial periods. If the shoreline dates to the last glacial maximum, the sedimentation rate at the eastern Mediterranean Sea is estimated to be ~0.9-1.7 mm/year.

The interpretation of the seismic volumes was facilitated by Schlumberger's PetrelTM and the interpretation of the 2D seismic lines was facilitated by Emerson E&P (Paradigm). Through the use of unique attributes, such as the "RMS Amplitude", it is possible to highlight changes in the nature of the seismic reflector, or to locate properties not clearly visible in a standard display. Due to changes in the reflector density typical to shorelines, this undersores possible ancient shorelines.

In order to more accurately assess the age of the paleo-contour, future work will include comparing our findings with samples from a geotechnical borehole off the Dor shoreline at a water depth of ~90m. These samples yield sedimentation ages of 14 kyr and 35 kyr at 28.1m and 33.7m (respectively) beneath sea floor. This agrees with the sedimentation rate mentioned above.

Future assessment of additional 3D seismic volumes may enable more extensive mapping of the paleo-contour. Reconstructing ancient shorelines constrains a reliable model, predicting conditions and processes that occurred during sea level lowstands. By assessing the shoreline and comparing with other data, it will be possible to construct a high-resolution model of the Mediterranean Sea level in the late quaternary.

Drivers of C exports in the deep southeastern Levantine basin

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We present the results of 18 month measurements of C export by automated sediment traps in the DeepLev observatory at the southeastern Levant, 50 km west of Haifa, at water depth of 1,500m, together with ^{234}Th profiles along the water column. The latter is used as a proxy for particle scavenging. We show that POC fluxes in the traps, as well as those derived from water column ^{234}Th deficits, are nicely correlated with stream discharge and significant wave height. This suggests that C export in this deep basin is mainly controlled by coastal discharge or shelf resuspension (winter peaks) rather than marine primary production. This is further demonstrated by larger POC fluxes in deep water, by tight correlation of POC with total mass flux and by deep water ^{234}Th deficits.

It is also shown that ^{234}Th deficit data are decoupled from sediment trap flux measurements, with large ^{234}Th deficits not necessarily identified by the traps. It is suggested that the traps capture the larger grain-size fraction, related to terrestrial discharge or large shelf resuspension, while the ^{234}Th method preferentially represents the finer grain size fraction, possibly related to dust deposition and primary production, wave resuspension or deep/intermediate water formation.

A 10-fold decline in the deep Eastern Mediterranean thermohaline overturning circulation during the last interglacial

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Present-day Mediterranean deep-waters are well oxygenated, but the episodic formation of organic-carbon rich sediments (sapropels) during solar insolation maxima indicates that this pattern was periodically perturbed in the past. Both high organic-carbon export productivity and disruption of the thermohaline circulation, leading to reduced deep-water ventilation, have been proposed to account for oxygen-depleted waters and sapropel deposition. The last interglacial sapropel S5 (128-121 ka) is considered one of the most strongly developed. Here, we apply the redox-sensitive Mo and U elemental and stable isotope systems to quantify the intensity of anoxic deep-water conditions in the Eastern Mediterranean Sea from Ocean Drill Project (ODP) core 967 (2550 mbsl), located south of Cyprus. Sapropel S5 shows strong Mo and U authigenic enrichments, coupled to progressive increase in $d^{98}/^{95}Mo_{auth}$ (1.2-1.8 ‰ to +2.0-2.3 ‰) and decrease in $d^{238}/^{235}U_{auth}$ (+0.10 ‰ to -0.15 ‰) from the beginning to the end of S5, suggesting increasing water column euxinia and removal fluxes of Mo and U. Based on modern euxinic basins, we show that sedimentary $d^{238}U_{auth}$ can be used to derive estimates of water column U depletion and, ultimately, deep-water renewal rates. These principles are first tested on the modern Black Sea with calculated deep-water renewal times of 830 (+690/-500) years, in good agreement with independent estimates. Applying these principles to the termination of S5 suggests bottom-water U depletion of ~50% and deep water renewal times of 1030 (+820/-520) years. The significantly slower deep-water renewal rates in the Eastern Mediterranean Sea compared to today (~100 years) would have played an important role in the formation of sapropel S5 and are consistent with the proposed suppression of overturning during the last interglacial due to increased stratification, mainly resulting from higher riverine freshwater input (River Nile) under enhanced monsoon forcing.

Bioturbation increases the preserved sulfur isotope fractionation of pyrite

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The term bioturbation refers to a wide range of processes through which biological activity displaces sediment particles and often includes the process of bioirrigation (benthic organisms flushing their burrows with overlying water). Bioturbation also affects the sediment and water column geochemistry because through irrigating to a certain depth, any existing chemical gradient is erased. Moreover, bioturbation drives water advection in and out of sediment, which promotes the movement of molecules that is orders of magnitude faster than the diffusive flux. The onset of bioturbation in the late Neoproterozoic, and its subsequent innovations throughout the Phanerozoic, transformed Earth's surface chemistry and the way the sulfur cycle operates. Therefore, understanding the impact of bioturbation on sedimentary geochemistry and on water column chemistry is key to understanding the link between subsurface carbon and the carbon in the Earth's surface reservoirs.

We present results from a sediment core in which we monitored the change over time in both the pore water and the water column chemistry with and without Polychaete worms (*Glycera sp.*). In the experiment with worms, there is a rapid mixing (in a matter of days) between the water column and the pore water. Our results show that sulfide concentration, alkalinity and pH in the porewater never reach the same concentrations as those in the water column, suggesting that microbial sulfate reduction is still taking place together with bioturbation even with the resulting increased oxygen flux. In addition, the sulfur isotope ratio between sulfate and sulfide in the sediment was affected by bioturbation in a counter-intuitive way. The difference in $\delta^{34}S$ between pore water sulfide and sulfate is much greater in the presence of bioturbation than in its absence. As a result of bioirrigation, isotopically lower sulfate enters the pore water, which lowers the $\delta^{34}S$ of the produced sulfide assuming the sulfur isotope fractionation during microbial sulfate reduction remains high. The onset of bioturbation at the dawn of the phanerozoic may not be a result of higher seawater sulfate concentration.

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

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Radon (^{222}Rn) is a radioactive inert gas formed by disintegration from ^{226}Ra as part of the ^{238}U decay series. In geological environments radon occurs at varying concentrations and shows large and complex spatio-temporal variation patterns which exhibit periodic and non-periodic signals of annual to daily scale. We aim at harnessing its noble gas character and its radioactive decay for using it as an indicator of geophysical processes.

Alpha and gamma radiation were measured under different environmental conditions in natural systems (air, seawater) and Enhanced Confined Mode (ECM) systems, in which nuclear radiation is measured from an artificial radon source inside a confined air volume. All were placed at the Gulf of Eilat [Inter University Institute (IUI)] at on and off-shore locations. The IUI experiments were located at a) approximately 3 meters above sea-level (PM-11 gamma detector), b) on the seabed (ECM Barasol alpha detector), c) dynamic vertical location underwater at different depths (PM-11 gamma detectors and ECM PM-11 gamma detectors).

The results at all locations for the natural systems exhibit systematic variations composed of periodic and non-periodic signals, implicating different pattern for each location. While the on-shore experiments indicate a clear daily signal (1 cycle per day), the underwater experiments reveal different tidal signal (~1.93 cycles per day repetition), which demonstrates a connection between the radon flux and the local marine tide. This marine tide frequency was also observed in air 3 meters above sea-level.

On the other hand, in water gamma ECM experiments (PM-11 gamma detectors with 100 kBq artificial sources) revealed clear daily signal with no marine tide signal - same as for identical experiments on land. Unlike the gamma ECM, the alpha ECM experiment (Barasol alpha detector with NH geological source) showed no distinct or clear pattern while was under water (four meters depth). Nevertheless when relocated out of the water, it exhibited different radiation patterns including day and multi day signals indicating influence of the local environmental conditions on the radon behavior.

The use of P- and S- wave displacement spectra for identification of small underground nuclear explosions

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explosions need to be confidently detected and identified due to their important political and military consequences. The reliable identification of small-scale forbidden clandestine NT is especially important for Israel, where strong earthquakes may occur. In this research we have investigated discrimination between earthquakes and small underground nuclear explosions, based on differences in their source mechanisms, by analyzing P- S-wave displacement spectra. Multi-station corner frequency discriminant (CFD), based on ratios P- to S-wave corner frequencies, is developed in GII for local earthquakes and quarry blasts of magnitudes Md = 1.4–3.4, which occurred at distances up to 250 km. It was shown that the ratio between $f_0(P)$ and $f_0(S)$ is higher for explosions than for earthquakes and this difference is a discrimination parameter which does not depend on the moment magnitude Mw.

In order to check the applicability of the CFD procedure to the nuclear explosions, 481 seismograms from 15 nuclear explosions (North Korea, Kazakhstan), that were recorded at the distance up to 1,200 km and 16 earthquakes (Japan, Kazakhstan) of magnitude from 4.1 to 6.3 were investigated. P- and S-wave displacement spectra have been computed following Brune's source model of earthquakes (1970, 1971). The corner frequencies of P- and S-wave displacement spectra were analyzed as the most important information about the seismic source type. Then comparative analyses between nuclear explosions and earthquakes of similar magnitudes and distances was performed for two data set - N. Korea and Kazakhstan (Semipalatinsk polygon). Studying of the both data set, it was found, that CFD, defined as the $f_0(P)/f_0(S)$, is higher for explosions than for earthquakes. The average estimations of the f0(P)/f0(S) obtained empirically are 3.09 and 2.21 for the explosions in N. Korea and Kazakhstan, and 1.31 and 1.24 for all earthquakes in Japan and Kazakhstan, respectively. Our results have shown the effectiveness of the CFD to identify underground nuclear explosions from earthquakes, which recorded at a distance up to 1,200 km with the empirical discrimination threshold value about 1.75.

A new empirical approach to the peak ground motion prediction applied to the early warning system in Israel.

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An alternative approach for prediction of earthquake ground motions in real-time is suggested based on geometry of the Israel Earthquake Early Warning System (IEEWS) with about 80 stations spread along the Dead Sea fault (DSF) and Carmel Fault (CF). Under the assumption that the strong earthquake in Israel or close to its boundaries most probably would occur in a narrow (up to 10-15 km) belt around the Dead Sea fault (DSF) or Carmel fault (CF) it would strike first several most close IEEWS stations where the amplitudes of the S-wave horizontal component can be measured in a few seconds after the earthquake start (up to 6 -7 sec). These amplitudes in turn can be used to predict peak ground motion PGM at the remote site via Ground-Motion-Prediction Equations (GMPEs) using pre-determined distance attenuation functions PGM(Rn), with distance Rn measured *not from the epicentre*, *but from any closest station*. Such GMPEs have been developed using a database of 40 local earthquakes in the magnitude range M_w3-5.5 that occurred along the Dead Sea Fault. Essential that the GMPEs developed does not require the source location and the magnitude estimation (usually inaccurate during the first few seconds), and is based only on the PGM measured at the first-triggered stations within an epicentral distance range up to 10-15 km. This approach was tested at greater magnitudes using a set of strong inland Japanese earthquakes with $M_j \geq 6$, showing that the GMPEs developed using Israeli small earthquakes data are close to the GMPEs obtained for the Japanese large earthquakes. Thus, we assume that GMPEs derived for the Israeli small earthquakes are applicable to the large earthquake that would occur in Israel. The best fitted GMPEs appeared to have an exponential form with variable regression coefficient and providing predictions of PGA with standard deviation 0.81 in natural logarithmic units. The algorithm was approbated via Monte-Carlo experiment simulating natural seismicity for 50000 years, which allowed us to choose optimal thresholds for the EEWS stations determined by the critical ground-shaking intensity.

Sediment trap and deep sea core-top sediments as tracers of recent changes in planktonic foraminifera assemblages in the Southeastern ultra-oligotrophic Levantine Basin

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Sediment trap and core top sediments were used to study the seasonal and longer-term variability in the distribution and assemblage composition of planktonic foraminifera (PF) in the ultra-oligotrophic Eastern Mediterranean Levantine Basin (LB). Bi- monthly samples were retrieved from a sediment trap deployed at 1300 m between May 2017 and May 2018. The core top sediments were collected close to the sediment trap mooring at ~1500 m water depth. The average annual planktonic foraminiferal (PF) flux is 93 specimens m-2 d-1, the lowest value yet recorded in the Mediterranean Sea that reflects the LB ultra-oligotrophy. A bimodal increase in PF flux occurs with the highest one, up to 452 specimens m-2 d^{-1} occurring in winter (February), responding directly to maxima in particle flux. A lower flux occurs from mid- August to mid-September with up to 197 specimens m-2 d^{-1}.

Ten species were found in the trap, the majority were symbiont-bearing spinose species with *Globigerinoides ruber* white predominating the assemblage composition mainly during the winter peak. Additional species that showed a distinct increase in numerical abundance during the winter maxima were *Globoturborotalita rubsecens* and *Globoturborotalita tenella* together with *Globigerinella calida*. The summer maxima was composed mainly by Orbulina universa and *Globigerinoides ruber* pink. The latter showed a distinct decline in its abundance compared to plankton tows and top sediment records, reflecting a very recent change in its abundance pattern that may result from its response to the ongoing increase in summer surface water temperature. The absence of deep dwelling species excluding *Hastegerina pelagica* and *Turborotalita quinqueloba* that occurred in extremely low numbers in the trap, reflect the difficulties of deep dwellers that proliferate in the highly productive western Mediterranean, to survive in the ultra-oligotrophic environment of the LB.

The Dead Sea Fault System and major circa North-South faults in the Atacama Desert – insights on the nature of large fault zones dissecting the Gondwana Continent

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The Dead Sea Fault System is one of the largest and complex fault systems in Israel comprising long segments oriented North-South accompanied by diagonal fault segments. Most of the tectonic activity along this fault system is attributed to the plate separation occurred along this fault zone since the Early Miocene. However, the cardinal differences in the Paleozoic stratigraphic sections across this fault zone in southern Israel and Jordan, still existing after restoration the strike-slip motion of circa 100 km, hints on an early phase of tectonic deformation along this fault zone. In addition, the Dead Sea Fault zone took an important rule during the Oligocene as it dictates the boundaries of diverse crustal blocks that were differently truncated by the Oligocene Regional Truncation Surface. This hints on differential vertical tectonic deformation culminated along the Dead Sea Fault System during the Oligocene, predating the plate separation by circa 10-6 Ma.

In research recently conducted in the Atacama Desert of northern Chile, several major circa North-South fault systems were examined. These includes the Atacama Fault System located near the Pacific Ocean in the west and the Domeiko Fault System located in the pre-Cordiliera mountain range in the east. These fault systems extend over 1000 -1500 km and constitutes the key physiographic structure of the region extending between the Andean mountain range and the Pacific coast. In the Early Mesozoic these fault accommodates mainly strike-slip motions while vertical deformation – mainly revers faulting - dominates their activity since the Late Cretaceous. From the Eocene to recent times these faults, and other North-South major faults located on both sides of the Andean range, dictates the present active morphotectonic domains of the South-America continent.

As these North-South fault zones were already active in Triassic-Jurassic times, they reflect ancient deformation that pre-dates the break-up of the Gondwana Continent and the development of the southern Atlantic Ocean. Some similar large scale fault zones are recognized in the African plate, especially in regions exposing the older portion of the stratigraphic section, such as in south-western Africa and in the Eastern Sahara.

Back to our region – in the light of the insights presented above, we can explain the pre-Miocene activity recorded along the Dead Sea Fault System as evolved along a major fault zone that was emplaced in the crust during pre-Paleozoic times. This old fault system was re-activated during several

younger tectonic phases, including in the Paleozoic and the Oligocene. Since the Early Miocene, the Dead Sea Fault zone accommodates the new plate boundary known as the Dead Sea Transform.

A Late Eocene – Oligocene 15 km wide sub-marine channels system, which transferred mass-flow from Judea Mts., Israel, to the deep basin in the west

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An extensive (15X7 Km) exposure of Late Eocene – Oligocene chaotic sequence extends to the east of Qiryat-Gat City. This unique sequence has been divided in the past to Bet-Guvrin and Lakhish formations. It was considered as a relict of a more extensive N-S oriented sedimentary belt that built the central Israel foothills and preserved here in a synclinal depression. We examined new exposures of this sequence along highway 6, ancient quarries and stream banks incised in this sequence, and combined new and old paleontological data sets, in order to reevaluate its sedimentary characteristics, depositional age and paleogeographic distribution.

We recognized two different provinces: a wide northern province capped mainly by Oligocene sediments, and a narrow southern province capped mainly by Late Eocene sediments. These are separated by a ridge composed of Lower to Middle Eocene chalk. All the outcrops over the entire region exhibit submarine mass-flow features, with no exceptions. They are composed of Oligocene hemi-pelagic chalky marl matrix, characterized by flow structures, with embedded Early to Middle Eocene chalk blocks, deformed Oligocene green marl pebbles and Oligocene hard limestone clasts ranging in size between a few millimeters to several meters. The Oligocene limestone clasts are gray or brown and contain grains of glauconite and apatite and macrofauna. Tens m size allochthonous blocks, built of stratified limestone and marl, also exist. The base of this mass-flow sequence is exposed along highway 6 where it fills several channels entrenched in the chalk of the Middle Eocene.

We suggest that this Late Eocene – Oligocene sequence was deposited in a wide sub-marine channels system which transferred huge amount of mass-flow from the Judea Mts. in the east to the deep basin in the west. These channels were presumably the tributaries of the Ashdod Canyon, which was incised in the continental slope during the Late Eocene – Early Oligocene. The limestone blocks and fragments were presumably originally deposited 20 km to the east in the shallow sea that covered the ridge of the Judea Mts., and were transported into the chalky marl sediments that were deposited in the deep sea which prevailed along the foothills. This mass-flow event might have been triggered by the Late Eocene – Early Oligocene uplift phase of the Judea Mts.

Evaluating Amplification Factors for Site-Response in Israel

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Due to relatively low seismicity rates and shortage in local earthquake measurements, the Israeli building code uses foreign site factors to incorporate site effects into seismic hazard practice. Consequently, both the definition of the reference rock conditions, as well as the classification into site categories and their associated site amplification factors, are all adopted from the California-based National Earthquake Hazard Reduction Program (NEHRP). While these factors are well-suited for California site conditions, studies in Israel suggest that the average bedrock velocity in Israel, as well as the respective site factors are currently underestimating the expected amplification and resulting hazard.

We use a large local database of velocity profiles, measured and compiled mostly by researchers from the Geophysical Institute of Israel (GII). Profiles consisting of rock surface lithology were used to define a new generic reference-rock velocity-profile for Israel. Corresponding amplification factors were then calculated with respect to the new generic profile by using the remaining 1500 profiles. We test the correlation of eight different site proxies with the computed amplification factors and show that the average shear-wave velocity is a good predictor of amplification at short spectral periods, while long spectral periods require an additional depth measure in order to accurately capture the resulting amplifications. We discuss optional depth proxies, including depth to a certain velocity (e.g. Z1100), as well as peak frequencies (fpeak) in the acceleration transfer function which are highly correlated with depth. Finally, a parametric model is suggested, predicting amplification as function of two site proxies. The model includes fpeak as a supplement proxy to VS30 and shows the highest statistical correlation as well as high applicability for the local engineering community.

Short duration shallow earthquake clusters in the Kinneret region

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During October 2013 and July-August 2018 earthquake clusters were recorded from the Kinneret region. The Kinneret fills an extensional strike-slip duplex along the Jordan rift. Here we show the mechanism of the five largest events of the 2018 cluster: NW-SE trending normal faulting. The events occurred at very shallow depths (<10±0.2 km), at a short duration (less than three months). The largest shock of the 2018 cluster (4/7/2018) reached Mw 4.4, at 3.2 km depth (uncertainty > 0.2 km). Other relocated events range 1.7-3.9 Mw, most of them clustered in July-August. We use the full waveforms recorded July and August by the Israel National Seismic Network, operated by the Geophysical Institute of Israel (GII). We relocate the events (epicenter anד depth) using travel-time stacking developed by Grigoli et al. (2013). We also calculate focal mechanisms, and magnitudes for the five largest events of 2018 by using the Eikonal source model developed by Cesca et al. (2010). The clusters are relocated to a NW-SE trend, more spread out and toward the depocenter (NE) as compared to the original locations. We also find that the epicenters plot off the traces of basin faults from available surveys (e.g., Reznikov et al., 2004; Hurwitz et al., 2002). From the results we postulate that the Dead Sea Transform at the Kinneret steps-over in a ductile pull-apart mode, as defined by Reches (1987). The Jordan Gorge segment, entering the lake from the north, curves to the west; The Jordan Valley segment, entering from the south, curves to the east. The curving of the strike-slip segment creates compressional areas, with a pair of transpressional splays (Sheikh Ali fault on the Arabian Plate and the postulated fault within the basin). We suggest that within the hanging wall of the transpressional splays, splay tensional zones formed. This curving hypothesis also fits the normal faults north of the Kinneret (Belitzky, 1987; Heimann and Ron, 1993) showing a similar trend. Therefore, the largest normal faulting mechanisms recorded are at that tensional zones, similar to the eastern Himalayan normal faults above the main thrust (Ni and Barazangi, 1984). Such normal faults result from the exchange of the order of the principal stresses with depth due to flexural bending of the hanging walls of the postulated transpressional splays.

Thermal history of the southern Golan basin – geothermal gradient measurements, source rock analysis and basin modelling

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The southern Golan Heights is known for its thermal anomaly which is represented in hot springs and high geothermal gradients measured in water wells around the Yarmuk Valley.

Recently, an oil exploration program was carried out by Afek Oil and Gas in the southern Golan Heights. During the exploration campaign, six new boreholes were drilled between the Yarmuk and Yehudiya valleys, targeting the Ghareb and Mishash (Senonian) source rocks. The study dataset consists of temperature logs alongside with a high resolution laboratory based geochemical log conducted on the cuttings intended to characterize the degrees of maturation of the organic matter (OM) in the source rock. While temperature gradients are a reflection of present day heat fluxes and thermal conduction throughout the section, maturation is affected by the cumulative thermal history which is a function of the historical heat flow and burial history.

Using the newly collected data, a forward basin model (BasinMod) was constructed, taking into account the burial history according to the stratigraphy and formation ages, lithology, porosity, thermal conductivity, and modern day heat fluxes. The thermal history is then altered in the model to fit the measured maturation data.

Present day thermal gradients near the Yarmuk are twice as steep as in the northern part of the basin. In contrast, rather consistent levels of source rock maturation were measured throughout the basin. The basin modeling suggests that a regional heating event had occurred in order to explain the measured degrees of maturation. The modeled extra heat extends rather uniformly across ~30 km from the Yarmuk region in the south and is bounded by the Sheik Ali Fault (SAF) in the north. The spatial extension of the historic thermal anomaly is thought to coincide with the cover basalt volcanism (dated between 5.3-3.5 Ma). North of the SAF (down thrown block), no significant maturation was measured and therefore, little excess heat was modeled. It is hypothesized that a developed hydrogeological system north to the SAF has removed the extra heat therefore resulting in the low measured degrees of maturation. This hypothesis is supported by a unique combination of low hydrogen index and low Tmax values. An alternate explanation to the lack of excess heat, north of the SAF, is a different heat regime due to a tectonic displacement of the block north to the SAF towards the Dead Sea rift, which is considered to be a cold basin.

The suitability of the Zohar structure (Arad area) for geological CO_2 storage

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One of the proposed ways to reduce anthropogenic CO_2 emissions to the atmosphere is carbon capture and storage (CCS). In this technique, CO_2 is separated and captured from large stationary sources, transported to the storage site and injected into suitable storage formations, typically saline aquifers. The main goals of the current research are to characterize and evaluate the potential of the Zohar and Kidod Formations (top of the Jurassic saline aquifer and base of its overlaying aquitard, respectively) for deep geological CO_2 storage in the Zohar structure (NE Negev). The Zohar Formation in this area has been previously used as a natural gas reservoir that became diluted with time. The petrophysical properties of this formation were therefore characterized by porosity, permeability and density measurements. The current study, however, also examines the petrophysical properties of the sealing unit (Kidod Formation). The study comprises of high-resolution petrological and petrophysical measurements that have been carried out on cores taken from boreholes in the research area, visualization of the boreholes profiles using logs, cross sections between the boreholes and seismic sections. As the Zohar Formation is characterized by fractures, four main groups of fractures and their densities were mapped in the outcrops of the formation in the study area. Evidence for these fractures to be a possible mechanism for fluid flow are the average measured core permeability values, which are within the range of 0.03-0.05 md. These values are considered low even for a carbonate resevoir like the Zohar Formation, in which limestone is the main lithology. Spatial interpolation methods used to estimate the geological storage capacity, resulted in an estimation of 29.5 Mt CO_2 assuming effective CO_2 saturation of 2% for the entire study area. Highly detaild characterization of the Zohar Structure, including the assumption that most of the reservoir area will be used for plume accumulation of CO_2 in the top of the structure, allows for the usage of bigger range of effective CO_2 saturations 3.8%-15%, resulting in 4-15.8 Mt CO_2 in the Zohar Structure alone. These CO_2 storage capacities calculated for the Zohar Formation in the saline aquifer in the Negev, allows the injection and storage of the by-product CO_2 for a few years up to decades. Few mercury injection capillary pressure tests for the Kidod Formation resulted in capillary pressure breakthrough values larger than 3000 psi and a typical pore throat size smaller than 0.01 µm, suggesting that CO_2 can fill the entire reservoir without leaking through the cap rock or damaging it. Given that the thickness of Kidod Formation is mostly larger than 70 m in the entire study area and larger than 90 m in the Zohar structure specifically, the Kidod Formation seems like a suitable seal for CO_2 storage.

Seasonal to decadal scale hydroclimatic response in the eastern Mediterranean to climate change during the last glacial

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Floods make up a dominant hydroclimatological phenomenon in aridlands, and bear significant implications for humans, infrastructure design and landscape evolution. However, determining flood frequencies during changing climate is rarely achieved because modern and paleoflood records in arid regions are often too short or discontinuous. To understand the impact of climate change on flood generation further requires independent climate reconstruction as available from lake sediment records. The sedimentary record of the Dead Sea provides a high-resolution archive of Quaternary hydroclimate in the eastern Mediterranean-Levant. Mean centennial to millennial climate changes are manifested in the hydrological balance of the Dead Sea, and are recorded by lake-level changes. These mean conditions are composed of sub-seasonal rainstorms born out of key synoptic circulation patterns that govern inflow and produce floods in the large watersheds draining directly into the Dead Sea. Late Pleistocene varve sequences provide a rare record of seasonal floods, and therefore provides information on the annual frequency of these synoptic circulation patterns within a single season. Two 700-year-long seasonally resolved flood time series were extracted from late Pleistocene (25-15 ka) varved sediment. They are contemporaneous with significant Dead Sea lake-level variations, reflecting contrasting long-term changes in the hydrological budget, where one time interval represents lake-level rise, and the other interval lake-level drop. In both intervals, floods are non-uniformly distributed and cluster into periods of intense flooding. Within clusters, flood frequency increases by +75% and +20% above their respective background frequencies during rising and falling lake-levels, respectively. These series demonstrate that changes in mean centennial precipitation in the eastern Mediterranean are coupled with drastic changes in flood frequency. Contemporary observations, point to the link between these drastic changes in flood frequencies and changes in the track, depth, and frequency of eastern Mediterranean cyclones during wetter and drier regional climatic conditions.

Sea level drawdowns in the Levant basin during the Lago Mare, late Messinian Salinity Crisis (5.5-5.33 Ma)

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During the third stage of the Messinian salinity crisis (MSC, 5.5-5.33 Ma), commonly known as the Lago Mare, the sea level of the Mediterranean fluctuated repeatedly. The magnitude of the sea level drawdowns have implications for connectivity between the eastern and western Mediterranean basins during the Lago Mare. These drawdowns in the eastern Mediterranean basin were estimated by previous studies to vary between <200 m to down to the abyssal plain. In the study presented here we propose a maximal drawdown of 630-900 m below present-day sea level.

Here, we propose that ravinement along a regressing-transgressing coastline abraded the upper margin down to a depth of 380-550 m below present-day sea level and lowered upper margin gradient. A break in the gradient of the slope was formed at the distal boundary of the formed erosional surface. The material of the eroded strata was evacuated downslope and deposited as wedge-shape clastic complexes downslope of the break in slope. During relatively short intervals, sea level receded ~100 m below the slope break. A regressive ravinement surface was formed on top of the clastic complexes, and the evacuated clasts were deposited basinward in prograding foresets. Gullies were incised by sub-aerial erosion into the slope break, and formed knickpoints for headward migration of fluvial incision. Subsequently, the gullies developed into channels, which incised dendritic drainage systems into the upslope zone of the erosional surface. Drainage systems with relatively faster retreat of knickpoints pirated the upslope catchments of slower drainage systems. Eventually, these catchments formed conduits for sediment bypass. Fan-deltas were deposited distally of the developed catchment outlets.

A major regression has occurred towards the end of the MSC. Sea level receded to 630-900 m below present-day sea level. The top of the clastic complexes was utterly exposed sub-aerially, but was not abraded by waves as the shoreline was located further downslope. Fluvial systems incised into the exposed tops of the clastic wedges and fan-deltas. Additionally, meteoric water dissolved evaporites within the clastic complexes. Subsequently, porosity and permeability within the complexes increased and subterranean and surficial karst processes accelerated. Sinkholes and dolines were formed, mostly downstream of the channels, which drained the upper margin.

During peak Lago Mare drawdowns, sea level was below the depth of the late Miocene Sicily sill, which separated the eastern Mediterranean basin from western basin. Therefore, during peak regressions these two basins were not connected, sub-aerial erosion processes dominated the upper Israeli margin, and hiatuses formed within the sedimentary record.

When two salt tectonic systems meet: Gliding downslope the Levant Margin and salt outsqueezing from under the Nile delta

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The combination of normal faulting along the Levant continental slope and folding and thrusting in the deep Levant Basin was previously interpreted as an example for the salt tectonic paradigm of updip extension and downdip contraction. However, examination of the age and amplitude of deformation shows that the two systems do not fit. Deep basin folding started ~0.8 million years after the extension along the continental margin and the amplitude of downdip shortening is significantly higher than the amplitude of updip elongation. This apparently indicates that the two deformation systems are independent. Extension of the continental slope expresses basinward gliding of the sediments overriding the salt whereas the deep basin folding, and thrusting belong to a circum-Nile deformation belt propelled by out squeezing of salt from under the Nile delta overburden.

On the other hand, slope perpendicular elongation and fold perpendicular shortening both decrease southwards. This suggests that the two different systems restrain each other where they meet and northwestwards gliding of the continental slope is restrained by the northeastwards motion of the circum-Nile belt.

Interestingly, the beginning of folding along the circum-Nile belt about 2 my ago coincides with the establishment of a continuous continental shelf from the Nile delta to offshore Israel. It is suggested that these two phenomena express maturity of the delta when it reached a size and shape that triggered salt outsqueezing towards the Levant Basin and at the same time produced a continuous continental shelf from Egypt to Israel. This continuous shelf allowed alongshore sediment transport from the Nile to the Israeli coast which allowed further propagation of the shelf northwards and westwards.

Suspended and bedload sediment transport into the Sea of Galilee during floods, Nahal Meshushim, NE Israel

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Nahal Meshushim (160 km^2; 45 km long) is the largest watershed draining the central Golan Heights into the Sea of Galilee. It originates from the basaltic Golan plateau as a shallow bedrock channel system, and further, cuts a deeply incised canyon where it drops steeply into the NE delta of the Sea of Galilee. Nahal Meshushim is a gravel-bed river that transports coarse sediments up to boulder size. It contributes large water and sediment volumes to the Delta, which support the most important ecological littoral cell of the lake. Yet, until recently, suspended sediment sampling was of low-resolution, sporadic and conducted during each flood season by Mekorot or during short-term studies, whereas data on bedload transport is almost absent.

The largest flood occurred in 1969 with a peak discharge of about 270 m^3/sec, which is larger than the maximum peak discharge of the Jordan River. Maximum annual sediment yield for the 1969 winter was estimated at 240 m^3/km/yr - a total of 40,000 m3 (Inbar, 1970).

As part of a large geomorphic study program in the delta, we present a new monitoring system in Nahal Meshushim which includes 3 optic turbidity sensors for tracking continuous suspended sediment transport (TSS – Total Suspended Sediments) since 2016-2017 and a system of 3 geophones for measuring real-time bedload transport. Sediment net traps were placed downstream of the geophone sensors to capture some of the bedload in motion in order to analyze the grain size distribution of the sediments as well as to calibrate the geophone signals. The geophones are located at the concrete weir of the hydrometric station of the Israel Hydrological Service with a calibrated pressure transducer (PT), which complements the sediment monitoring system with the concurrent discharges.

The bedload system was first tested in the hydrological year of 2017-2018 which was the fifth consecutive drought year in northern Israel. Nevertheless, several small and medium flows, occurred and enabled to test the bedload monitoring system for the first time. During most flows, suspended sediment usually lags the quick changes in the hydrograph creating anti-clockwise hysteresis loops.

During winter base-flows the water are clear. The geophones were able to capture bedload motion during all flows, from incipient motion of loose gravel at the beginning of the year up to significant movement of the bed, when the discharge peaked at 42 m^3/s. The bedload motion is also heterogeneous along width of the X-section where the highest instantaneous values are not necessarily at the channel center. Bedload sediment sizes were predominantly sand up to coarse gravel, but cobbles and small boulders were also in motion. The entire system is active during the present winter 2018-2019, where until now, already 2 floods exceeded 40 m^3/sec.

Daily periodicity of radon in an enclosed 120-cm-long pipe

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Radon is an inert gas that is wide-spread in nature. Radon is readily detected due to its radioactivity; the most stable isotope, ^{222}Rn, has a half-life of 3.823 days. Geophysicists monitor radon gas in order to trace temporally and spatially varying processes, yet still some physical mechanisms that govern radiation patterns from radon (and progeny) in various environments are not well understood.

Experiments aimed to observe radon signals in closed chambers are termed “Enhanced Confined Mode” (ECM). A Laboratory ECM experiment is performed in a horizontal 120cm stainless steel pipe. A 222Rn source of activity ~100 kBq is connected via tube to one end of the pipe, which contains air at atmospheric pressure. Count rate measurements are performed at several positions along the pipe using five NaI (36x76 mm) gamma-ray scintillation detectors; two detectors are positioned parallel along the pipe’s axis and three detectors perpendicular to the pipe’s axis. Measurements are made at one minute resolution, for over 120 days.

Radon gas diffuses into the ECM chamber; there it (and its gamma emitting daughters) disintegrates due to radioactive decay. A model for radon concentration along the pipe as the function of time was calculated, assuming constant radon diffusivity. The model predicts a steady state of diffusion and radioactive decay rates over time. However, Power Spectral Analysis of the measurements reveals statistically significant peaks at 1 cycle/day frequency, for the five gamma count rate time series gathered. The absolute power and the fitted relative amplitude of the daily cycle are greater for detectors that were placed farther away from the source. Also, radon diffusivity analysis using steady state count rate measurements suggests that radon diffusivity changes over time in the enclosed pipe. Radon diffusivity fluctuations are found to be laboratory temperature-dependent. Therefore, it is concluded that gamma count rate daily periodicity is most probably controlled by a temperature-dependent gas transport process within the enclosed pipe.

Dissemination of the geology of the Elat/Timna area

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The stratigraphy and structure of the well-exposed rocks in the extreme arid desert climate of the Elat/Timna area document the geologic evolution of this area from Neoproterozoic to the Holocene times and thus make the geology of this area so attractive. Therefore, this area was extensively studied and has turned into a field laboratory for geoscience students. Accordingly, at the annual meeting of the Israel Geological Society at Elat 2016 we presented an abstract, and guided a field trip in order to present our published GSI/10/2015 report "The Elat area as a field school for geology"(Beyth and Calvo, 2015). The goal of this report, available from the Geological Survey of Israel, and presented as a poster, was to make the unique geology of the Elat area, more attractive to students, amateur geologists and tourists. This effort was based on up-to-date research and recent mapping (Beyth et al., 2012 partly revised 2018). The final goal is to make the geology of the Elat area, especially around the Israel National Trail, accessible to visitors also through a mobile multi-sensory cellular application. A similar pioneering approach was presented for the Timna Valley in the GSI/09/2014 report "The Timna Valley as a Geological Park" (Beyth and Calvo, 2014). We elaborated the dissemination idea of the Elat area by working on especially attractive trails like the "Mount Shelomo geological Track" (Eyal et al.,2017) and the "Nahal Gishron geological track, Elat area" (Beyth et al., 2018). All these reports are publically available through the Geological Survey of Israel website (www.gsi.gov.il). These presented works of the Elat/Timna area encourages additional effort of the Geological Survey to disseminate geological data to the public.

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Depositional and diagenetic evolution of the Albian-Turonian Levant carbonate sequence, new integrated approach

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The Cretaceous strata onshore and near shore Israel offers a unique aperture into the evolution and dynamics of carbonate deposition, and provide potential analogues for offshore highs in the southeastern Mediterranean. This study revisits these sites, integrating well logs, data compilations, geological maps, existing publications and onsite examination to aggregate a database of thickness and facies across Israel. Individual localities across Israel were sampled and analyzed in detail to provide a more granular understanding of the observed trends.

Following the shift from siliciclastic dominance during the Aptian and Albian, an extensive carbonate platform was established on the southeastern margin of the Levant Basin. This platform extended from the southern margin of the Palmyride trough and the modern Israeli shelf/coastal plain in the northwest and ~ 100km inland (south east) in the Albian to >200 km in the Turonian. The outer part of this platform was characterized by rudist buildups while the inner parts of the platform were dominated by shallow water depths, characterized by relatively low energy conditions. Outer clinoforms are encountered near the modern coastal plain and intertidal microbialites characterize the shallowest part. Consequently, extensive early dolomitization occurred across the platform until its subsequent drowning at the end of the Albian.

Two additional cycles of shallowing and deepening occurred atop the platform during the Cenomanian, both marked by extensive dolomitization of the platform during periods of relative low sea level conditions.

Volcanoes developed in the platform margins and were rimmed by short lived neritic carbonate buildups. Finally, during the Turonian and following Oceanic Anoxic Event 2, the principal depositional platform areas experienced a major backstep, which resulted in non-deposition and bypass of the Albian/Cenomenian platform edge. The outer clinoforms migrate proximally over 100km while the

abandoned platform edge experiences significant erosion and formation of submarine canyons concurrently to the supply of reworked material of the platform outer margin. Early dolomitization became extremely rare at this phase. The Turonian backstep marks the shift to hemipelagic dominance atop the Levant margin, which persisted until the Middle Eocene. Overall, the Levant margin maintained a large carbonate platform as of the Aptian. This platform exhibits a continuous transgressive trend through the Albian, Cenomanian and Turonian, transitioning to deep water in the late most Cretaceous. This transgression moves the main grain factory (rudists) farther away from the platform edge to the southern east. This transgression is punctuated by periods of shallowing which became exceedingly shorter, and are characterized by dolomitization in the Albian and Cenomanian but not in the Turonian or afterwards. While onshore epicontinental flooding accommodates this increase in relative sea level, offshore on isolated carbonate platforms it may have led to the drowning and termination of shallow-water, porosity-rich facies.

Textural and physical modification in the upper mantle due to annealing and recrystallization processes

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Earth's upper mantle (i.e., 300-400 km thickness layer at depths of ~5-40 km) has a substantial role in the initiation, and evolution of plate tectonics such as plates formation and mantle flow. Olivine, the most ubiquitous mineral in the upper mantle comprises ~ 70% of its volume, strongly affects the upper mantle's dynamics and seismic properties. Olivine crystallographic preferred orientation (CPO), grain-size, and dislocation-density from peridotite xenoliths (i.e, olivine-rich samples from depth carried to the surface through volcanic eruption) are often used to infer the current/past flow and stress state from the depth of origin. However, under certain conditions recovery processes (annealing) will modify these microstructural signatures. We investigate features of recovery in natural peridotites through coupled microstructural (EBSD) and geochemical analysis (EPMA, SIMS) of xenoliths from Williams kimberlite, Wyoming Craton (Montana, USA). We focus on a distinctive feature of the xenoliths - tablet-shaped, faceted olivine grains showing cross-cutting relationship with surrounding grains. Intragranular strain in the tablets is negligible, yet the surrounding olivine grains show high intragranular strain. This texture indicates a post-deformation recovery process driven by reduction of strain energy. Both olivine populations (tablet and matrix) are homogeneous with respect to major elements and water contents (7-22 ppm). Analysis of subgrain boundary orientations is consistent with dominant activation of [100](010) and [100](001) slip systems; together with the low water contents, this indicates that the last deformation occurred under relatively anhydrous, low-moderate stress conditions. In addition, the CPO of the tablets appears to be modified with respect to the bulk sample; the CPO of the former is weaker and rotated 10-15° from the original CPO. Remarkably similar observations were shown by annealing experimentally deformed samples. The analysis of natural and experimental tablets shows that, contrary to previous studies, the growth mechanism of olivine tablets is not related to fluid-mediated processes but rather driven by the strain energy and CPO in a solid-solid medium. We will discuss the applicability, kinetics and implications of this style of recovery mechanism in our interpretation of the upper mantle microstructure and tectonic history.

Subsurface investigation near sinkhole sites in the Dead-Sea using Gravity, Magnetic and Reflection Surveys

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Sinkholes occurrence is continuously increasing along the shoreline of the Dead-Sea leading to infrastructure damages and instability to human activity in this region. Researches led by the Geological Survey of Israel suggests that sinkholes development is controlled by numerous factors such as the rapid decrease of the Dead-Sea sea level, the extent of the subsurface salt layer, dissolution processes and fluvial surges channeled through fault lines. Aiming to detect geological features such as faults and examine their relation to sinkhole development, a multidiscipline land geophysical survey was conducted by the Geophysical Institute of Israel.

This survey combines gravity and magnetic measurements along three lines crossing the Hever, Mishmar, and Zeelim alluvial fans and two reflection lines in Hever and Zeelim. Gravity and magnetic exploration are an indirect method to map the subsurface by sensing physical characteristics of rocks such as density and magnetization, respectively. These methods can help locate minerals, faults, large cavities, and structural changes. The results from the reflection, gravity, and magnetic methods are integrated in order to improve interpretation and provide a better understanding of the subsurface geology.

The magnetic results show no correlation between the lines and are composed of short wavelength anomalies that might be related to shallow subsurface facial changes in the coastal sediments. The residual gravity anomalies show a dominant wide low anomaly that is correlated between the three lines with amplitudes and width increasing northward. This anomaly might be related to a north-south marginal step fault. Both reflection lines show a structural bend on-lapping eastward dipping reflectors in an area situated between dense sinkholes zones. Only one reflection line shows a clear discontinuity of reflectors indicative to the presence of a large vertical displacement fault.

Seasonal changes in the $\delta^{13}C$ and $\Delta^{14}C$ in groundwater DIC due to acidic deposition over a phreatic aquifer

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The age and flow rate of groundwater are important parameters needed for the optimal exploitation of groundwater. This data can usually be obtained using radiocarbon measurements on the dissolved inorganic carbon (DIC); but, this presupposes a constancy of the $\delta^{13}C$ and $\Delta^{14}C$ in the recharge water. We report finding seasonal variations in ground DIC near to the power plant (before its conversion to gas) in the dune aquifer along Haifa Bay. The sediments of this sandy aquifer were laid down during a higher sea- level stand approximately 4000 years ago, and includes sea shells from this time. The chemistry of the young aquifer water is now laterally variable, and characterized by excess SO_4^{2-}, high Sr^{2+} concentrations above that of modern sea water, high alkalinity markedly enriched $\delta^{13}CDIC$ values, that become more enriched in the winter. The $\Delta^{14}C$ likewise decreases during the winter compared to the summer. The wells studied lie in near proximity to the power station which emitted at least 15,000 tons of SO_3 annually. Acidic winter rains, formed from SOx and NOx gaseous emissions from the power station, leach the dry deposition that had accumulated across the dune surface during the dry summers. The acidity also partially dissolves the old aragonite sea shells in the dune sands. As a consequence, this adds Sr^{2+}, Ca^{2+}-excess, and alkalinity, while leading to enriched $\delta^{13}CDIC$ and lower ^{14}C in the recharge water immediately surrounding the power plant. During the summer lateral flow of groundwater, further removed from the power plant emissions, replaces/mixes with the water most altered by the acidity.

Dispersion Image Analysis: Active Vs. Passive

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Shear-wave velocity (*Vs*) has long been known to be an essential proxy evaluating the dynamic properties of soils. The average shear-wave velocity in the top 30m (Vs_{30}), is widely used around the world, including in Israel by the Standards Institute of Israel (SII 413). In order to evaluate the *Vs* profile over the shallow subsurface, several seismic methods were developed: Multichannel Analysis of Surface Waves (MASW) over its three components, Refraction Microtremor (ReMi), Extended Spatial Auto-Correlation (ESAC), refraction, etc. Most of these methods are based on Fourier transformation from the time-space domain into the frequency-velocity domain, and picking the fundamental curve from the dispersion image. It is common to divide these methods into two groups: Passive methods are based on recording ambient noise, versus active methods, characterized by recording an active source (accelerated weight, explosive, or sledgehammer, which is usually most common due to its simplicity and convenience).

Previous studies show that using a sledgehammer as an active source limits the dispersion image at the low frequencies, and it is not sufficiently clear for picking the dispersion curve. In passive methods the source is undetermined and could be characterized by lower frequencies. Therefore, deeper information could conceivably be available (the lower the frequency, the greater the depth of the shear-wave profile). It follows that the passive methods can produce better dispersion images at the lower frequencies, while the active methods are clearer for the higher frequencies. Hence, merging the spectrum of the two methods can enhance the clarity of the final dispersion image. A clear dispersion image characterized by lower uncertainty of the final *Vs* profile.

To test this concept, we compared dispersion images from the two different methods at three sites. Among the three sites we surveyed, two are located within an industrial zone and one is located in a "quiet" area where environmental noise may be neglected. At the "quiet" site, where environmental ambient noise is very low, the passive method is unexpectedly preferable over the active one. At the two industrial sites, although the environmental noise was significant, the dispersion images calculated from the active surveys are clear for most of the spectrum. However, in all three cases the integration of the active and the passive methods yields the best dispersion image.

Shallow fault detection using different seismic acquisition methods, new results

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Shallow fault detection is an essential part of assessing the seismic hazard of specific sites in Israel. For this reason, the Israeli Geological Survey is conducting research trying to map faults at shallow depth. While classic geological methods yield good results in detecting faults and assessing their activity using rock outcrops, a lot of areas within Israel are covered by active alluvial fans and agricultural activity, effectively masking the presence of displacement. One of the common methods for detecting a shallow fault, is to conduct a high-resolution seismic survey. Although the term “High-Resolution” is not an official term, the term usually suggests a sensor spacing below 10m and an energy source activated every other point or less. We present new seismic data acquired in the last year (2018) and using a variety of sources, recording systems and line lengths. Each site was investigated using previous geophysical and geological data to gain an approximation of where the fault is expected. Results show a variety of data quality related mainly to the geological settings, emphasizing the importance of the use of supporting data that contribute and validate the seismic interpretation. We conclude that the need for a good complete and available data base for geological and geophysical data that is accessible, is essential for successfully planning and interpreting shallow seismic surveys.

#Geology- Twitter as a leading science communication tool

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In recent years, the social media has become an important tool for scientists to communicate within the scientific community as well as to communicate to the general public their scientific discoveries and advancements. In particular, using Twitter in the Earth sciences community is becoming an immediate tool to communicate a new or an upcoming publication, new findings, research funds, job offers, conferences and special sessions, support underrepresented groups in STEM, field trips, scientists life and philosophy, humor (complaining about peer reviews mostly) and more. It provides a broad space for discussions, publications and collaborations. In light of the fast and wide publicity potential of twitter, worldwide leading publishers are nowadays measuring the twitter activity on articles and relate it as important visibility factor. Among the 'tweeters' (i.e. the community of people using Twitter) you can find scientists, students, universities, research institutes, research departments, research groups, leading scientific journals, research expeditions and cruises, industry people, the NASA missions, and many more.

We will start with an introduction to Twitter and its benefits in the scientific world. Afterwards it will be all hands on: A quick guide to help you take your first steps into the tweeting world.

Cross-shelf redistribution of coarse gravel and fluvial incision following shelf exposure: Observations from the Dead Sea

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Global eustatic lowstands can expose vast areas of continental shelves, and occasionally the shelf edge and the continental slope. The degree of fluvial connectivity to receding shores influences the redistribution of sediments across these emerging landscapes. Recent shelf and slope emergence in the Dead Sea offers a rare opportunity to examine evolution of stream connectivity in response to continuous base-level decline. We characterize the connectivity evolution of two streams, using high-resolution time series of aerial imagery and elevation models, field mapping, and grain-size analyses. Our rich spatiotemporal dataset of evolving channel geomorphology, sediment transport conditions, and sediment redistribution, allows calculating potential coarse sediment mobility in response to base level decline. Following shelf emergence, alluvial fan has prograded onto the low-gradient shelf under unfavourable conditions for transporting coarse sediment to the regressing shoreline. With the shelf and slope emergence, the two adjacent streams evolved differently. The smaller, more arid watershed maintains highstand delta progradation on the shelf and is practically disconnected from the receding lake. The nearby larger, more humid catchment with narrower shelf presents incision, channelization, and renewal and intensification of sediment transport from the highstand to the lowstand deltas. Sediment mobilization to lowstand shorelines is controlled by the evolution of the channel profile and by the average speed of gravel transport (10s-100s m/yr). These findings from the Dead Sea are relevant to fluvial processes operating on continental shelves during glacial maxima. Streams would have commonly stored high proportions of their coarse sediment on the continental shelves rather than efficiently connecting with the lowstand level. Additionally, high spatiotemporal differences in sediment routing patterns should exist among nearby streams, primarily due to continental margin geometry and watershed hydrology.

New luminescence ages for the Pleistocene sediments of the southern coastal plain of Israel

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The coastal plain of Israel is built mostly of alternating calcareous aeolianites (Kurkar) and reddish clayey paleosoils (Hamra). Its southern part is poorly exposed, however occasional exposures are found along stream channels, in quarries and along road cuts. The chronology of these sediments is poorly known but was estimated to extend to the Early Pleistocene. Up to now only a few sections were partially dated by optically stimulated luminescence (OSL) which is the most applicable method. However, it is limited to 200 ka due to signal saturation.

Development of new luminescence techniques for both quartz and alkali-feldspar enabled us to date sediments older than 200 ka and improve the Pleistocene stratigraphic framework of the area. Here we present new luminescence ages of four sections along the southern coastal plain: Kerem Shalom, Ruhama, Zikim and Kisufim; each representing a different morphological feature. Together, the four sections were dated from late Holocene to Early Pleistocene. The new ages suggest that each section was deposited at different time and rate; implying that one cannot expect continuity of the different sedimentary unites across long distances. This highly complicates the correlation of the subsurface.

Negev Precariously Balanced Rocks – stability analysis of in-situ rock pillars and implications for seismic hazard studies

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Precariously Balanced Rocks cannot withstand strong ground motion. When a strong earthquake occurs in their vicinity they are likely to break or topple. By evaluating the stability of Precariously Balanced Rocks (PBRs) and determining their age, it is possible to constrain the maximum PGA that has occurred at PBR sites during their life time. This methodology has been proven as effective in determining the maximal earthquake magnitude of faults around the world, and has been applied to improve both deterministic and probabilistic seismic hazard analysis. In the Negev, slender, in situ rock pillars constitute a particularly important subset of PPRs as their seismically induced motion may be amplified if their natural frequency is within the range of seismic wave frequency (1-10 Hz). The motion of such pillars may be complex with an initial stage of resonance swaying followed by toppling or failure of a weak layer or crack.

An analysis of plausible pillar motion based on its dimensions and structural characteristics indicates that certain slender pillars are likely to experience resonance motion leading to toppling or failure. Non-slender pillars have a high natural frequency and therefore are not likely to experience resonance motion, and on the other hand, extremely slender pillars are more likely to topple before experiencing resonance motion.

In the Negev, several pillars that were found to be ~10,000 years old, were used to explore potential implications for constraining the maximum magnitude of earthquakes along the Negev-Sinai Sear Zone faults and the Arava Fault. We show that assuming a plausible amplification of motion, the pillar analysis may yield strong constraints on fault seismicity parameters and may indicate a need to re-evaluate ground acceleration maps. Dating and stability analysis of PBR and pillars provides important new insights for regional seismic hazard studies.

Self-evaluation tool for the public – am I ready for an earthquake? What's my risk level?

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Many Israelis live in areas of significant seismic risk, and yet they tend to be indifferent or reluctant to undertake the minimal preparations to safeguard their family. National Emergency Authorities worldwide have long realized that in order to improve communal resilience and self-reliance, they should promote personal and familial preparedness.

We present a newly developed self-evaluation online tool that will disseminate personalized risk and preparedness information in order to encourage individual and familial involvement in earthquake preparedness. The online application will provide relevant data from national seismic risk maps (Israel Standard 413) based on user input of location and simple house details. The app will also enable self-evaluation of readiness, identify weakness in personal readiness and give immediate personalized feedback (Israeli Home Front Command's recommendations deemed most relevant to the specific respondent). The personal preparedness data collected will provide a basis for innovative mapping of urban readiness patterns (by neighborhood). Analysis of this data will provide important insights for authorities regarding specific weaknesses in familial and community resilience. The use of a popular interface to social networks will promote comparison between homes among friends, and will attract a broad sector of the public to take part and assess their risk and preparedness. We believe that the interactive tools and social connectivity will increase the public's willingness to actively minimize their community's and personal risk.

The goal of the study is to enhance the ability of communities to cope with disaster by fostering personal and communal self-reliance and by identifying preparedness and risk patterns, and areas of weakness within cities. A pilot study focused on Mitzpe Ramon was used to map significant spatial patterns of risk and preparedness and to identify neighborhoods with relatively high-risk and low communal preparedness. Future development of the methodology may provide a tool for improving municipal and regional emergency planning and risk reduction efforts.

A New Look at the Jonah Ridge and the Israeli Levant basin in light of a nearby tectonic discovery

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The Jonah Ridge is an early Mesozoic morpho-tectonic giant extending along the eastern Levant Basin offshore Israel. It is the largest and most significant structural feature there. The ridge is associated with an outstanding magnetic anomaly and the enigmatic cone shaped “Jonah-High” rises up in its southern part.

It is currently widely agreed that the tectonic evolution of the Levant basin was dictated in the early Mesozoic by extensional processes associated with crustal thinning, rifting and opening of the Neo Tethys. Structural interpretations therefore suggested patterns of early Mesozoic extensional horsts and grabens. Jonah Ridge was interpreted accordingly in terms of an early Mesozoic giant horst block associated with super imposed intrusives and extrusives.

The recent discovery of “Dakar” dome, a deeply buried giant fold of early Mesozoic age, in the immediate vicinity, south of Jonah Ridge highlighted the unambiguous existence of an early Mesozoic significant folding phase. There was no clear evidence for extensional fault blocks.

The uppermost sequence in “Dakar” fold exhibits characteristics of a mobile sediment that forms diapir penetration into overlaying sediments. The southern part of the fold appears to be disturbed by super imposed intrusives, extrusives, re mobilization and possibly carbonate buildups. As the result, in the south the quality of the seismic imaging seriously deteriorates to a degree that interpretation becomes uncertain.

In the northern part of the fold the existence of a “clean” undisturbed window resulted in excellent seismic imaging and therefore reliable identification of structural and stratigraphic characteristics.

Based on these observations an analogy is suggested between “Dakar” fold and Jonah Ridge. Both structures are located on a continuous structural and magnetic trend along the eastern margin of the Israeli Levant Basin. Both are of early Mesozoic age and exhibit folding tectonics with super imposed intrusives, possibly extrusives, later re mobilization with diapirization and possibly carbonate buildups.

Collapse of volcanic voids and pit craters, and their manifestation in the Golan Heights, Israel

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Recent collapse volcanic features in Hawaii are termed pit craters. They are compared with a vertical collapse void in the Golan volcanic plateau ('Gevei Maish Cave') and the closed depressions locally termed 'juba'. We further compare these features with other closed depressions observed in the world, including various regions of Harrat Ash-Shaam (Jordan, Syria), as well as collapse dolines over karstic caves. With the lack of high-resolution subsurface imaging and bare earth digital elevation models, we focused our methodology on field measurements and air-photo analysis. These measurements indicate that the morphology and deformation history of 'Gevei Maish Cave' and the 'juba' depressions resemble the Hawaii pit craters, and we therefore suggest that they formed by magmatic-volcanic process. No ejecta, rim deposits, or lava tubes were found in association with these depressions. The voids relate to the last, late Pleistocene volcanic phase of the northern Golan. Similar to Hawaii, we suggest that the magma has been channeled through faults and fractures without reaching the surface. If the ‘juba’ depressions are indeed pit craters, they indicate that inflation by pressurized magmatic intrusion could cause extension along the unstable flanks of the deep Hula basin, while during the deflation stage the evacuated magma left voids which reached the surface by consecutive roof collapse. Since the collapse reached the surface, recent erosion and sedimentation have modified the original morphology of the pit craters, commonly forming smooth and shallow bowl-shaped depressions. The youngest pit crater in the Golan, 'Gevei Maish Cave' breached the surface during the Holocene, still demonstrating the typical vertical pit morphology, similar to recent pit craters in Hawaii.

Recent deformation of the Dor-Disturbance region imaged with high-resolution Seismics

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Detailed geophysical imaging of the seafloor structural integrity and potential geo-hazards is a key element of offshore infrastructure development projects and site surveys. The desired imaging should be at sub-meter resolution to allow its correlation with direct seafloor sampling (e.g. cores, CPT, etc.), but is usually also required to include the structural context to depths of tens to hundreds of meters below the seafloor. These combined requirements are not easily met by traditional or even modern (e.g. AUV based) imaging techniques. Here we demonstrate some superior results of newly acquired very high (~0.3 m) resolution (VHR) multi-channel seismic surveys, obtaining >200 m sub-seafloor imaging across the continental slope of Israel. In this poster we focus on Dor Disturbance (north central Israel), located along prospective infrastructure development route and portray the combination of substantial sub-seafloor thin skin faulting, acute bathymetric steps and a dense array of submarine slide scars. Surveying utilized our newly purchased 48 channels, 3.125 m group interval, Geo Marine Survey Systems Geo-Sense streamer and Geo Source 400 sparker, both actually utilizing the frequency content of 0.5 to 3 kHz. Processing and interpretation, using Emerson Paradigm software suite, handles the high positioning resolution and sample rate of these data within an exploration standard desktop environment. Here we demonstrate the insight obtained by the high fidelity imaging in the context of geo-hazard assessment with two examples:

1) We present evidence for recent (<< ~14 ka) abrupt activity of salt tectonics in the upper continental slope and propose that the latest phase of re-activation of the imaged fault yielded a vertical offset of ~20 m.

2) We map a small scale (estimated transported volume ~ 0.05 km3 and runout distance of ~5 km) retrogressive slide complex estimated to be younger than ~14 ka. The slide complex contains five sliding event generations, an estimated ~3 ka reoccurrence interval.

Localized versus distributed fracturing in the damage rheology model with evolving yield conditions

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The process of rock faulting is different for crystalline versus highly porous granular rocks. While the first tend to form highly localized discrete slip surfaces, the later may develop tabular zones of deformation bands in several areas prior to the formation of a slip surfaces and total yield. On the other hand, some pre-failure phenomenon, such as the Kaiser effect, are observed in a wide range of rocks and materials and showcase the similarity between damage formation process in different materials.

We study the localization pattern of the brittle deformation in a framework of the damage poro-elastic rheology model with evolving yield envelope. Using a series of semi-analytical 1-D solutions, we obtain different patterns of the brittle deformations including damage localization, de-localization, and transition between the two phases, which allows the formation of runaway slip-surfaces as well as deformation bands prior to faulting. We connect the obtained deformation pattern with the amount of elastic energy stored in the bulk of the material, and the dependency of the yield cap on the accumulated damage.

The destruction of the Herodian harbor of Caesarea reconsidered

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Archaeological and geological features are used to identify sea-level changes, seismogenic events and extreme natural effects such as tsunamis, earthquakes and tectonic displacements. Ancient findings and natural deposits can be modified and displaced from their original location by various natural and man-made mechanisms, and often it is not easy to distinguish between those features. Thus, to reconstruct historic morphodynamics processes and events, there is a need to evaluate and analyze the archaeological, geological and historical evidence with caution. The Herodian Harbor of Caesarea was an important facility of the Roman Empire, and its construction was mentioned and described in details in the historian records, especially by Josephus. Roman shipwrecks recovered on the main, southern breakwater indicate that the harbor ceased to function ~100 years after it was completed. The causes and nature of the destruction are still being debated. It was proposed that the harbor was destroyed by catastrophic events such as earthquakes and/or tsunamis. Other scholars however, suggested that gradual settling derived by extreme wave storms or active creep faulting disrupted the harbor. Re-evaluation of the archaeological, geological and historical evidence may shed more light on this issue. Tsunami events and earthquakes did hit the Levant in historical times. However, no unequivocal historical, geological or archaeological evidence of a destructive earthquake or a tsunami that hit Caesarea and destroyed its harbor during the 1st century AD is known. In fact, the Hebrew sources attributed to the 115 AD tsunami (Shalem, 1956) are highly vague, and the first earthquake damage in Caesarea is ascribed to the 363 AD event. Furthermore, no clear tsunami deposits dated to the 1st century AD were identified in land excavations or in core drillings off Caesarea and off Jisr az-Zarqa (e.g. Reinhart et al. 2006; Goodman et al. 2009), as well as on the coastal lowlands south of Caesarea (Kibbutz Sdot Yam, Muassi agricultural plots and Hedera coastal area) and north of Caesarea (Taninim stream and Kibbutz Ma'agan Michael). Our interdisciplinary reevaluation suggests that the declined of the harbor was due to gradual changes rather than a single catastrophic event. The western basin of the harbor, which was built on sand in the open sea, subsided due to drift of sand and settling of several meters caused by repeating sea storms. The central basin however, which was built on the kurkar ridge, remained stable. Although the possibility that tsunami events had occurred in this region cannot be excluded, there is no conclusive archaeological, historical or geological

evidence indicating that such a destructive tsunami destroyed the Caesarea harbor soon after its construction.

The Afiq Canyon-A major fairway of Oligo-Miocene siliciclastic deposits into the Levant basin

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The Afiq Canyon is the largest erosional feature entrenched in the Late Tertiary Levant continental shelf. It extends for more than 150 km from the Northern Negev through the southern coastal plain and into the Levant Basin Offshore. The Canyon was identified in wells in the 1960's, but a detailed description of the canyon's subsurface morphology, age and geologic history were provided by Druckman et al (1995), which was the first work to suggest that the canyon was formed by submarine gravity flows and not by subaerial erosion.

More recent studies build on this pioneering work and demonstrate the importance of the canyon as a fairway for submarine, coarse-grained gravity flows in Oligo-Miocene times. Druckman et al (1995) proposed that the canyon was initiated during the Oligocene by identifying the P19-P22 biozones within several tens of meters thick marls overlying Cretaceous deposits in the Nahal Oz-1 well drilled in the center of the canyon onshore. Seismic data shows that in the offshore the Oligo-Miocene canyon below the Messianin salt is boxed-shaped, several kilometers wide features and its fill reaches more than 2 km, indicating to the intense erosion and deposition that took place on the Levant shelf at this time.

Several wells drilled offshore in the proximal part of the canyon e.g Gad-1, Nir-2 and Shimshon-1 show that the Oligo-Miocene fill contains thick beds of conglomerate and sandstone interpreted as submarine channel deposits. 3D seismic data from the distal part of the canyon show series of high-amplitude reflections which in time and depth slices display lobe geometries and are interpreted as base of slope, sand-rich turbidite fan.

The many occurrences of coarse-grained depositional features as well as the size and length of the Afiq Canyon indicate that it was a major route of transport for sediments derived from the Arabian shield and the Levant interior into the Levant Basin. The significance of these deposits to hydrocarbon exploration is not sufficiently evaluated and they may turn out to be an additional important sources of gas offshore Israel.

Using mini-posters to explain and teach geology in the field

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In Israel, hundreds of interesting geologic phenomena and varied landscapes are exposed to the public. There are several ways to guide in the field: oral explanations, teaching aids, and using songs and stories to demonstrate processes and sites.

During the last few years we have developed a simple way to share our knowledge with the public. These are simple and colorful mini-posters that serve as teaching aids for guides and teachers.

The goal of the mini-posters is to disseminate scientific knowledge about the landforms and geologic processes that form the scenery and phenomena observed in the field. We designed and distributed a large set of explanatory, colourful A3 and A4 sheets that contain graphic descriptions of natural phenomena complemented by concise explanations that are tailored for a wide audience (from independent hiker to tour guide and even for geology students).

The geologic mini-posters can be divided to two groups: 1. Universal mini-posters that contain phenomena such as rock descriptions, magmatic structures, development of floods or formation of fossils, etc. 2. Regional mini-posters that focus on the geological history of a region, display columnar sections of a region, geological cross sections or geological maps.

The mini-posters that we have developed can be used by every guide with a background in geology, with no need for professional training.

We conducted a simple research to assess the efficiency and ease of field guiding using mini-posters. The research collected questionnaires and interviews from 120 travelers and 25 tour guides. More than 90% of the travelers and guides claimed that mini-posters are the best field guiding tool. They say the mini-posters are like "field slides" that clearly explain processes and phenomena. The concise text on the back of the mini-posters is very helpful for the guides. The mini-posters are a very clear way to guide and contribute to the understanding of the material. Correct use of the mini-posters elevates the interest and pleasure of fieldtrips.

One remark that was repeatedly raised in the research is the importance of correct use of the mini-poster, at the right site and time. In order to widely distribute the mini-posters, we posted them online on the Dead Sea and Arava website - http://www.adssc.org; most mini-posters are freely

available for download. The mini-posters are sold to tour-guides, field-schools and outdoor education centers.

First evidence for high-pressure metamorphism in the Kyrenia Range, northern Cyprus

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The Kyrenia Range of northern Cyprus is an orogenic edifice that evolved in response to the Africa-Eurasia convergence and crustal accretion on the northern flanks of the southern Neo-Tethys. The range extends along most of the northern coast of Cyprus for approximately 160 km, its width is not more than 5 km and its height reaches 1024 m, it thus stands out as a remarkably elongated but narrow topographic ridge. The uplift of the range mainly took place during late Pliocene to Quaternary time, but two large-scale thrusting events that occurred by late Cretaceous and late Eocene contributed to the accretion of its rock units before. These events imbricated tectonic slices of Permian to late Paleocene carbonate rocks with various detrital rock units, including widespread mélanges and turbidites, ophiolite derived fragments and late Cretaceous bimodal volcanic units designating earlier accretion at the active margin. Two metamorphic events affected the Kyrenia range rocks, the first one by late Cretaceous and the second one by the late Eocene, eventually forming greenschist-facies metamorphic rocks. We investigated particular rock units including meta-basic rocks and quartz-rich meta-sediments that were previously mapped as basement slices of unknown affinity, and are tectonically interleaved within the Kyrenia range rock pile. Petrographic examination alongside microprobe analyses of these rocks revealed new information on the conditions of the metamorphic event that led them to their present form. At the present state of the research two samples were analyzed: a quartz-mica schist and a greenish, foliated meta-basic rock. The quartz-mica schist is predominated by alternating quartz and mica layers, the micaceous layers hosts fine needle-like green-bluish amphiboles. The meta-basic rock reveals green amphibole crystals with bluish rims, alongside white mica, epidote and clinopyroxene. The microprobe analysis of the mineral assemblages of both rocks indicated that the mica crystals have a phengite composition, the bluish crystals in the quartz - mica schist and blueish rims in the meta-basics are Na rich amphiboles. The presence of phengite crystals alongside Na-rich blue amphibole, suggests that the studied rock unit reached HP-LT metamorphic conditions and that the metamorphic pressure conditions that were attained may have been higher than thought before. Further determination of the P-T magnitude these rocks experienced will provide a new idea about the subduction depth of the Kyrenia continental fragment during the closure of the southern Neo-Tethys.

Mapping the potential of reservoir rocks in Israel using porosity and permeability measurements: the Nirim geotop project

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In the beginning of 2018, the Department of Geological and Environmental Sciences at the Ben-Gurion University hosted several groups of students from the Nirim youth village (at-risk youth) who came for full three days in order to complete their 'Geotop' – research, which they carried out as part of their five bagrut units in the field of geology. The petrophysical laboratory at BGU hosted the 'oil and gas' group, which focused on the question: which type of rocks is the most suitable for constituting high quality reservoir rocks in Israel. First, the students learned about the conditions and processes required for the creation of significant oil and gas fields and about the ways to explore them. Afterwards, we went on a field trip to observe geological structures and phenomena and to collect samples. These samples were used for laboratory measurements of the total porosity, the effective porosity, and the permeability in order to assess the suitability of the rocks to serve as reservoir rocks. Finally, each group member wrote a detailed report summarizing the results of the project, and the whole group presented their work before the rest of the groups.

In this lecture, the project will be presented according to its different stages. Additionally, the original samples will be presented and passed between the audiences, enabling each one in the crowd to try and guess which sample they think will perform as the best reservoir rock. We will summarize the implications of the findings of the Geotop Project and connect them to the latest oil and gas discoveries in the Eastern Mediterranean region in the past few years.

We are also covered by the media: http://in.bgu.ac.il/pages/news/Nirim-Youth-Village.aspx

Multi-Scale fluid substitution study for geophysical exploration: examples from organic-rich carbonate Systems

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One of the important developments in rock physics in the last decades is the significant progress in the quantification of the relations between geological processes and geophysical signatures. A key step for quantifying rock properties correctly from seismic data is to use appropriate fluids substitution calculations - a procedure which enables modeling fluid effects on rock velocity and density. Since the matrix and dry rock moduli do not change when a different fluid is introduced, these equations allow to assess the influence of different fluid properties on the saturated rock modulus. The importance of this procedure grows as seismic data are increasingly used and advanced tools such as amplitude variation with offset (AVO) seismic inversion becomes more accessible.

As part of the comprehensive investigation of organic-rich carbonate systems from laboratory rock samples and seismic data, a fluid substitution study was carried out in order to find the most suitable calculation method. The study focuses on samples from two basins in Israel and one in Texas, USA: the Shefela and the Southern Golan Heights, and the Eagle Ford Shale, respectively. Laboratory investigations show that the fundamental assumptions of Gassmann's equations are not always valid for organic-rich carbonates, hence other fluid substitution techniques should be used in this case. The Iso-Frame and Marion's BAM effective medium models were used for fluid substitution calculation and for comparison with Gassmann's equations. These models are based on the Voigt-Reuss and Hashin-Shtrikman bounds and produce more reliable results.

DULAB – Differential uplift landscape evolution box: a new apparatus for landscape evolution experiments at the scale of a mountain range

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The relief and the drainage pattern of uplifted fluvial terrains are controlled by the geometry of the basins that tile the landscape. Basins, in turn, form and evolve when fluvial incision into the bedrock takes place in response to local or far-field gradients in the vertical uplift motion of crustal rocks. As a consequence, the geometry of fluvial basins should reflect the gradients in the rock uplift rate, and when these gradients vary in time, basin geometry could change by processes of drainage network reorganization. During reorganization, water divides migrate, are breached and newly constructed as part of river capture and drainage area piracy. Despite this general understanding, the specific links between changes in tectonic gradients and the mode and rate of reorganization are far from being well understood.

To identify the various processes by which a whole drainage network responses to tectonic changes, we designed and constructed an apparatus for landscape evolution experiments called DULAB (Differential Uplift LAndscape evolution Box). DULAB is one-of-a-kind in the world for its ability to impose time-variable spatial gradients in the uplift rate that leads to drainage network reorganization in the experiments. DULAB is made of a 50 x 90 cm^2 Plexiglas frame that encloses six prisms, which are attached to six electrical car jacks. The prisms are overlaid with a sheet of natural rubber, and each experiment starts when we fill the frame with a 0.5-m thick layer of saturated silicon powder. The car jacks are attached to power supply units that are controlled by a computer program. Changes in the voltage, commanded by the code, control the rate of uplift of the attached jacks. In each experiment, we change the code to reflect the desired space-time variable uplift history of the particular experiment. Cameras document the evolution of the relief from different angles, and DEMs of the fluvial topography are generated at the post-processing stage by using a Structure from Motion algorithm.

We use DULAB to study the integration of a drainage network into a growing plateau, the evolution of fluvial relief and tectonic signal propagation in response to a step increase in uplift rate, and the effect of tectonic tilting on the spatial distribution and on the style of fluvial reorganization.

Formation of a rectangular drainage pattern governed by an orthogonal joint system and piping erosion in the Ami'za Plain, Dead Sea Basin, Israel

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The pattern of fluvial drainage networks is widely considered to be a function of environmental conditions that persisted during the lifetime of the rivers. Particularly, rectangular drainage patterns, where tributary junction angle and river bends are approximately 90°, have been previously suggested to form in association with an orthogonal system of fractures. Despite the circumstantial observational association between rectangular drainage patterns and joint systems, the physical processes by which such structures control the evolution of drainage patterns remain loosely constrained. To address this gap, we focused on the Ami'az Plain and Nahal Peratzim area in eastern Israel, where a rectangular fluvial drainage network and a system of orthogonal clastic dikes both dissect the soft late Pleistocene Lissan formation comprising the Ami'az Plain.

In this study, we conducted field surveys and analysis of high resolution topography, including ground-based LiDAR scanning and a 0.5 m/pixel DEM produced from airborne LiDAR. We mapped the primary geomorphic features that characterize the surface and shallow sub-surface environment of the plain and studied the relations between them. These features include lineations, sinkholes and 'courtyards' (Collapse structures with subaerial connection to the fluvial drainage network). In addition, we identify amphitheater channel heads, bank-parallel joints, collapse of bank material, and importantly, piping caves of different sizes. Some of the piping caves are observed within the collapsed material in the river bed, but most of the piping features form caves that extend inward from the river banks and often are connected to sinkholes. We observed that clastic dikes are typically located along the ceiling of piping caves. A morphometric analysis reveals that the dominant orientation of the lineations, which were previously suggested to form above clastic dikes, is similar to the dominant orientation of the Perazim tributaries. We suggest a positive feedback mechanism that controls the formation of the Pratzim tributaries along the dike system: Underground flow along semi-orthogonal clastic dikes (i.e., joint filled with clastic material) creates piping caves. This flow is likely to be induced by pressure gradients with zero pressure at the river bank where dikes are exposed. Lineations appear to mark the surface expression of this underground flow. Sinkholes and courtyards form where sections of the caves ceiling fail and collapse. Coalesces of collapse structures gradually form a new tributary, exposing new dikes along the banks and activating new underground flow paths. Newly formed

tributaries are then subjected to fluvial erosion and bank collapse that continuously modify their geometry.

Normal faulting above salt wedges in continental margins: numerical modelling

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Most salt basins are highly deformed and consist of complex faulting systems that is difficult to reconstruct. In contrast, in the Levant basin, the deformation of the Pliocene-Quaternary overburden on top of the Messinian salt is relatively mild, providing a rare opportunity to explore a young salt basin in its early stages of evolution. In the Levant continental margin normal faulting occurs mainly above the wedge of the salt layer where it rapidly thins from a few hundred meters to less than 100m. Recently, chronology of faulting in the Levant continental margin improved. It was indicated that during the Pliocene (duration of 2.7 My) faulting activity was minor. In the Gelasian (duration of 0.8 My) faulting activity peaked alongside huge slumping. Then, in the past 1.8 My, faulting and slumping had both decreased, although they are still mildly active today.

These observations raise questions such as: why didn't faulting start immediately after salt deposition? Why had faulting peaked when it did, and then why did it decrease? In this work we wish to understand the mechanism of normal faulting in continental slopes bordering salt basins. What drives salt motion? How does this motion cause faulting in overriding rocks? Where exactly will faults initiate and how will they progress in space? What controls the rate of faulting and when will they shut down?

This study uses 2D numerical simulations to explore these questions. The model assumes that salt behaves as a viscous material and that sediment above it behave elastoplastically. Our model uses a Stokes flow solver, specifically a finite difference/particle-in-cell numerical approach, that can simulate both viscous and elasto-plastic–brittle rheology.

Answering these questions will contribute to the understanding of halokinematics in young salt basins and will allow better assessment of seismic hazards related to salt related deformation.

A new mechanism for drainage reversal across topographic escarpments: a general model and a field example from the southeastern Negev, Israel.

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Drainage reversal is a particular mode of fluvial reorganization that occurs when a channel that used to flow in one direction reverses its flow while maintaining its own antecedent valley. Reversals are commonly identified by the presence of barbed tributaries, with junction angle >90°, that preserve the antecedent drainage geometry. This phenomenon has been documented in various settings worldwide and is particularly common along topographic escarpments. In this configuration, the reversed drainages used to flow over the escarpment highland, perpendicular and away from the escarpment, and due to reversal they currently drain toward and across the escarpment. Flow reversals are commonly attributed to tectonic tilting toward the new flow direction. However, for escarpment-perpendicular channels that reverse toward the escarpment, such tilting is inconsistent with geodynamic models that predict the opposite sense of tilting - away from the escarpment. We propose an alternative mechanism for highland flow reversal toward escarpments, that is based on preferential erosion of erodible rock types along the escarpment: (1) As the escarpment retreats, antecedent highland drainages that flow away from the escarpment are truncated, forming saddles on the edge of the escarpment. The bed of these saddles is covered by erodible valley fill. (2) Within the truncated valley, the asymmetry across the drainage divide expedites the evacuation and transportation of sediments from the saddle, down the steep slope of the escarpments face. This causes migration of the drainage divide along the antecedent valley and away from the escarpment and promotes the development of a reversed channel segment between the receding divide and the escarpment edge, where a waterfall is formed. Fluvial incision along the reversed segment further preserves the slope asymmetry across the divide that promotes the ongoing drainage divide migration along the antecedent valley. (3) Eventually, the receding divide might traverse a tributary confluence and form a barbed tributary, that comprises an identifiable morphology of reversed drainage. (4) The increased discharge that now drains to the reversed segment further enhances the fluvial erosion, and potentially promotes escarpment embayment via waterfall retreat.

We demonstrate this mechanism along highland channels that drain toward the escarpment between the southern Negev and Arava Valley in Israel. Drainage reversal is established by observations of

barbed tributaries, valley-confined windgaps, and oppositely grading terraces. We show that the reversal extent correlates with the thickness of the erodible fill, in agreement with the predictions of the proposed mechanism. This new reversal mechanism is independent of tectonic tilting, which implies that tilting is not a necessary condition for drainage reversal.

Can Sr stratigraphy dating capture the true age of nummulites from the Matred Fm., Israel?

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Nummulites are large Mg-calcite lens-shaped foraminifers which were common during the Paleogene and early Neogene period, where they inhabited shallow-water tropical marine environment. In this study the Sr stratigraphy method of dating is applied to nummulites specimens. Nummulites are present in the Matred Formation in the Negev, Israel and for the current study 7 samples were collected from several sites, each consist of 5-10 specimens who varied in diameter and evolution stage (A or B forms). The specimens are identified as belonging to the *Nummulites Gizehensis* group which generally are considered of early - middle Lutetian age (48 to 40 Ma; GTS 08).

The surface of ca. 30 sub-samples was cleaned using ultrasonic bath and tooth brush to remove any adhered particles. Samples were dissolved using 0.5 M CH_3COOH (acetic acid) until total dissolution of the $CaCO_3$ was achieved. The solutions went through Sr Ion-chromatography and Nu HR MC-ICP MS analysis following standard GSI procedures.

The elemental compositions of the solutions support $CaCO_3$ dissolution where insignificant amounts of Al, Si and S were detected, confirming that no Sr contribution from dissolution of clays or anhydrite occurred. In addition, a good correlation is observed between Ca and Sr and non between Al and Sr. Finally, the $^{87}Sr/^{86}Sr$ ratio has no correlation with 1/Sr hence no two endmember mixing behavior is suspected.

Assigning age to the $^{87}Sr/^{86}Sr$ ratio is challenging since ratios suits two age frames; one 35-48Ma and the second 52 - 63 Ma. Each sample yielded similar ages for all specimens. For example, sample DKY-4 (n=5) yielded average age of 48.3±0.4 Ma or 52.3±0.7 Ma. In general, the younger interval age is more suited to the assumed age of 40-48 Ma. Yet more questions arise such as diagenetic processes.

Insights on fluvial incision processes in an artificial landscape: preliminary results from controlled laboratory experiments

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In uplifted mountainous landscapes, surface uplift is balanced by erosion processes that remove rock volume and transport sediments in hillslopes and channels. Despite its importance, acquiring detailed information about spatio-temporal fluvial incision rates and incision processes is surprisingly challenging. To overcome this difficulty, conceptual models that describe incision rates as a function of basin morphology are widely used and commonly calibrated in the field. Controlled laboratory experiments provide a unique opportunity to study incision processes and rates in detail, by constraining climate, tectonic and lithologic parameters. Whether fluvial incision rates in these models obey similar scaling to natural incision rates remains an open question. In this study, we utilize DULAB (Differential Uplift LAndscape-evolution Box), a newly designed experimental apparatus that simulates mountainous landscape evolution, to evaluate the ability of an existing model to predict experimental incision rates. We specifically focus on the Stream Power Model (SPM) that is based on the assumption that incision rate is proportional to shear stress exerted by the flow. The model predicts that incision rate (I) scales with drainage area (A) and channel bed slope (S), according to: $I=KA^m S^n$, where K is a constant that depends on lithology and climate and m and n are empirically derived positive exponents. Under steady state assumptions, the model predicts that slope is proportional to drainage area: $S \propto A^{(-\theta)}$, where θ is the concavity index. Our experimental scheme consists of two stages: in the first stage, a low uniform uplift rate is applied, and in the second stage, the uplift is increased in a discrete time step. The latter stage is meant to simulate upstream propagating knickpoints. During the experiment, precipitation is held constant and snapshots are taken in predefined time intervals. Following the experiment, the snapshots are processed to build 3D models with commercial software that applies a 'Structure from Motion' algorithm. These models are interpolated to yield high resolution DEMs, and differences between consecutive DEMs are used to estimate the incision rate. We regress the incision rates against measured drainage area and slope at multiple locations, to yield optimal values for K, m and n. Preliminary results suggest that the concavity index is in the range of 0.1 to 0.2, which is lower than in natural settings. The experimental insights have the potential to improve our understanding of dominant fluvial incision processes in a controlled simulated landscape.

Dead Sea Fault area microearthquake observations from 4 borehole stations

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Seismological measurements conducted in deep boreholes can provide information not available in measurements taken on the surface. We demonstrate this with 4 borehole stations along the Dead Sea Fault. One is a seismometer in the Masada Deep borehole (MDBI), an abandoned oil well, at a depth of 1,256 m (1,516 bsl). This installation has been in operation since end of 2012. Recently another borehole station (YEL3; an abandoned water well) was installed in the Dead Sea basin, about 8 km south of MDBI. Both stations are located near the Western Boundary Fault of the Dead Sea basin. Another two borehole stations, about 160 km north of the Dead Sea basin, were installed on adjacent sides of the Sea of Galilee, near this basin's boundary faults.

In this talk we present observations of Dead Sea Fault microearthquakes at each station. Only a few of these events were recorded by the Israel Seismic Network (ISN). The seismic background noise reduction of these stations has obvious advantages in detection and identification of earthquakes and explosions. For example, the stations detect about 30% more quarry explosions as compared to observations of the ISN. As a result, we also show that borehole seismograms are broader-band than the on-surface observations of nearby comparable seismometers. Many of the earthquakes, sometimes in clusters, occurred directly underneath MDBI, at depths of 10-25 km. These events have unique waveforms, not previously seen in Dead Sea Fault earthquake signals. Using cross-correlation technique we have found several new locations of seismic activity, either underneath the station or along the Dead Sea Fault. To better understand these new locations and waveforms, we are seeking to add further downhole sites, including the testing of new borehole instruments and data analysis methods.

Quantifying the effects of climate properties on soil wetting depth distributions and potential proxies for depth to calcic and gypsic horizons

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Rainfall is the main driver for translocation of solutes in soils. In arid and semi-arid regions, carbonate and gypsum are accumulated in shallow soil horizons as a consequence of high evaporation and low rainfall. Depths to carbonate horizons are frequently used to reconstruct paleo mean annual rainfall as it has been shown that the two are positively correlated. Although other climatic properties also affect this correlation, such as intra-annual rain properties, they were rarely examined in the past. Here, we couple a compartment model for infiltration together with a stochastic weather generator to simulate long-term soil wetting depth distributions in soils of the northern Negev, Israel. The mean wetting depth, and depths where cumulative water fluxes are 30% of the total rainfall, correlates with depths to carbonate horizons and therefore may serve as their proxies. Our simulations show that changing the number of annual rain events or their mean rainfall depth can vary the depth of the proxy by up to 25 cm for the same annual rainfall in northern Negev and by up to 1m in areas with more intense rain storms. The potential evapotranspiration greatly affects both the trends and the depth of the proxies. For soils with greater sand-silt compositions, the effects of the climate properties mentioned above would be even greater. Other potential proxies for depth to gypsic horizons were found to be more sensitive to climate variations. To conclude, we have introduced an approach to study long term soil water dynamics and its relationship with climate properties and soil horizons. We quantify how deeper can carbonate horizons may be as a result of increased annual rainfall, lower evapotranspiration, or having fewer, but more intense storms. The results of our study can improve interpretations of past climates that are based on properties of buried calcic and gypsic horizons.

Caesarea's Cloaca Maxima: reconstructing past coastlines and the secrets of ancient infrastructure

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The Cloaca Maxima of roman and byzantine time at Caesarea, Israel, is being investigated within a multidisciplinary effort, by implementing earth sciences methods in an archeological context. The Cloaca is located on the shoreline, to the north of the ancient city of Caesarea, next to the aqueduct that has provided water to the city at past times. This study aims to answer archeological and paleoenvironmental questions, mainly regarding the Cloaca's function and its surrounding environmental setting throughout time and history. The ancient shoreline location at the area is still under debate, and searching underwater for the continuation of the Cloaca can be used as a relative marker for distance from the ancient waterline, both vertically and horizontally. This search is performed

by conducting a seismic survey in tandem with sediment sampling and coring. The original function of the Cloaca is under debate as well, mainly between its possible function as a swage drainage, to its possible function as a drainage tunnel of surplus water from ancient Caesarea. In 2010, a patch of fine silty mud was identified ~600 meters offshore of the Cloaca, suspected to be related to the ancient sewage effluent. The marine seismic survey and sediment samples taken in this study are also used to try and locate more of this mud patch, and its origin. Marine archeological excavations follow results from the seismic survey and sediment coring, held mainly in locations with a potential to find more mud patches and submerged remains of the Cloaca. Other Sub-bottom targets of interest are excavated as well, mainly within the effort to locate the ancient shorelines. The spatial understanding of the sedimentological setting offshore the Cloaca, will provide information on the environmental facies at different time periods during the Cloaca time of function, as in times it was abandoned. The terrestrial portion of the Cloaca is suffering from constant destruction and deterioration in recent years, as a result of winter storms, coastal erosion, and human activity. This study will help to gain a more comprehensive understanding of the Cloaca Maxima history, and its surrounding coastal geomorphological history, before it may be lost forever.

Mapping site-effect models for ground-shaking assessment and seismic intensity estimation for large future earthquakes in Israel

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Velocity model for site-effect characterization plays essential role for prediction of the ground-motion during strong earthquakes. Thus, building a dense grid-based velocity model for Israel remains an important task in Hazard assessment and production of the fast intensity maps during the earthquake disaster. The preliminary maps of the kind based on the VS30 (topographic inference) and soil amplification (Gvirzman and Zaslavsky, 2009) are too arbitrary and require more accurate consideration, based on the field measurements and geological expertise. Over the years, the Geophysical Institute of Israel has conducted site investigations in several thousands of sites across Israel including more than 30 towns and many surrounding villages. For each such site the multi-layer 1D soil-column and velocity models have been estimated. Based on measurements and geological data Aksinenko et al., 2013 and Perelman et al., 2015 compiled multi-layer 1D soil-column site models in a grid with 1.5 km spacing covering however, only the Northern part of Israel. Recently, such characterizations have been provided also for the sites of the Earthquake Early Warning System (EEWS) network now being constructed in Israel.

The task of the project was to review velocity models for all the sites of the EEWS and make 1D shallow velocity assessment for 123 cities in Israel with population over 10,000 and for 2000 sites of the "school seismic network" equipped by simple accelerometers within the respective project of the Ministry of Education. This data was complimented by 1D shallow velocity models, for the 60 so-called phantom station grid points covering all Israel at a distance range of about 20 km from the EEWS stations in the city centres (Pinsky et al, 2018). For the sites where there were no measurements, we collected detailed geological characteristics for each of selected sites, according to the available geological maps and geological-geophysical information and site seismic surveys conducted before. Based on geophysical data and data from previous studies the dynamic properties of different lithological and stratigraphic units were estimated for subsurface 1-D multi-layers soil column models using expert assessment method.

We anticipate that this approach is yet much more accurate than using V30 method, based solely on topography and 1-layer model approximation and more accurate than map of soil amplification.

Mass-wasting related marine geo-hazard along the continental slope off shore Israel

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Submarine mass wasting events (e.g. submarine-landslides) are part of the morpho-dynamic evolution of continental slopes. These events pose a significant geo-hazard in cases where they directly hit offshore infrastructure, or if they induce tsunami. We recently mapped 447 submarine-landslides along the south-central Israeli continental slope, which cover over 20% of the studied continental slope. Their pronounced relief suggests that these landslides are young and might pose a current offshore geo-hazard; however, their age is only vaguely determined.

Here we explore the dynamic and the temporal setting of these submarine landslides using 3-4 m long gravity-cores sampled offshore southern Israel at ~900 m water-depth. At first we CT-scanned these cores to create an X-ray based 3D tomography. Next we sliced the cores lengthwise, described their stratigraphy, and sub-sampled along their axis. We utilized oxygen isotopes and foraminiferal taxonomy along the cores to locate the transition to the Holocene (dated ca. 12 kyr). High TOC values (>2.5%) define the last S1 sapropel event (dated ca. 10-7 kyr). Adding to the above temporal proxies, a profile of radiocarbon ages (on G. ruber shells) was used to better constrain the event ages.

Based on their heterogeneous deformational structures, at least 3 suspected intervals of potential instability events were detected along core AM113 (sampled in a mapped landslide scar). Events predate S1 (located ~1m down core) and are contemporaneous or closely-predating the transition to the Holocene. The largest event, 0.5 m thick, showed mixing of glacial and interglacial foraminiferal species, in contrast to the under and overlaying hemipelagic sequences that host either cold or warm water planktonic foraminifera species. Radiocarbon-age along AM113 increases with depth and indicates an average sedimentation rate of 14 cm/kyr. However, within the instability intervals (dated: 22.1, 18.7, 14.5-12.8 kyr) ages do not increase with depth, but are rather mixed or constant. Suspected instability events were also detected in two cores sampled further north, out of a mapped landslide scar (AM015, AM137). Similarly to AM113, events predate S1 and are contemporaneous or closely-predating the transition to the Holocene. This is supported by radiocarbon ages of 16 and >30 kyr in AM015 and >22 kyr in AM137. In contrary, core AM149, sampled near AM113, reveals heterogeneous interglacial sediment all along its entire 3m, thus representing a Holocene landslide deposit.

The above novel results might suggest that mass wasting activity is declining since the transition to the Holocene, with AM149 being the single exception. Results also reveal that thin mud-flows are widespread along the studied slope, and are found in or beyond landslides scars area. We assign

relative hazard levels to the different parts of the continental slope by weighting the size of the relevant natural hazardous process and its reoccurrence-time.

Transport and accumulation of sediment and POC in the eastern Levantine basin, new insights from the DeepLev mooring station

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DeepLev is a deep-sea mooring station in the eastern Levantine basin (ELB), equipped with an array of sediment traps and instruments for measuring physical, chemical, and biological properties along the water column. The station, located ~ 50 km offshore Haifa, at a depth of 1500 m has been deployed since November 2016. Using particle flux data and current measurements from DeepLev we show that despite the mooring's distance from the coast and the open-sea characteristics of the water column, the bulk of sediment fluxes to the seafloor at the study site arrive via lateral transport from the continental margins. This happens mostly via plumes of intermediate nepheloid layers, entering the study area between depths of 180 and 800 m. Bottom currents at the study site are weak (average ± SD = 3.5 ± 2 cm s^{-1}) and are unlikely to further remove settled sediments. Based on sediment fluxes in the traps and sedimentation rates in sediment cores, we calculated the total and particulate organic carbon (POC) accumulation rates at the study site as 95 to 110 and 0.5 to 0.6 g m^{-2} y^{-1}, respectively. About 1 g m^{-2} y^{-1} of the POC flux to the seafloor decomposes in the sediment. Offshore changes in sedimentation rates and in surface sediment elemental ratios, show that sediment inputs from the margins reach and may dilute sediment fluxes from the upper water mass (photic layer), to a distance of 100 km offshore, and possibly more.

The origin of oceanic plagiogranites: coupled SIMS O and U-Pb isotope ratios and trace element contents of zircon from the Troodos ophiolite, Cyprus

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Oceanic plagiogranites have been suggested to form either by extreme fractional crystallization of mantle-derived mafic melts or by partial melting of hydrothermally-altered mafic crust. The uniform mantle-like $\delta^{18}O$(Zrn) of the modern lower oceanic crust could be viewed to favor closed system magma differentiation, however some ophiolites bear lower than mantle $\delta^{18}O$(Zrn) values, indicating a certain contribution of altered crust. In the Troodos ophiolite, Cyprus, plagiogranites are well exposed at the sheeted dike-gabbro transition zone and their chemical compositions extend along crystal fractionation trends of both tholeiitic and boninitic lava series. Crustal anatexis is evident, however, by the occurrence of migmatites at the roof of a gabbro intrusion. Here we report U-Pb ages, trace element compositions and oxygen isotope ratios of single zircons from five plagiogranite intrusions of the Troodos ophiolite using Secondary Ion Mass-Spectrometry (SIMS). Our results support previous studies that show that the main phase of tholeiitic magmatism in Troodos took place at 92 – 91 Ma. An earlier phase of incompatible element-enriched magmatism is identified at 94.3 ± 0.5 Ma. Boninitic magmatism in Troodos overlapped the main tholeiitic phase, at about 91 Ma. Average $\delta^{18}O$(Zrn) values in the Troodos plagiogranites range between 4.18 and 4.75 ‰. The lower values in this range are significantly lower than those expected in equilibrium with mantle-derived melt (≥4.7‰), indicating substantial contribution, up to ~40% in some intrusions, of hydrothermally altered deep-seated oceanic crust. The inferred crustal assimilation suggests the existence of a shallow axial magma chamber, typical of fast spreading MOR settings, within the Troodos slow-spreading ridge environment. This apparent contradiction may be reconciled by episodically intense magmatism within an otherwise slow, magmatically-deprived spreading axis.

High-density fluids and time-temperature history of diamonds from Venetia, South Africa

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Fibrous diamonds reflect fast growth from a super-saturated medium under high driving force conditions. This leads to entrapment of numerous nanoinclusions (commonly 100-500 nm) that give the diamond an opaque or translucent appearance. The nanoinclusions trapped high density fluids (HDFs) from which diamonds grow during a metasomatic event. The HDFs range in composition between four end members: a saline melt, high-Mg and low-Mg carbonatitic melts and a hydrous silicic melt. All carry carbonates and water and are rich in K and incompatible elements.

Most diamonds carry nitrogen that replaces carbon atoms in the diamond lattice. The nitrogen enters as single substitution (C-center) and migrates to form pairs, substituting for two carbon atoms (A-centers). Two A-centers couple up to a B-center; a carbon vacancy surrounded by four nitrogen atoms. The aggregation process is a kinetic phenomenon and depends on the nitrogen content, on the residence time of the diamond at mantle temperatures, and on the temperature. The kinetic process is commonly used to determine the diamond mantle residence time or the average temperature residence history of the diamond. For typical cratonic lithosphere temperatures (~1100 °C at 5-6 GPa) and diamond nitrogen concentrations of few 100s ppm, the transition from C- to A-centers takes millions of years and from A- to B-centers – billions of years. Most diamonds carry both A- and B-centers, which reflect long resident times. In contrast, most fibrous diamonds carry only A-centers (only few were found to have low proportion of B centers), suggesting a short mantle residence of less than 100 Myr.

Here we show results from 9 fibrous diamonds from the Venetia mine in South Africa. The HDFs in the Venetia diamonds show high-Mg carbonatitic compositions, similar to diamonds from Siberia and Guinea. Their unique characteristic is an unusual high N aggregation state (up to 60-90% B-center). The high proportion of B-centers can be caused by high temperatures or by a long mantle residence time (2-3 Gyr). Assuming these diamonds are ~100 Myr old, we obtain temperatures in the range of 1115-1325 ºC, higher than common lithospheric temperatures recorded by diamonds. It is possible that the diamonds are older. For residence time of ~2 Gyr (the age of octahedral diamonds from Venetia), we calculate temperatures in the range of 1150-1230 ºC. Alternatively, the diamonds may originate from deeper levels, where HDFs are stable at higher temperature.

Comments on the use of numerical models in planning coastal constrictions in Israel.

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The use of numerical models in planning coastal constrictions in Israel is a common presider. However, oversea consultants who are not fully know the Israeli coast run most of the numerical models used in the last 10 years. Therefore, many of the assumptions made were wrong in: a) sand availability b) wave direction c) grain size d) model calibration e) coastal management.

Not even in one single case were the model's results accepted by the Israeli reviewers without major changes.

Late Permian distal northern edge of the world-wide Gondwanan Paleozoic siliciclastic belt; insights on the end of the period as recovered from Pleshet 1 and David 1 boreholes by foraminifera and stable isotope systematics, Judea Graben margins, Levant Basin

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This research examined two successions from the SE Levant Basin, Judea Graben margins, that were facing the proximal marginal marine of the western tropical Tethys seaway; a zone under constant terrestrial siliciclastic influxes (up to 90%; Saad and ‘Arqov formations) during climate warming trends. the Guadalupian-Lopingian boundary (GLB; global event) is defined below the FA of the BF species *Codonofusiella kwangsiana, C. erki* and *Paraglobivalvulina mira* assemblage, and appears at awakening stage of carbonate recovery level reached 55%, a change supported by stable isotope positive excursions (climate cooling trend). The Wuchiapingian-Changhsingian boundary (WCB; global event) is defined by the decline of the Palaeofusulinidae, followed by the prevail of Ozawainellidae; the WCB is marked below the FA of *Reichellina leveni, R. pulchra, R. media, Colaniella minuta and C. minima* assemblage, and corresponded to a global warming and carbonate content reduced in sediments. This work shows: 1. the close connection between global warming trend and the development of intensive light isotopes contribute systems that overprint on distal carbonate far in the marine system. 2. the ca. 30% carbonate content as a marked turning point from hostile to a supportive environment for relative LBF. 3. the very ability to correlate known global events, with the changes in the tropical super-continent-marine-connected belt that itself is actually the global climate driving force, by that to provide complementary insights into the end-of-the Palaeozoic-life factors.

TRUA Project: upgrading Israel's seismic warning network – towards earthquake early warning in Israel

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The Geological Survey of Israel is in the final Stage of upgrading the seismic network of Israel, aiming to achieve Earthquake Early Warning capabilities for the state of Israel. The new network will consist of 120 stations, 24 of them are with co-located broadband seismometers and strong motion accelerometers, and the rest with high-quality strong motion accelerometers. In addition, the network will consist of 8 stations with high rate GNSS instrumentation. The network will have many levels of redundancy in order to achieve high availability of the network in cases of crisis. The network is designed to have two routes of telemetry from each station, in which the fast route will have <1s latency, while the backup route will have <3s latency.

The new seismic network has been going through the upgrade and expansion process since June 2017, consisting to-date: a) 94 out of the 120 stations planned, and b) 2 datacenters, one as main and the other as recovery. Both data-hubs are currently collocated for testing in the Seismology division at the Geophysical Institute in Lod. Once tests will prove an efficient operation and synchronization between both data-hubs, the main data-hub will be re-located to the new Geological Survey location in Jerusalem. Data is already available through an FDSN server operated by the Division of Seismology (see poster of Nof et al. 2019), and the high density continuous data acquisition had already proven to add significant data to the seismic catalogue in Israel, especially during the July-August 2018 seismic swarm in Sea of Galilee. In addition, still in testing mode, but hopefully operative by the end of 2019 – we hope to achieve full operational capabilities by the end of 2019, with the Earthquake Early Warning System.

The role of pre-magmatic rifting in shaping a volcanic continental margin: An example from the Eastern North American Margin

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Both magmatic and tectonic processes contribute to the extension and breakup of the continental lithosphere leading to the formation of volcanic continental margins. Whereas crustal structure and the tectonic processes that shape it are well constrained in magma-poor margins, much less is known about pre-magmatic rifting at volcanic margins. The evolution of volcanic margins is typically considered to be short-lived leading to a relatively narrow margin (<150 km). Yet, this model fails to explain wider volcanic margins as well as variability in width along some margins. To further examine the pre-magmatic phase of volcanic margin formation, we mapped and studied the structure of the Eastern North American Margin- a classic example of a volcanic margin. With more than 300,000 km of seismic reflection data tied to 40 wells along with published results of refraction, deep reflection, receiver function and onshore drilling efforts, we observed and quantified along-strike variations in the distribution of rift related structures, magmatism and post-rift sedimentation. Results indicate that the southern segment of the margin is narrow (80-120 km) with a sharp hinge. A wedge of basalt flows in the form of seaward dipping reflectors is located under the continental shelf, ca. 50 km seaward of the hinge zone. The northern segment is wider (up to 200 km) and its rift-related volcanism is found under the continental rise, about 200 km seaward of the hinge zone. Whereas in the southern segment few rift basins were identified, the northern segment has well-developed synrift structures with detachment faults that sole into the middle crust. Early post-rift depocenters, treated here as proxies of thermal subsidence, overlay areas of thinned continental crust in both segments but spatially correlate to the breakup volcanism only in the southern segment. We suggest, that the distinctive crustal structure and distribution of volcanism at each volcanic segment points to different modes of rifting. The southern segment had undergone little thinning prior to the volcanic phase and/or thinning that was highly localized to the area of future breakup. Pre-magmatic thinning in the northern segment was more profound and not restricted to the area of future breakup. Post-rift thermal subsidence, as indicated by the distribution of early post-rift rocks, was produced by cooling from two separate processes: 1) lithospheric thinning, and 2) breakup-related magmatic additions. The extent of pre-magmatic thinning of continental crust may be important for understanding variations in basement morphology, fault geometry and sediment thickness in volcanic margins.

Detecting Plio-Quaternary gas accumulations migration and seepage patterns offshore Israel

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Recent seafloor exploration campaigns offshore Israel, namely E/V NAUTILUS 2010 and 2011 surveys and EUROFLEETS SEMSEEPS 2016 project, discovered several seafloor fluid seepage features (e.g. pockmarks, cold seeps communities and hydrocarbon-related microbial activities) at the base of the south-eastern continental margin of the Levant Basin and the eastern border of the Nile Deep Sea Fan. To-date many uncertainties exist as to the controls on the distribution of these features, the nature and sources of fluids feeding them and fluid migration pathways.

Here, we employ detailed interpretation, attribute analyses and RGB blending techniques on commercial (12.5 m) resolution 3D seismic datasets to identify and characterize seafloor seepage edifice, and examine the controls on their distribution. The research is currently focused in water depths of 1000 to 1300 m around the compressional domain of the Palmahim Disturbance, a large-scale salt-controlled rotational slide in the southern continental margin of Israel. We identify possible fluid migration pathways within the Plio-Quaternary sedimentary stack, through which the seafloor seepages may be fed.

Pockmarks are observed in the seismic data as: 1) ridge-crest centered seafloor depressions, underlain by high amplitude anomalies and sub-vertical acoustic masking effects; and 2) sub-circular seafloor depressions sitting atop a pervasive, multi-level and discontinuous system of sub-seafloor high amplitude reflectivity, to the west and south of the Disturbance. Maps created by RGB blending of multi-level seismic attribute extractions reveal that the pervasive high amplitude reflectivity represents a buried channel-levee system. The RGB maps also reveal a number of localized high amplitude responses on the seafloor, e.g. at areas where a seafloor channel incises the sub-seafloor high amplitude reflections.

Our analyses reveal high amplitude anomalies, which are suggestive of gas accumulations around the base of fault-bounded Plio-Quaternary MTD blocks lying hundreds of meters below the ridges-confined seafloor pockmarks. Consequently, we hypothesize that the seafloor high amplitude responses represent seepage features and that channel incision of gas-rich paleo-depositional elements (channel-levee system) and breaching of sub-seafloor seals facilitate fluid escape along the walls of the channel. This hypothesis is supported by field observations of the 2016 SEEMSEEP cruise. We suggest that two closely-interacting fluid plumbing systems are active in the study area, within which fluids are conveyed via lateral-to-updip and/or sub-vertical routes: a) shallow gas bearing

intervals, within sub-seafloor channel-levee complexes, from which fluids escape with a predominant paleo-depositional control; (b) deeper gas bearing intervals, within folded and faulted blocks, from which fluids escape with a predominant structural control. These results provide an example of the variability of gas accumulation and migration pathways during the formation stages of a microbial (biogenic) gas system.

Intermediate dense water formation and current variability at the DeepLev moored station in the southeastern Levantine Basin

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We present an eighteen month long (Nov 2016-June 2018) high-frequency record of velocity, temperature and salinity of the entire water column (1500 m depth) at the DeepLev station in the southeastern Levantine basin, 50 km off-shore Israel. Continuous temperature and salinity records at the LIW core, and down to 400 m depths, show first concrete evidence for LIW formation in this area during February-March 2017 and January-February 2018. Current meters throughout the water column reveal two separate water masses in terms of velocity. The upper 200 meters and the lower 1000 meters (from 400 m depth almost down to the seafloor), are each completely barotropic and decoupled from each other. The upper layer has a strong seasonal cycle, with strong currents in winter reaching 50 cm s−1 and weak in the summer, whereas the deeper layer shows no seasonal cycle. Near-inertial waves dominate the spectrum at all measured depths.

Mount Sedom salt diapir as a source for solute replenishment and driving force for dilution of the deep last glacial Dead Sea (Lake Lisan)

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During the late Quaternary several hypersaline lakes occupied the tectonic depression of the Dead Sea basin, depositing sequences of primary-evaporitic mineral phases: aragonite, gypsum and halite. Halite was mainly deposited during arid interglacial periods, whereas aragonite and gypsum were the dominant phases during the wetter glacial periods. The formation of aragonite and gypsum required significant import of bicarbonate and sulfate ions to the lake. While bicarbonate was likely derived from dissolution of limestone and calcitic dust that were available in the watershed, the sources of sulfate remained elusive. Here we investigate and quantify the long-term changes of the sulfate reservoir in the deep last glacial Dead Sea (Lake Lisan) using concentrations and stable isotopes in pore-fluids from the Dead Sea Deep Drilling Project (DSDDP) cores that were drilled at the modern lake floor (2010-11). In the extended last glacial sediment interval of the deep-lake core, sulfate concentrations increased and reached supersaturation with respect to gypsum, peaking at the last glacial maximum (ca. 20ka). Over the entire depth, stable isotopes of sulfate ($\delta^{34}S$ and $\delta^{18}O$) are similar to the values found in bulk sulfate minerals on Mt. Sedom. We suggest that the combined dissolution of halite and anhydrite on Mt. Sedom provided the ions required for the accumulation of chloride, sodium and sulfate in the deep lake. Relatively diluted paleo-epilimnion water facilitated the dissolution on Mt. Sedom, resulting in a localized increase in solution density. This solution subsequently sank and mixed with the saline hypolimnion water, simultaneously enriching the chloride, sodium and sulfate reservoirs, while diluting it with respect to other solutes.

Wide angle seismic refraction survey across the Dead Sea fault and along Jordan Valley, northern Israel

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The main objective of the research was to obtain an image of the Dead Sea fault sub-surface geometry and a map of the sub-surface seismic velocities along the axis of the basin to a depth of 15-20 km at a resolution of ≥1 km.

Two perpendicular wide angle seismic refraction / reflection cross-sections were acquired in order to image the Dead Sea fault structure in the northern part of Israel; A west-east line, from the Mediterranean coast line near Acre in the west to the Syrian border in the Golan Heights in the East with total length of 72 km; A south-north line, from Kibbutz Kfar Rupin in the south to Almagor settlement in the north crossing the Sea of Galilee with total length of 50 km. The seismic energy sources were 12 underground explosive shots, 300–400 kilograms each located every ~10 km, while the 550 seismic receivers were located every ~200m along the lines. Additionally, the array recorded 143 earthquakes and mining explosions from the surrounding area, which will be analyzed for a more regional crustal structure.

The results are 13 shot gathers showing medium quality data. First results of refraction waves gives a penetration depth of about 8 Km probably imaging the crystalline basement. More detailed models will be presented.

Characterizing seismites with anisotropy of magnetic susceptibility, Dead Sea Basin

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Characterizing seismites is a key factor in understanding earthquake kinematics and dynamics. Usually, the rearrangement of the deformed volume is typically not well understood, hampering the possibility of inferring their kinematics and dynamics. In order to overcome these difficulties, we analyzed the anisotropy of magnetic susceptibility (AMS) of various seismite types and late Pleistocene syndepositional normal faults that have been formed during the activity of the Dead Sea Fault (DSF) system. In this study, the magnetic lineation (L) and the shape of the AMS ellipsoid (T) of the seismites were presented in a newly constructed T-L plot. Depending on the type of material, the seismites were distinguished according to the following characteristics. Injection structures are characterized by a nonlinear correlation curve; damage zones lie on a common linear correlation curve; earthquake-triggered folds also show a linear correlation with those that have undergone major deformation displaying low T and high L values. Breccia layers show a range of T and L values similar to that of primary sedimentary layers, implying that such seismites were formed by material deposited from suspension immediately after an earthquake.

Our results also demonstrate that the associated inelastic deformation zones are compatible with coseismic dynamic faulting and the effects of the local strain field during earthquakes. Most of the AMS fabrics show a conspicuous similarity to that of the fault-plane solutions.

This novel application of AMS provides an effective tool for: i) defining the shape of the damage zones; ii) determining the principal axes of the local strain field and; iii) resolving the kinematics and dynamics of a wide variety of seismites in soft rocks. We outline a robust procedure to infer the seismite mechanism which is helpful in recovering paleoseismic records in complex geological settings and defining potentially hazardous geological areas.

Hydrogeological modeling of the eastern mountain aquifer, Israel

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Terminal Lake levels fluctuate in time as a result of climate change and/or anthropogenic reasons. This phenomenon has recently occurred in some lakes around the world (e.g. Aral Sea in Uzbekistan, Lake Urmia in Iran, Chad Lake in Africa, Mono Lake in California, etc.), which serve as a discharge base of groundwater basins.

In this study, the effects of extreme fluctuations of the Dead Sea and Lake Lisan Levels on the flow field of the Eastern Mountain Aquifer (EMA) were examined by a numerical hydrogeological model and found to be significant. The model was first calibrated to the current condition and then simulated the paleo and future groundwater-flow-field within the EMA. The results show that currently, 90% of the EMA water discharges in springs located at the Dead Sea shore, at an elevation of ~-430 m below sea level (mbsl), with almost no discharge north of the Dead Sea. However, when Lake Lisan stretched over larger area within the Jordan Valley, at elevations of -160 to -250 mbsl, as much as 35% of the EMA water discharged through paleo-springs at the central Jordan Valley (Jericho-Gilgal-Fazael area).

The high levels of the Lake Lisan affected the groundwater flow pattern by two means: (1) The hydraulic gradient was different from the current one, thus the flow from the Samaria Mountains discharged in the close paleo-springs, in the central Jordan Valley; (2) The groundwater flow within deep sub-aquifers was blocked due to higher location of the fresh-saline waters interface. Furthermore, the modeling show that as the Dead Sea level drops down to ~-550 m, as expected to occur in the next centuries, the current coastal springs will dry up and the groundwater will migrate and discharge close to the Dead Sea along delta-fans. The water of Zukim springs will migrate to Kidron fan, while the water of Kane-Samar springs will migrate to Darga fan.

The controls of pre-MSC Morphology on the thin skin deformation patterns and styles at the Dor disturbance offshore Israel

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Thin-skinned tectonics plays an important role in passive continental margins shaping and stability. The deformation of salt and overburden manifests as an intricate pattern of faulting and sub-basins formation. The regional displacement of salt and overburden across the Israeli continental margins was discussed by past studies. However, the local 3D complexity of deformation and its modes have not been fully addressed. This seismic interpretation study addresses the kinematics of the Dor Disturbance, a prominent focus of thin-skinned tectonics complexity offshore north central Israel, covering an area of c. 40 km^2.

To examine the control of the pre-MSC morphology on the thin-skinned deformation, we analyzed the structural elements of both the Dor Disturbance and the base Messinian surface (N). Analysis combined the interpretation of three 3D seismic datasets and a grid of 2D seismic profiles. More than 500 fault segments were interpreted across the study area using both amplitude sections and coherence slices. Our results find three main classes of faults within the study area. These classes delineate three different domains of the Disturbance: (1) Upper slope extensional belt, which is dominated by normal faults that are rooted into a pre-kinematic Pliocene unit; (2) Base of slope extensional belt, which is dominated by normal faults that are rooted into the base Messinian surface N; and (3) Translational domain that is dominated by oblique or pure strike slip faults, which are interpreted as dextral faults. The two extensional belts converge to one system at the center of the Disturbance and diverge southwards. The base Messinian N-surface slope is steep and semicircular around the center of the Disturbance, and becomes gentler and wider, forming two to three steps in the southern part of the Disturbance. In general, the N is inclined to the west-northwest. An exception is a c. 6 km belt ~30 km southwest of the Disturbance focus, where the dip is directed southward, and the gradients are significantly lower. The translational domain defined above is located above this belt. Furthermore, a Ramp Syncline Basin is located to the south of the Disturbance at the Messinian rooted extension domain, with a close association to a pronounced step of the N.

An estimation of flow direction was obtained from the dip and dip-azimuth of the N-surface, indicating a match between the faulting directions in the different domains and the estimated flow vectors.

Moreover, the maximum thickness of the Plio-Quaternary overburden coincides with a convergence of the flow lines. Therefore, we conclude that the pre-MSC morphology has a key role in setting the deformational patterns of the Dor Disturbance, explaining its complex 3D kinematics.

General trends of the top sand unit along the coastline of southern and central Israel

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We mapped the regional trends of the top sand layer along the coast of southern and central Israel, and characterize the sand in this layer. This work is based on a comprehensive, as much as possible, collection of existing datasets, which was a major challenge by itself. In total, our database combined 451 seafloor sediment samples from 12 reports; 126 lithological logs, from 6 surveys, of which 88 logs were sampled at water depths ≤35 m; and 11 high-resolution seismic surveys, with a total running profiled length of ~4,000 km, of which 1181 km were acquired at water depths ≤35 m. This pervasive database still leaves significant holes in the coverage of the research area, particularly near the coastline in its southern part.

Across the entire research area the top sand layer contains, at the seafloor, fine (0.125-0.25 mm) clean (usually >95%) sand to a water depth of ~30 m, ~3 km from the coastline. Beyond that depth, there is a sharp transition to silty-clayey sediments. The median grain sizes (D50) decreases from 0.23±0.03 mm near the coastline to 0.15±0.03 mm at a distance of ~1 km from the coastline, and a water depth of ~15 m. At greater distances and water depths the sand D50 remains approximately constant at 0.15±0.03 mm. A few samples, which were collected 1 m below the seafloor, suggest that the presence of D50 >0.2 mm is limited to the proximity of the seafloor. At depth the small grain sizes are more abundant closer (at least to a distance of 200 m) to the coastline.

In the northern part of the research area there is a series of Kurkar ridges, sub-parallel to the coastline. Along most of the coastline and to a distance of at least 1 km from it the Kurkar is exposed or shallowly (<6 m) buried. However, to the south of Tel Aviv Kurkar bodies are prominently found in different and not correlated sub-surface levels. Elevated areas of exposed or shallowly buried Kurkar bound relatively large basins (to depths >30 m) aligned possibly along drainage outlets.

Along most of the research area the top sand layer is thin (<2 m thickness). It thickens slightly, reaching thicknesses >4 m, only along a narrow (~1 km wide) set of slivers, which stretch sub-parallel to the coastline at a distance of ~1.5 km and ~2 km from it in the south and north respectively. The total sand volume in this layer across the research area is ~700x106 m^3, out of which ~450x106 m^3 are concentrated in the sand slivers; the majority of this sand is characterized with D50 of ~0.15 mm (and certainly less than 0.2 mm).

Seafloor gas seepage in the southeastern Mediterranean Sea: controls and implications

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A variety of seepage features were recently discovered in the southeastern Levant Basin. Here we provide a preliminary review of the scope, geological context and variability of gas seepage within the relatively small Israeli offshore. This review encompasses a set of works, and is based on geophysical analysis of 3D seismic data, coupled with ROV surveying of E/V Nautilus in 2010 and 2011, the EUROFLEETS2 2016 expedition SEMSEEPS onboard R/V Aegaeo, CSMS-IOLR 2017 ROV cruise and some of Leviathan Partnership extensive seafloor AUV and ROV surveying. The seepage features include pockmarks of various types and sizes; carbonate buildups, intense seafloor perturbations, chemosynthetic fauna and sporadic gas bubbles emission. The predominance of microbial methane within these seeps is preliminarily suggested by two short sediment cores, and low $\delta^{13}C$ values of authigenic carbonates and sampled biota. Two distinct domains of 'active' seepage edifice are defined by us. The first relating to shallow buried channel-lobe complexes of the Nile deep sea fan, and the other relating to salt retreat structures at the base of the continental slope of Israel. The Nile fan seepage sites may be associated with changes in the boundary of hydrates stability, currently at 1250 m water depth. Additional, apparently inactive and presumably more ancient, seepage related carbonates currently host an overgrowth of deep-sea corals and associated phenomena. Activity of these seepage edifices is suggested to be controlled by changes in the water properties of the Levantine Deep Water, as a consequence of global and regional changes. Importantly these seepage-related features constitute biological and biogeochemical hotspots, which may have a crucial environmental role in the ultra-oligotrophic southeastern Mediterranean.

Seismic volume interpretation, there's more to the picture than meets the eye

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In order to demonstrate the advantages of volume interpretation we compare this novel approach to ‘standard' conservative interpretation methods, using examples from the East Mediterranean and the North Sea. We highlight hidden stratigraphic and structural features using spectral decomposition (GSD), 2D reconstruction and geobody extraction (multi-volume based).

At first we model a “wedge modeling” to analyze vertical resolution and estimate frequency limitation around pinchouts. Results were used to extract subvolume using top and bottom interpreted horizons and with the projection of amplitudes on both we were able to map accurately ancient shorelines.

To accurately analyze faulting we reconstruct offsets in 2D, comparing reflector packages on either side of the fault. Covering the section with a heterogeneous mesh we are able to estimate shear and dilation across the fault and quantify extension within the section boundaries. Applying this technique on numerous faults proves useful for classification of fault growth models.

In order to identify hidden stratigraphic features we decomposed spectra of multiple seismic volumes containing narrow frequency bands. We blended the output into a single volume, color coded for each input frequency. Using this workflow we were able to reveal and isolate hidden features like a buried river at a depth of about 400m below sea level that would not be identified in a standard amplitude 3D volume due to small amplitude contrast.

These advanced methods and others enable a deeper understanding of the subsurface through the constructing of more reliable models, the computation of volumes and sediment quantities, and a more precise mapping of geological structures. This provides valuable insight for the purpose of both research and industry.

A review and new insights into potential source rocks for hydrocarbon generation in the Levant Basin

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Organic-rich sediments are a critical component necessary for the formation of economic hydrocarbon accumulations. We present an overview of source rocks (SR) in the Levant, and our new data and ideas regarding SR potential in the region. Shallow to deep-water marine environments have characterized the Levant region for over 300 Myr, which resulted in several potential source rocks:

Upper Triassic-Lower Jurassic, probably shallow water SR, are assumed to directly undelay mature oil shows in the Yam wells, at great depths (>5000m). Age equivalent SR feed major oil fields in the Arabian Plate (e.g., Iraq, Saudi Arabia, Qatar), yet are not proven as SR in the peri-Levant.

Middle to Upper Jurassic SR are abundant in the Levant region. They include the Barnea, Zohar, Sderot, and Kidod formations, spanning the Alenian to early Oxfordian. Some speculate that the Barnea Fm is the source for the Heletz oil, found in contact with it. However, this is controversial. Kimmeridgian and Tithonian (uppermost Jurassic) SR are known from the peri-Levant, e.g., in the coastal region of Antalia, around Jeita, in northern Lebanon, and in Egypt. However, no equivalent organic-rich strata are reported from Israel.

Lower Cretaceous SR are presumed to have sourced several oil shows in the region, although definitive proof for this is lacking. Organic-rich sediments of this age are abundant across the Levant and neighboring areas (e.g., Gevar'am Fm, Alam El-Bueib Fm).

Upper Cretaceous oil shale deposits are by far the richest, thickest, regionally pervasive, and show the highest hydrocarbon-generation potential of the SR in the region. Their distribution and low maturity onshore raises questions as to their potential to generate oil and gas in the offshore.

Eocene deposits were never included in the list of potential SR in the Levant. However, here we present results from a lower-mid Eocene 150m thick organic-rich section from northern Israel. Our study is supplemented by known Eocene SR intervals from Syria, Jordan and Egypt. Together these imply that the upwelling-induced high productivity event did not terminate in the Upper Cretaceous, as previously assumed.

The Miocene to Plio-Pleistocene shales and marls have moderate to good SR properties and are likely sources for the Yafo petroleum system. These SR are not relevant for deep hydrocarbon prospecting of the distal Levant Basin. We present new data regarding the potential of Miocene deposits from the Dolphin-1 well offshore Israel.

Lastly, we present examples of SR consisting of terrestrial organic-matter in the region, potential sources for the Mango-1 and Ziv-1 oil shows, as well as results from a newly drilled onshore Lower Cretaceous section in northern Israel, consisting of terrestrially-derived organic-matter. Together with the Gevar'am Fm, this attests to a regional organo-sedimentary system transporting organic-matter towards the deep Levant Basin.

Geological provenance of decorative tiles and cookware, made from bituminous chalks discovered in archaeological sites in Israel.

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During the past 30 years, bituminous chalks (oil shales) have been uncovered at archaeological excavations in Israel, particularly from Roman-Byzantine times. The objects range in size from large building tables (up to 0.6 m) s to cookware and to small mosaic tiles. For example, large slabs of oil shales where used in the construction of the decorated hexagonal ambo (stage) of a church discovered in the early 1990s at Khirbet Beit-Silah (north of Givat Ze'ev) and today on display at the Museum of the Good Samaritan in Ma'ale-Adumim. In other sites, smaller building tiles, whose color range from grey to green were uncovered. Their function was largely decorative, used for adornment. Smaller cubic tiles of oil shales that had been used in mosaics, have also been uncovered. Indeed, the finds can be classified into three groups:

A. Relative large slabs (as pieces of the Beit-Sila Church) and kitchenware (e.g. the Jumbo Tray found at the Martirius Monastery at Ma'ale Adumim)

B. Building tiles, of various sizes, used to adorn special structures, such as the water pool at Bet-Shean.

C. "Non-Tumeah" cookware and utensils, made from bituminous chalks having relatively lower organic- matter content.

The question arises as to what was the source rock and where was it quarried for each of these groups. Preliminary research indicates that group used a different rock source:

The A group was probably quarried from partially metamorphosed bituminous chalks from the highlands of central Jordan, east of the Dead Sea. The rock sequence is probably correlative to sections of the Mishash Formation in Israel. The partial metamorphism that the rocks underwent contributed to imparting improved strength and durability. This made them suitable for use as building material in relatively large structures.

The tiles of the B group can be sourced to coming, in part, from either the quarries suggested for the A group or from more local sites such as Nabi-Musa and east of Bethlehem.

The source of the bituminous chalks of relatively low-organic matter content was probably the Menuha Formation in the Judean Hill, such as from the old quarry, east of Mount Scopus. This material (C group) was used during the 2nd Temple Period for producing "kosher" kitchenware.

Global pattern of strong triggered earthquakes

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Remotely triggered shocks (earthquakes that occur at large distant over the globe interacting one with another) represent a central focus of recent studies and remains one of the most least understood aspects of earthquake behavior. Several studies have shown that there is a connection between earthquakes over great distances, but no global pattern has been suggested. Here we suggest that the majority (92%) of all recorded M≥6.6 earthquakes since 1900 occurred in an orderly global pattern. In this pattern the initial (first) earthquake of high magnitude is triggering, within weeks, one or more earthquakes of similar magnitude. The remotely triggered event(s) occur at the same or anti-latitudes in a different seismogenic zone , hundreds and thousands of kilometres from the epicenter of the initial earthquake

A statistical analysis of such clusters of time depended earthquakes, so far analyzed, demonstrate that the probability of successfully forecasting the triggered earthquakes who followed the suggested pattern is by orders of magnitude higher than the probability of random occurrence of a strong earthquake in the triggered area. This observation is likely to lead to operational earthquake forecasting, despite the fact that the possible triggering mechanism is yet unknown.

Provenance of the siliciclastic Miocene sections in Israel defined by detrital zircon U-Pb-Hf: similarities, variances and plaeogeographic implications

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The Miocene continental section in the area adjacent to the east of the Levant Basin, in Israel and Jordan, includes two main sedimentary provinces: 1) A southern province whose outcrops occur in the Negev and nearby areas in Jordan, and are included in the Hazeva (Israel) and Dana (Jordan) Formations. 2) A northern province whose outcrops occur in a restricted area near the Sea of Galilee, and are included in the Hordos Formation. The southern province is considered a long-distance fluvial system that transported sediment from the uplifted shoulders of the Red Sea Rift toward the Levant Basin, whereas the provenance areas and sediment transport directions in the northern Miocene province are poorly constrained. In order to examine their potential provenance areas and possible sedimentary linkage we have conducted a combined study of heavy mineral assemblages, detrital zircon and rutile U-Pb dating and zircon Hf isotope analysis in a set of samples from these two sedimentary provinces. Our results show that the detrital zircon populations in both sedimentary provinces are dominated by Neoproterozoic ages (550-1000) and negative $\epsilon Hf_{(t)}$ values, a priori in line with recycling of older Paleozoic and Mesozoic sandstone. The Neoproterozoic-aged detrital zircons in the Hazeva Formation show clear bimodal distribution peaking at 600-650 and 950-1000 Ma, resembling the detrital zircon spectra in the Cambro-Ordovician and early Cretaceous sandstones of southern Israel and Jordan. However, the distribution of Neoproterozoic zircons of the Hordos Formation yields a prominent age population at 700-800 Ma. Such an age distribution was never observed in the sandstone packages of Israel and Jordan, in which the 600-650 Ma population is generally the most prominent. Inspection of previously-published detrital zircon U-Pb data from the Middle East indicates that the detrital zircons age spectrum of the Hordos Formation better resembles that of Ordovician and Devonian sandstones exposed in Tabuk area in northern Saudi Arabia, which are also dominated by 700-800 Ma zircons. This suggests that Paleozoic sandstone of northern Saudi Arabia may be an important provenance for the northern Miocene siliciclastics in Israel. Sand transport from Tabuk area to northern Israel requires the existence of a large-scale, NW-directed, early Miocene fluvial system across the Arabian plate in eastern Jordan. This system could have developed along the Azraq-Sirhan Graben following the regression of an Oligocene internal marine basin that invaded from the NE. As a whole, although the detrital zircon fingerprints of both Israeli

Miocene siliciclastic provinces indicate similar provenance by recycling of older sandstone units that resided on the eastern flank of the Red Sea, it also suggests different transportation systems for the two provinces.

New method for heavy mineral assemblage analysis in the Geological Survey of Israel using SEM-EDS phase mapping

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Heavy mineral assemblage analysis is a fundamental tool in sedimentological studies. Yet over the years, the actual work of heavy mineral identification and quantification using optical microscopy became a vanishing craft, possessed by few. This is quite understood given the significant amount of time needed for heavy mineral analysis under the microscope and the level of expertise needed for proper mineral identification. Adding to that are long-standing problems that cannot be solved confidently with optical microscopy alone, including the identification of; opaque and intensely-altered minerals, detrital grains as small as a few microns, and colorless grains with uncertain orientation and rounded morphology. Here we present a relatively simple method for heavy mineral assemblage analysis using scanning electron microscope (SEM) equipped with an energy dispersive spectroscopy (EDS) detector, routinely performed in the Geological Survey of Israel SEM laboratory. Heavy mineral analysis is performed by EDS mapping of a 2×2 mm grid with a resolution of ~40,000 10µm pixels. The resulting EDS element distribution maps are in turn used to construct mineralogical phase maps by plotting the composition of all individual pixels on a ternary diagram constructed for specifically chosen elements and selection of the compositional range of each mineral. Successive series of ternary diagrams for different elements are used until all major mineralogical phases are identified. Remaining unidentified grains are manually identified based on their EDS spectrum. The relative abundances of all mineral species found in each sample are then normalized to a sum of 100% to account for empty (epoxy or carbon tape) pixels in each frame. The processing of the EDS data is done using Oxford Instruments INCA® software. For higher statistical significance, three frames are usually mapped for each sample; summing ca. 300-500 grains per sample. Although the method can be automated, the full ability and experience of the operator is essential for efficient application of the method in sedimentological studies. The potential of the method is demonstrated by comparing the heavy mineral assemblages of modern (Nilotic) coastal sand and Miocene sand of the Hordos Formation from the Golan Heights.

A Theoretical Model for Reach Morphology Adjustment in Boulder-concentrated Bedrock Fluvial Channels and its Exploration along a Steep Catchment in Taiwan

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Bedrock channel morphology controls the rates and efficiency of fluvial incision and sediment transport within a river. Yet, the processes and parameters that govern changes in channel morphology at the reach scale are not well understood. Notably, width and slope are commonly parameterized using empirical basin-scale relations that disregard the potentially paramount role of fluvial sediment grains. Mobile sediments are long considered to have a dual effect on incision: at low sediment flux conditions, they act as erosive tools, but as sediment flux increases, they may also cover the bed and protect it from erosion. This approach neglects the existence of very large, almost immobile boulders within fluvial channels. To develop quantitative understanding of channel morphology when large boulders cover the channel bed, we amend a sediment-flux dependent incision model to capture the dependency of channel width, slope, and sinuosity on boulder-concentration (ratio of boulder aerial cover and the total fluvial reach area, Γ). Three presumptions are incorporated into the model: (i) the immobility of the boulders means that they shield the bed from erosion by impacting sediment particles. (ii) Stationary boulders can route bedload sediments around them, such that the tools act on a smaller effective area, and (iii) boulders act as roughness elements and reduce the energy of the flow. Our model predicts that the steady state channel width (W) increases with boulder concentration (Γ) according to: $W \propto (1-\Gamma)^{-\gamma}$, where γ is a positive constant. To test the model, we study the Liwu catchment (620 km^2), a steep terrain that drains the eastern flanks of the central mountain range in Taiwan. This basin is characterized by channel reaches with high boulder concentrations, and boulder sizes of up to 20 meters in diameter. Drone surveys and available aerial photographs are utilized to map the morphology, boulder size and boulder concentration of numerous channel reaches. A preliminary analysis reveals an increase of channel width with higher boulder concentration, in agreement with the theoretical model. Our modeling framework could be consequential for the evolution of bedrock channel morphology in response to intense environmental events, such as landslides and rockfalls.

Evolution of Normal Faults: Displacement Patterns in 3D Seismics from the Eastern Levant Basin

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The continental shelf offshore Israel is densely populated by slump units in the Pliocene -Pleistocene section. The gigantic unit known as the Israel Slump Complex (ISC) and its overburden are incised by thin-skinned fault systems. Quantitative fault displacement analysis presents the relation between the slump units and the evolution of normal faults incising them.

Following structural standard interpretation, slump units and an array of normal faults and are mapped in the Gabriella seismic volume, a high-resolution 3D seismic survey (depth-migrated) located 12 km offshore Netanya. The stratigraphic column of the volume includes the post- Messinian section of Saqiye and Kurkar groups. Fault systems are characterized by unrestricted

blind faults and restricted growth faults. The Middle-Late Pleistocene progradational settings make distinguishing the two types of faults a challenge.

Fault displacements are analyzed based on ten key horizons using a step-by-step workflow which includes throw-versus-depth profiles, displacement contour diagrams and displacement gradients. Growth stages within the faults are highlighted using expansion indices and restoration models. Combination of these methods proves useful both for growth model classification and accurate fault mapping. Variations in displacement patterns underscore the control of chaotic features, acting to restrict the growing faults.

Four sampled faults yield distinguishable types of growth: (1) Blind fault, where both horizontal and vertical tips close gradually; (2) Restricted growth fault initially evolving as a blind fault, associated with an incision into the ISC at 0.51-0.7Ma; (3) Blind Restricted fault, with two zones of high displacements, associated with the incision of a small slump unit; (4) Blind restricted fault, characterized by high displacement gradients at its deeper part. Maximum displacement zones imply the faults nucleated at 600-700m depth. The restricted growth fault is characterized by shallower maximum displacement zone, interpreted to result from a transition from blind to growth propagation.

We find that chaotic structures control fault activation, which depends on the spatial relation between the structures. This can result either locally with segmented activation within the fault, or with lateral growth initiation on the entire fault. The linkage between proximity to slump units and growth pattern may lie in the compaction potential of the latter.

The research provides empirical evidence for distinguishing a fault growth and blind stages. This can be especially helpful where faults have similar dimensions and ranges of throw values, which result in minor displacement differences. The presented workflow can also be used for illuminating geo-hazards related to fault activation.

Seismic data at the seismological division – new online services

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The Israeli Seismic Network is operational in its digital form since the 1980's, collecting data from ~25 seismometers and ~50 triggered accelerometers, at the Seismological Division's acquisition center in Lod. Since October 2017, the network is undergoing significant upgrades and modifications, with new stations added or upgraded, using new sensors, and dataloggers, aiming for a total sum of ~120 stations country-wide, sampling data at 200 samples per second. The expected amount of seismic data requires new approaches for researchers to access the data.

Here, we will present new online services for obtaining seismological data, including raw data, stations metadata, seismic events data and seismo-engineering data. The data is available through several web-applications and protocols that will be elaborated along with common-practice methods to obtain them.

The seismological division officially stores seismological data in an in-house designed offline database. Since 2016, these data were converted to a more modern and commonly used database format and the online services were running in an experimental mode, providing access to the data to researchers at the Geological Survey and universities in Israel. This testing mode provided data to the researchers and provided data quality feedbacks to the seismological division, including missing information, errors and inaccuracies that allow constant improvement of the services.

Raw seismic data include: a) triggered events, since 1979, in which events are recorded in short time frames (of the order of several minutes), and c) continuous data, in which daily streams of full day records are recorded since 2008. Seismic events include over 5000 event records per year, from local, regional and teleseismic earthquakes, quarry blasts and other seismic sources. The Metadata include information for both historical and currently active seismic stations and the seismo-engineering database includes site parameters and classifications, response spectra, PGV, PGA, PGD associated with the seismic events.

We invite the scientific and engineering community to access the data and use it for research and to provide feedbacks in order to improve these services to the community.

Timing deformation along an active plate boundary: U-Pb ages of fault-related calcite from the Dead Sea Transform, Israel

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The Dead Sea Transform (DST) plate boundary extends along 1000 km linking the Red Sea seafloor spreading center in the south with the Bitlis-Zagros continental collision zone in the north. Despite its importance, its exact initiation age, propagation pattern and stages of evolution are relatively poorly constrained. In addition, the links between the fault branching pattern adjacent to the restraining bend in Lebanon, the associated uplift in this region and the pattern of propagation are not well understood. In this study we utilize novel U-Pb calcite geochronology to date syn-faulting carbonate precipitates along the DST faults. These new constraints on the temporal pattern of faulting help to decipher the timeframe of major tectonic events in the region.

U-Pb ages from 30 well-constrained Tera-Wasserburg isochrons along the Sion and Guvta faults delineate a major mid-Miocene (18-10 Ma) faulting activity with a prominent mode at 14 Ma. No younger ages were observed. Ages obtained from samples along the western DST strands (Korim fault) seem to be as old as in the east suggesting that faulting in the restraining bend area was initially distributed. U-Pb ages from the southern part of the DST (Eilat) delineate prominent faulting activity during the Early to Mid-Miocene (20-10 Ma) with a prominent mode at 18 Ma – 4 Ma earlier than in the north. This pattern suggests that the DST plate boundary was initiated in the south, adjacent to the Red Sea rift, and migrated northwards.

GOAL (Geoethics Outcomes and Awareness Learning): an international partnership Erasmus Plus Project

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The International Association for Promoting Geoethics (IAPG) was established in 2012, during the 34th International Geological Congress (IGC) in Brisbane (Australia). It is an international, scientific, multidisciplinary platform, created to widen the discussion on ethical issues related to the Geosciences.

The "Cape Town Statement on Geoethics" was launched in 2016 during the 35th IGC in Cape Town, South Africa. It reflects an international consensus and aims to capture the attention of geoscientists and organizations, and to stimulate the improvement of their shared policies, guidelines, strategies and tools to ensure they consciously embrace (geo)ethical professional conduct in their work.

Geoethics consists of research and reflection on the values which underpin appropriate behaviours and practices, wherever human activities interact with the Earth system. Geoethics deals with the ethical, social and cultural implications of geoscience education, research and practice, and with the social role and responsibility of geoscientists in conducting their activities. More specifically Geoethics deals with questions such as:

- How to combine the freedom of research and actions with the principles of sustainability?

- Where should the line be drawn between preservation of the geosphere and economic development, especially in low-income countries?

- How can the relationships between geoscientists, media, politicians and citizens be made more profitable, particularly in the defence against natural hazards?

- What communication and educational strategies should be adopted to transfer the value of the geosciences to society?

The international GOAL (Geoethics Outcomes and Awareness Learning) partnership project was approved by the EU Erasmus Plus in 2017. This project consists of members of six different partner countries (Portugal, Austria, Italy, Israel, Lithuania Spain) who bring expertise in overlapping multidisciplinary areas, and these intellectual synergies will contribute to a wider approach in geoethics. Specifically, the project integrates researchers and practitioners with skills in geoscience

education, geological heritage and geo-resources, georisks, environmental sciences, theoretical aspects of geoethics and information and communication technologies in education.

The project aims to develop a geoethics syllabus and to offer suggestions for educational resources to be used in Higher Education, in order to promote awareness-raising on ethical and social implications of geoscience knowledge, education, research, practice and communication, thus enhancing the quality and relevance of students' knowledge, skills and competencies. Educationally, the project will follow a contextualized approach supported in diverse methodologies and strategies to elaborate the teaching and learning resources. This international network and subsequently the syllabus and educational materials will contribute added values at European- level to a specific target group of Higher Education students.

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Earth science education in the Israeli high school: conclusions following 25 years of implementation

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Earth science is taught in the Israeli high school as an independent discipline for 5 matriculation credit points for about 20 years. The curriculum is based on the holistic earth systems approach and its main goal is to develop environmental literate citizens. The curriculum materials emphasized the development of thinking skills such as scientific thinking, spatial and temporal thinking and system thinking. The learning is based on inquiry based in variety of learning environments: laboratory, outdoor and computer and includes over 100 activities that were developed for the outdoors and indoors learning environments. The program is quite complexed, but the Israeli earth science program is well known and appreciated all over the world and serves as an international model. The Israeli activities were translated to English, Spanish, Portuguese, Arabic and Chinese and workshops were conducted for teachers in Argentina, Chile, Uruguay, Brazil, Peru, USA, Germany, Portugal and Ethiopia.

However, although its achievements and prestige, the status and profile of the earth science within the Israeli educational system are still much lower than the other sciences. The program does not compromise on quality of the teaching and evaluation methods, which makes it difficult for high schools' principles who prefer quantity over quality to cope with its complexity. However, the main reason for the low profile of earth science education in the Israeli educational system countries is the result of being trapped between the Devil and the deep blue sea. Namely, the conservative science education establishment that form combination of ignorance and superiority feeling prevents the earth sciences from taking an equal share in the school science curricula and the geography education establishment that from combination of selfishness and inferiority feeling refuses to free the earth sciences and drown it into social sciences environment that lack the knowledge to deal properly with this natural science field. This combination of ignorance and political consideration is also supported by the Council of University Chairs (VATAT).

Thus, only a massive involvement and vigorous action of the academic leading earth scientists in their universities and among the top decision makers in the Ministry of Education might improve the status and profile of the earth science education in schools. However, the level of involvement of the academic geosciences establishment, so far, is insufficient to lead to change.

Fast Intensity Distribution Maps Using Real and Synthetic Seismograms

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New shaking Intensity Distribution Maps (IDM) have been developed based on new earthquake waveform synthetic procedures, new ground motion attenuation equations, new site-effects evaluation due to the fusion of the existing seismic and geological data in Israel, historical earthquakes information and real Israeli and foreign earthquake recordings. The synthetic procedures that have been used are based on known AXITRA code to provide broad-band waveforms in the 1D medium followed by the BROAD-BAND tool to account for heterogeneity of the medium. The realistic synthetic waveforms obtained this way are calibrated using Campbell-Bozorgnia (2008) ground-motion prediction equations, modified to meet specific conditions realized during the historic Dead-Sea earthquake of 1927. Synthetic seismograms "recorded" at the virtual network of seismic stations (the new ISN network under construction) and/or the network of school accelerometers are used as input to the linear dynamic models determined by the site 1D shallow velocity structure to account naturally for the site-effect. For building IDMs from each 3C synthetic recording the geometrical mean horizontal component maximum amplitude velocity PGV and acceleration PGA are used to compute instrumental intensity by method of Wald, 2006, Sokolov, 2013, which in turn serves as input for the GMT maps, based on the USGS "shake-maps" method of Wald, 2006. Within probable scenarios of strong earthquakes in Israel the IDM maps can be issued in a four-stage sequence. First, preliminary one, due to the maximum intensity at the first station and given attenuation curves. Second, due to the data from the 122 stations of the regional EEWS that will deliver information in real time. Third, the IDM is updated according additional information delivered by the network of school accelerometers. Finally, the IDM using all available data can be build including ground motion attenuation, site-effects and finite fault information. The IDMs built can be used for the earthquake training exercises and serve as the input for the existing hazard and loss-estimation procedures.

The effect of a phosphonate based antiscalant on precipitation kinetics and morphology of gypsum in Dead Sea – Seawater mixtures

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According to the planned 'Red Sea – Dead Sea Project' (RSDSP), Red Sea water will be desalinated, and the Reject Brine (RB) created during the process will be discharged into the Dead Sea (DS). Introducing RB into the lake will lead to the precipitation of gypsum ($CaSO_4*2H_2O$). If the precipitated gypsum remains in suspension for a long period of time, an increase in turbidity may cause 'whitening' of the lakes surface. Suspension of the crystals or their sinking out of the water column would be determined by crystal size and morphology. These in turn are determined by the precipitation kinetics which is likely to be affected by the presence of antiscalants from the desalination plant.

Seawater and RB containing a phosphonate-based antiscalant (Osmotech 1070) were collected at the Soreq desalination plant. A diluted reject brine (DRB) with a composition similar to that which would be discharged into the DS was prepared by mixing RB and Seawater. A similar brine but with no antiscalant was prepared by evaporating seawater (ESW). Mixtures of DS and DRB or ESW were used to determine the influence of the antiscalant on gypsum precipitation kinetics and morphology under RSDSP conditions. Two sets of experiments were run – a) a seeded experiment in which gypsum seeds have been added to solution and b) an unseeded experiment. Gypsum precipitation throughout the experiments was monitored by measuring SO_4^{2-}. At the termination of the experiments the precipitated crystals were separated from solution and imaged with a binocular for morphological analysis.

The induction time - Tind, which is the time that elapses between the attainment of oversaturation and the identification of gypsum in unseeded solution is defined here as the time required before the identification of a change in SO_4^{2-} concentration. A complex dependency between Tind and chemical parameters of the solution (pH, oversaturation, stoichiometry, etc.,) was found but in all experiments a longer Tind was measured in DS-DRB solution compared to the equivalent DS-ESW solution. After the detection of gypsum, its precipitation rate, as measured by the change of $SO_4^{2-}$with time, was faster in DS-ESW solutions compared to their antiscalant-containing equivalents. Crystals precipitated in DS-DRB solutions were larger, fewer and had a more equidimensional habit in comparison to the minerals precipitated from a similar DS-ESW solution. However, precipitation rate of gypsum in solutions with gypsum seeds were impervious to the presence of antiscalant. It is thus concluded that

under the hyper-saline conditions of the RSDSP a phosphonate-based antiscalant retains its ability to inhibit gypsum precipitation while altering the minerals habit. Having larger crystals and fewer of them reduces the chance of massive gypsum suspension in the water column and a whitening of the lake.

3D gravity modeling of the Kinneret-Kinarot-Beit-She'an basin complex, along the Dead Sea Fault

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Transform faults displace older structures crossing their paths, marking a visible shift between the two sliding plates. The fate of these pre-transform structures within the damage zone is less understood – to what extent they are preserved and what structural heritage they dictate. The current study focuses on a unique crossing region between the Oligo-Miocene NW-trending Irbid rift and the N-trending Miocene to recent Dead Sea Transform (DST). The structural heritage aspect is examined through 3D forward modelling of gravity data across the Kinneret-Kinarot-Beit-She'an (KKB) basin complex of the DST. The model includes pre-Senonian to recent formations, highlighting key volcanic and evaporitic units. By calculating the depth, thickness, and 3D density distribution of each lithological unit the study constructs the volumetric geometry of the sub-basins and suggests central stages in its geological development: the southern, Beit-She'an, basin began as part of the Irbid rift and was later hijacked by the younger DST at the transform-rift cross region. The transform displacement initiated en-echelon mini-basins from the Beit-She'an basin northwards to form the proto Kinarot and Kinneret (Sea of Galilee) basins. Volcanic phases record the deformation, leaving a reliable time frame for the subsidence mode, faulting and the role of salt tectonics. During the Plio-Pleistocene the general displacement developed a trishear structure that includes the Kinneret-Kinarot-Beit-She'an complex, bounded by two longitudinal faults stemming from a single deep-rooted fault.

The Department of Geology foundation at the Hebrew University: Between the researcher and the institution, between theoretical research and the applicative one (1924-1948)

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The Hebrew University of Jerusalem was founded as a Research Institutes University in 1925. One of the first research institutes established was the Institute of the Nature of Eretz Israel (המכון לטבע ארץ-ישראל). The research and teaching activities in geology began under the auspices of this institute, in addition to the Institute of Chemistry. The need to include this research field was already raised during the deliberations of the university committee in April 1925. However, the practical activities for the establishment of the department began only after the arrival of Dr. Yehuda (Leo) Picard to Palestine and his temporary admission to the university. In the present study we aim at following the organizational processes and geological research carried out by Picard and his colleagues. As a result of these actions, the Department of Geology was recognized as a major department, and Picard and his colleagues achieved international recognition. The activities of the Department of Geology and the research work of Picard constitute an interesting example of the university contribution to the Jewish settlement effort. As opposed to the apparent image of the university as an elitist and detached institute, we present a collection of evidences about Picard's involvement in the Yishuv activities, mainly in the field of mapping and groundwater exploration. An examination of the quality of Picard's scientific work (using maps and sketches) will allow us to describe the way Picard has integrated applicative and theoretical research. Hence the present study discusses two interrelated issues: the establishment of the Department of Geology at the Hebrew University and the contribution of the geological research to the build-up the scientific knowledge that empowered the infrastructure development of Eretz Israel.

Tracking Permafrost Thawing and intra-permafrost processes with Radium Isotopes

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Permafrost in circum-polar regions and high mountains is undergoing thawing, with severe environmental, current and future consequences, including the release of greenhouse gases that may amplify global warming. Thawing is usually studied by monitoring temperature in boreholes or by following changes in the thickness of active layer. We suggest using radium isotope ratios as permafrost fingerprints. Permafrost ground ice and active layer water were sampled by drilling in two sites at Adventdalen, Svalbard, and permafrost radioisotope signature was characterized. We show that ratios of $^{226}Ra/^{224}Ra$ and $^{226}Ra/^{223}Ra$ are higher in permafrost ice than in the overlaying active layer water, which we attribute to the permafrost closed system and possibly to the long residence time of ground ice in the permafrost. Another, somewhat enigmatic observation was that the daughter-parent $^{224}Ra/^{228}Ra$ ratios are lower in permafrost than in the active layer. This is attributed to the presence of liquid water films, which allows the removal of ^{228}Th (parent of ^{224}Ra) from the permafrost pore space by adsorption onto solids. These fingerprints were also identified in a local stream, confirming the applicability of this tool to tracing thawed permafrost in periglacial watersheds. Notably, a combination of radium isotope ratios and 3H allowed the identification of recent intra-permafrost ice segregation processes. The permafrost Ra fingerprint should be applicable to other permafrost areas, which could assist in regional quantification of the extent of permafrost thawing and carbon emissions to the atmosphere.

Plate boundaries and intra-plate deformation new insight from Syrian Arc Fold belt

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The Syrian Arc or Levantine fold belt is assumed to express stresses resulting from the convergence of Africa and Eurasia as part of the Tethys closure. Recent analysis of folds evolution in offshore Israel revealed that folding occurs in the same NE-SW azimuth for more than 80 m.y., regardless of ~ 200 anticlockwise plate rotation and major tectonic events along the plate's boundaries. The offshore folds orientations are in accordance with the NE-SW trending monoclines in the Northern Negev. Druckman et al. (1995) interpreted ~900 m displacement along reverse faults underneath one of the folds. Furthermore, they observed thickness variation within the Triassic and Jurassic section. Hence, they provided robust support to the hypothesis that the Late Cretaceous compressional regime reactivated old (Early Mesozoic) extensional faults giving rise to reverse faults and monoclines flexures. Interestingly, faulting underneath the folds is less commonly observed and reactivation of older normal fault in reverse slip is rarely interpreted on most of the offshore seismic lines displaying similar folds. An additional alternative for explaining the constant folding orientation is by horizontal rheological contrast between sediment and basement rocks, as proposed and modeled by Lafoss et al (2016) for the Western Alps's inverted basins.

In contrast to the consistency of folding azimuth, offshore observations reveal that spatial distribution and intensity of folds varied through time. Folding during the Santonian – Middle Eocene was widespread reaching up to ~200 km west from the Israeli shore-line. It confined to the eastern part of the basin (East to Jonah high) during the Late-Eocene – Oligocene and rejuvenated in the deep basin during the Early Miocene along with new folds that evolved throughout the basin. Since the Late Miocene folding decreased and confined eastward to the shelf area. Concurrently, major plate tectonic reorganization took place: several subductions phases and continent-continent collision occurred as part of the Tethys closure in the north and north-east of the Levant area. Additionally, the Red Sea – Gulf of Suez opened in the south since the Oligocene and the Dead Sea Transform evolved in the east since the Middle Miocene. The evolution and development of these plate boundaries is believed to provide the "first order" mid-plate stress field that prevailed in the Levant and which affected the activation or rejuvenation of folding. However, the processes controlling the spatial variation and intensity of folding remain enigmatic. Particularly, why folding ceased during the Late-

Eocene – Oligocene in the deep basin and rejuvenated in the Early Miocene, and what is the role of subduction along the Cyprus Arc and its predecessors in folding locality and rate?

We therefore suggest that modeling the folding mechanism in the Levant area should take into consideration the pre-existing crustal rheology heterogeneity and geometry as well as the timing and the kinematics of plate boundaries evolution.

Stress and failure around rough interlocked fault surface

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We explore the effect of fault roughness on stress patterns and failure conditions around interlocked fault surfaces using an analytical approach, where out-of-fault static stress pattern is calculated based on perturbation theory. Stress amplification and failure conditions around the surfaces are controlled by the ratio between roughness amplitude to wavelength, and therefore, small power values increase failure associated with short roughness wavelengths, immediately nearby the interface. Increasing both amplitude to wavelength ratio and amplitudes heights enhance failure and seismic activity in zones around the interface, but at the same time decreases stress and blocks seismicity in other zones. In contrast, failure around faults with less heterogeneous geometry is initiated at larger external loads and is predicted to be associated with larger magnitude events. Calculations of stress around fractal and non-fractal interfaces indicate that earthquake nucleation, locations, intensity and magnitudes are all dictated by the initial surface geometry. We find that stress asperities and barriers during slip or throughout the seismic cycle are strongly driven by the geometrical irregularities of the fault surface.

Proposed Methodology for Qualitative Assessment of Earthquake Hazards to Large Inventories: the Case of Historical Monuments in Israel

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There are numerous historical and archaeological monuments in Israel, many of them are deteriorating but still host many visitors. Since Israel is vulnerable to damaging earthquakes, there is an urgent need to retrofit these monuments, yet budgets are limited. The Israeli Antiquity Authority (IAA) has already identified the most valuable monuments and approached the Geological Survey to conduct evaluation of earthquake hazards and rank the sites by level of hazard.

Accordingly, we have developed a systematic, qualitative method capable of assessing earthquake hazards to large inventories. First, we formulated scales that describe the level of hazard in a given site for each of the earthquake induced effects: surface rupture, ground shaking and amplification of ground motion, slope failure, liquefaction and tsunami. We then assessed the degree of hazard at each of the monuments' sites, but soon realized that the outcomes did not accord with the historical experience. As a result, we introduced importance weighting to each of the earthquake effects, as they are different in their damage potential. Furthermore, we also applied a correction factor to compensate for the different frequencies of damaging earthquakes across the country, as indicated by the historical experience.

The final assessment and ranking showed that monuments along the Dead Sea Transform and Rift Valley are exposed to the highest level of hazard. High levels also appear in sites along the Mediterranean coast. The outcomes were delivered to the IAA, which in parallel evaluated the vulnerability of the listed monuments, and eventually will determine the risk facing the monuments and prioritize anti-seismic retrofit.

Anthropogenic Impacts on the End of a Sand Nourishing Littoral Cell- a Case Study from the Eastern Mediterranean

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Beaches are a dynamic environment that are morphologically affected by natural processes and, in many cases, by man-made changes. In unique environments such as the termination of a littoral cell, the disturbance in the natural sedimentary regime might have a greater effect on beach erosion, width and topography. The Israeli coast (Eastern Mediterranean Sea) is characterized by massive anthropogenic development. The coastline of Haifa Bay, the northern terminal depositional basin of Nile Delta derived sand, has undergone major developments in a relatively short time since it was settled in the beginning of the 20th century. The population in the bay has grown by more than 23 times in the past 100 years, and the urban and industrial areas have expanded accordingly on what used to be coastal dunes and sandy beaches. Ports and breakwaters were built, underground pipes were buried and removed, etc. After evidence for erosion of the southern beaches, artificial sand nourishment was carried out in an effort to reconstruct the coastline of the bay. It is unknown how these man-made changes impacted the coast, its morphology and compositional character during the last century. This study examines the geomorphological changes that occurred in Haifa bay between 1918-2018 and the sedimentological changes that occurred since the first round of artificial sand nourishment (2011-2018). It relies on coastline change assessment based on georeferenced aerial and ortho-photographs, as well as chemical and physical characteristics of sediment cores that were taken from the nourished beach. Initial results show that the southern part of the bay is undergoing erosion despite repeated nourishments, while the northern part, with no active restoration, is expanding. This and other results will be discussed.

Diapir piercement through the ocean floor: New evidence from Santos Basin, offshore Brazil

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Diapir piercement through the ocean floor marks the final stages of a dynamic migration path. Once exhumed, a diapir extrudes from the seafloor, placing an obstacle for the flow of ocean bottom currents. While the hydrodynamic response of the flow has been previously studied, the detailed depositional and weathering modifications involved in the piercement process are less understood. To bridge this gap, we gathered already available multibeam bathymetric data and multichannel 2D seismic reflection profiles and collected new single-channel CHIRP profiles, Acoustic Doppler Current Profiler data and sediment samples across Santos Basin, offshore Brazil. In this region, the processes connecting the uppermost subsurface with the lowermost section of the water column are unknown. Data show three main stages of diapir exhumation: pre-, syn- and post-piercement into the seafloor. Extensional faults crown the pre-exposed diapir, before its piercement through the seafloor. Ocean bottom currents rework the top of the faults to form elongated depressions. The bottom currents tightly detour the diapir during and after its exposure at the seafloor. This interaction forms a drift and moat contourite depositional pattern. Our high-resolution data allow relating these morphologies to seafloor processes and distinguishing them from other reflector geometries related to diapir flank deformation, such as outward dipping of reflections. We further use this geometrical distinction to suggest a key for interpreting the exposure versus burial history of other diapirs worldwide.

Hierarchy of source-to-sink systems

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A standard source-to-sink approach examines sediment transport along an imaginary axis (regarded here as primary) extending between land, the continental margin and a nearby basin. This approach oversimplifies the development of depositional environments located off the axis (regarded here as secondary). Similarly, it imposes that factors affecting the primary source (e.g. climate) will directly be reflected in the secondary sink. The current study examines this suggested hierarchy in a confined basin, where the sedimentary budget remains closed. It evaluates the mechanism connecting between the primary and secondary axes. The study focuses on the Nile sedimentary system, across north-eastern Africa and the eastern Mediterranean basin (primary axis) and the Levant depositional system (secondary sink). We hypothesize that since secondary river input into the Levant basin is negligible, the main secondary source is seafloor currents. The Levant Jet System (LJS) transported sediments from the Nile cone along the Levant margin at depths between 0 and 350 m, during the Holocene and until today. Once the LJS reaches its capacity to transport sediments, the surplus falls downslope to the deep basin. By integrating seismic and bathymetric data, this paper suggests a unifying mechanism integrating deposition, erosion, and transport of sediments across the Levant margin and basin throughout the Quaternary. Results show that during both highstand and lowstand conditions the primary source-to-sink axis delivers sediments to the deep basin via south to north meandering channels. The LJS transports sediments that build the shelf, while unconfined overspills slide downslope to accumulate across the continental rise. However, when sea levels drop, the capacity of the LJS weakens. This results in a drastic decrease in sedimentation across the shelf and rise, accompanied by confined downslope turbidity flows into the deep basin. In principle, seafloor currents serve as an immediate supplier from the mouth of the primary source to the off-axis system. Variations in seafloor current dynamics and their capacity to transport sediments will be directly reflected in the secondary sink. The primary continental source is expected to have only an indirect effect on the secondary sink.

Integrated ground, marine and aeromagnetic study of the Kinneret–Kinarot tectonic basin along the Dead Sea Transform, northern Israel

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High-resolution magnetic mapping is crucial for understanding the spatial distribution of magmatic lithologies and geological structures. Aeromagnetic and common Marine surveys deliver lower resolution regional coverage with a high cost. Ground surveys are much cheaper, yet their coverage is limited to site surveys. Quantitative integration of varying datasets is one of the challenges of the magnetic method. These datasets differ in the type of acquisition equipment used, geographical coverage, measurement height, distance between measurement points and profiles, different datum. Here we tackle these challenges through (1) designing a new method for collecting high-resolution magnetic data using a bike as equipment carrier. (2) applying a new multilayer modification of the equivalent source technique to integrate all available data sources (ground, marine and air), upon their high variability. (3) constructing magnetic anomaly maps of a 45×65 km area. The unprecedented 1 km grid resolution of the calculated TMI and RTP maps allows for the first time to interprate the magnetic data in conjunction with independent geological, geochronological and geomorphological data. Results show a high correlation between mapped volcanic centers and RTP anomaly peaks; between the spatial extent of volcanic units (outcrops and subcrops) and the coverage of magnetic RTP anomalies; between distribution of faults and lateral truncation of RTP anomalies.

Age and structure of the Levant basin

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Large parts of the Mediterranean were formed during the Mesotethys Ocean opening and subsequently became land-locked in the midst of the Africa-Eurasia plate convergence. Since the Neogene, this convergence has concealed key sections of the original basins. Previous studies widely agree that the Levant Basin opened during the Permian to Early Jurassic (PJ) and accordingly explain the architecture of the basin and its margins. However, since the PJ model was suggested in the late 1990's a flood of new evidence has arrived since the hydrocarbon exploration, some of which do not fit in with the PJ model, and some remain unexplained. The current research re-examines the old and new evidence from the Levant basin, its margins, the surrounding landmass, the adjacent Eratosthenes Seamount and the eastern part of the Herodotus Basin. The integration of geological and geophysical data suggests that the Levant Basin formed ~100 Myr later than previously thought, i.e., during the Cretaceous. Its opening was triggered by the 'Levant-Nubia' mantle plume that induced a sequence of wide-spread Ocean Island Basalt volcanism. The resulting crustal updoming and stretching led to the breakup of the Levant landmass since ~141 Ma, and drifting of the Eratosthenes Seamount since ~125 Ma. Back-arc extension shaped the Levant Basin as a hybrid crust comprising continental slivers intervened by oceanic patches. The basin opened during the Long Normal Cretaceous Polarity Chrons between ~122 and ~84 Ma, and therefore it does not show any magnetic lineation. The opening of the Levant basin occurred while the Herodotus basin floor subducted eastward under the Eratosthenes Seamount. The subduction hinge did a roll-back and facilitated the Seamount drifting. The Seamount absorbed intensive volcanism while chasing the subduction roll-back and sliding between two Subduction-Transform Edge Propagator (STEP) faults that bounded the stretching Levant back-arc basin. The Turonian-Maastrichtian compression stress regime, or inversion, halted the extension of the Levant Basin, stagnated its hybrid fabric, and prevented the development of a spreading center. The evolutionary scenario suggested here is a game changer for future exploration in the Levant and may serve as a global analog for the formation of marginal seas.

Drainage response to Miocene uplift of the Anatolian Plate: Insights from provenance analyses from the Kyrenia Range, northern Cyprus

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The sedimentary and drainage evolution of the Eastern Mediterranean Basin is controlled by the tectonic interplay of the African, Arabian, Eurasian and Anatolian plates. The Cenozoic siliciclastic sedimentary succession of the Levant Basin is considered to derive predominantly from Africa (Nile River) and Arabia, whereas the northern contribution of detritus from mountain-building processes of the Alpine-Himalayan Orogen shaping the Anatolian Block and the Zagros Mountains is not well documented. In this work, the nature of the detrital content of Tertiary sedimentary units flanking the northern part of the basin at the Kithrea (Değirmenlik) Group of the Kyrenia Range, northern Cyprus is investigated. Sedimentological studies of these strata, including textural evidence for middle to late Miocene westward transport direction, suggest sediment derivation from Anatolian/Zagros terranes, possibly via an outlet that is equivalent to current-day Gulf of İskenderun. The Kithrea Group is dominated by siliciclastic turbidites and includes both strata that predate and postdate a prominent regional contractional event that is most evident in the Late Miocene uplift of the Anatolian Plate. In an attempt to recognize the effect of the Anatolian uplift on Eastern Mediterranean strata, we present a combined examination of heavy mineral assemblages, U-Pb geochronology (zircon and rutile), and quantitate assessment of grain morphology and isotopic compositions (Hf and Th/U data) of detrital zircon from various stratigraphic levels of the Kithrea Group. Results indicate Oligocene to Early Miocene age clastic turbidite successions (containing clasts/fossils of 34 to 22 Ma) to consist of a common age spectrum that is significantly different from that found in corresponding Middle to Late Miocene (~13 to 7 Ma) strata, highlighting a pronounced change in provenance and/or drainage. Specifically, the data indicate the inclusion of late Cenozoic (first cycle) igneous input and exclusion of otherwise-abundant early Neoproterozoic and late Mesoproterozoic components from the age spectra of post uplift sediment (i.e., Late Miocene). The Miocene change in provenance, as indicated by the detritus, provides an independent indication to the drainage response to the AfroArabian-Eurasian convergence, as well as insights into the paleodrainage and tectonic evolution of the East Mediterranean Basin and its surrounding.

Detrital zircon as palaeodrainage indicator: Insights into southeastern Gondwana from Permian basins in eastern Australia

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Radioisotope geochronology of detrital grains coupled with a quantitative classification of grain morphology can provide valuable insight into the history of sediment transportation and recycling. We demonstrate the use of U-Pb ages that are coupled with values of abrasion from relatively understudied Permian sedimentary successions in eastern Australia. The quantitate abrasion values are calculated for each age population, whereby the average values serve as a proxy for the relative source-to-sink distance and the standard deviation provides insights into the modality of age populations. We use discreet cumulative proportion curves for age groups that correspond to plausible source regions and show it to provide insights into the palaeodrainage, even if the basin stratigraphy is relatively poorly constrained. This approach is particularly suitable for investigating complex depositional systems that received inflow from different provenances, such as back-arc and intra-cratonic basins.

Wellbore stability and damage accumulation

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The introduction of a wellbore opening at depth with a free surface to tectonically stressed rocks perturbs the natural stress field and may promote rock failure along the borehole walls. This often results in an elongation of the borehole cross section in the direction of the minimum principal stress orthogonal to the borehole axis. The classical approach to borehole stability analysis is based on Mohr-Coulomb failure criterion to the stress distribution around a circular opening in an elastic material. This approach is popular because it allows for successful determination of stress orientation. However, it neglects time dependent processes that can lead to continuous failure events that often occur in crystalline rocks and reported/observed in several deep boreholes (e.g., KTB, Kola, Siljan Ring). The elongated shape created by breakouts enhances unstable conditions due to stress concentration near the elongated axes. The Mohr-Coulomb failure analysis fails to explain wellbore stabilization that occurs after breakouts.

In this study we present results of three-dimensional simulated breakouts and well stability using a damage rheology model for poro-elastic rocks. The model includes damage- and porosity-dependent yield criterion (Kaiser Effect) constrained using laboratory measured elastic and damage properties of a porous arkosic rock (Zenifim formation). We show that for crystalline Westerly granite properties, the shape of the well cross section grows continuously and does not stabilize. Using elastic and damage properties of the porous arkose with rock strengthening, the occurrence of breakouts stabilizes the wellbore and inhibits further failure.

Identification and characterization of proximal dust sources in Israel using deposited and suspended dust: preliminary results

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Located at the margins of the global dust belt, dust storms are common in Israel, mostly believed to originate from distal sources (i.e. Sahara, Arabia). During the late Quaternary, the region accreted thick sequences of dust from both distal and proximal sources that can serve as a local source to current storms. However, these local dust sources were mostly neglected in past research. Our research aims to differentiate between modern dust that originates from distal sources (i.e. Sahara, Arabia) and from local sources (i.e. near or within the Negev) using independent databases of deposited and suspended dust. We examined 28 deposited dust samples, selected from a much longer (2000-2016), monthly-resolution sampling campaigns near the Soreq Cave and Mount Hermon, which can be assigned to deposition during individual dust storms within these months. Backward trajectories of these storms indicate three main routes: A. Saharan dust storms over a Mediterranean route representing contribution from distal sources. B. Saharan dust storms over Sinai and the Negev that potentially activated proximal sources. C. Dust storms that occurred only in Israel, indicating contribution only from proximal sources. Analyses of mineralogy and grain size using SEM revealed that: the A-route storms are characterized by low quartz/clay ratio, whereas the other routes exhibit higher quartz/clay ratio. Samples from Mount Hermon exhibit higher content of fine grains (<10 µm) comparing samples from the Soreq Cave. In both sites coarse grains (>40 µm) are more abundant in the C-route and least abundant in the A-route. The opposite trend is evident for the fine grains (<10 µm) content in the Soreq Cave. In addition, we analyzed suspended dust data (sampled every three hours) from Be'er Sheva, Jerusalem and Karmie'l monitoring stations of the Ministry of Environmental Protection, and precipitation data for the years 2001-2015. We found that in northern Israel annual suspended dust is negatively correlated with precipitation. i.e., in rainy years dust is probably washed out of the atmosphere before arriving to northern Israel. Central Israel stations present a positive correlation between annual dust and precipitation, but the dust season follows the rainy season with a short lag time. In southern Israel, a positive correlation between annual dust and precipitation is detected. In this case, however, high dust values were obtained both in the rainy season and after it. Lastly, we found that the monthly average amount of deposited dust from the Soreq cave and Mount Hermon are positively correlated with the monthly average concentration of suspended dust from

nearby stations. Our study suggests that suspended and deposited dust in Israel partly originate from local dust sources (near or within the Negev).

The internal structure of the Dead Sea Transform and ground motions in Northern Israel

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The Dead Sea Transform (DST) fault system forms the eastern boundary of the state of Israel. The DST is a left-lateral strike slip fault with an average slip rate of 4 mm/yr, with numerous historic earthquakes of M > 7. The 1927 M 6 Jericho earthquake, the last major event on the DST, predated instrumentation of the region. This makes the assessment of ground motions during future earthquakes difficult and highlights the importance of computational methods to bridge the instrumental data gap.

The DST forms a deep and narrow valley comprised of deep sedimentary basins separated by structural highs. North of the Dead Sea depression these are the Bikaa (BV), the Kinnarot (KV), the Sea of Galilee (SG), and the Hula (HV) valleys. Branching westward from the DST is the Carmel Fault Zone (CFZ) along which the Jezreel, Harod and Bet-Shean valleys are found. Within the deep basins, the young sedimentary fill is several km thick, overlying the hard carbonates of the Judea Gr. The SG and HV are separated by the structural high of the Korazim Saddle (KS).

In this work, we studied the impact of the DST internal structure on ground motions and seismic energy distribution in northern Israel, using a series of 3D numerical models. We developed schematic, yet realistic, g geological models, of increasing complexity for the northern DST, based on well-log data, seismic surveys and structural maps. We simulated three different source scenarios based on past activity and slip deficit.

We show that the DSTV structure creates a significant ground motion amplification by trapping of seismic waves between the valley walls. We also show that the KS acts as a seismic barrier with a strong edge effect. When source location is south of the KS it effectively shields the HV hence reducing ground motions. When the source location is east of the KS the edge effect amplifies waves traveling in the N-S direction. Northward deepening of the BV refracts waves traveling from the south, focusing them to the surface where they constructively interfere with waves reflected by the KS.

Frequency of runoff-generating storms, sheetwash efficiency, and form-process relationship along hyper-arid talus-pediment slopes

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Predicting hillslope response to hydroclimatic forcing is crucial for a better understanding of landscape evolution. The evolution of talus-pediment slope sequences (talus flatirons) was often linked to Pleistocene glaciation-deglaciation cycles, although the physical processes that perform this linkage remain poorly understood. Slopes in arid regions are especially sensitive to convective and high-intensity rainfall events whose geomorphic impact is potentially strong. Here we present quantitative hydrometeorology analyses of potential causative rainstorms and of the geomorphic processes involved in the evolution of talus-pediment slopes in the hyper-arid Negev desert, Israel. The morphometry of the slopes was analyzed using high-resolution topography based on LiDAR, and grain size was measured in the field. Rainfall, runoff and sediment fluxes of artificial storms, designed from intensity-duration-frequency curves, were simulated in the field. Natural storms were monitored using X-band radar and time-lapse cameras. A fully distributed hydrological model was used for upscaling measurements obtained in these physical experiments. Our integrated analysis constrains the rainfall threshold for local runoff generation (rain intensity >14 mm/h with duration of >5 min) and provides high-resolution characterization of small-scale runoff-generating rain cells. The frequency of such rain events is 1 to 3 per year, generating runoff over a relatively small part of the slope. In contrast, full extent runoff from the entire slope occurs under rare rainstorms with at least 100 years return interval (1%). Over experimental plot-scale (2 m^2), erosion by sheetwash is limited to fine materials (<2 mm). However, sheetwash efficiency rises with the downslope distance. Beyond a threshold distance (~100 m), runoff during rainstorms with ≤ 1% annual probability is capable of transporting the locally available grain size. The efficiency of these storms implies that extreme episodic rainstorms can control the evolution of these slopes and highlights the potential role of discrete events in shaping dry regions landscape.

Modelling hydroclimatic control on accreting sedimentary halite-mud sequence

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Lacustrine sedimentary record analyses are widely applied in paleo-hydroclimatic reconstructions. Commonly, studies use sedimentary facies to infer relatively drier and wetter conditions, under the assumption of a direct connection between the characteristics and thickness of these sediments and the environmental forcing. However, this underlying assumption and establishing of quantitative relations between such sedimentary facies and their causative hydroclimate are weakly resolved. These limit us in making comparisons between sediments along a sequence: should two identical halite units along a single core be interpreted as equally dry intervals? Moreover, how dry is “dry”?

As a part of testing these questions, we apply a simple mass-balance model (HaMud) of a terminal hypersaline lake; annual rainfall is the input and the HaMud simulates deposition of a simplified sedimentary sequence, composed of either halite or mud. In the broad sense, HaMud model translates water balance into a sedimentary sequence, taking into account the interplay between rainfall, hypsometry, salinity and evaporation. To evaluate this model it is applied on the post-glacial interval from the core recovered by the Dead Sea deep drilling project (ICDP-DSDDP). This part of the sequence is characterized by a massive halite unit, followed by several alternations of halite and mud layers.

Model simulations indicate that such a sequence can be deposited during a sharp decrease in rainfall, followed by an oscillatory pattern around low rainfall values. Moreover, deposition of halite without an influx of external dissolved halite reduces the total amount of dissolved halite in the lake. Thus, consecutive halite intervals indicate lake level drops, where each drop must reach lower lake level than the preceding level minimum. Therefore, rather than halite thickness indicating equal hydroclimatic conditions, identical thickness of halite layers and intervals actually can represent increasingly drier intervals, if appear in a sequence. Conversely, a similar magnitude of negative water balance interval leads to a reduced thickness of halite beds up the sequence. Consequently, decreasing lake level would result in increasingly limited spatial distribution of halite units over the lakefloor. To conclude, similar climatic trends may result in different sedimentary patterns, and similar sedimentary patterns may represent different hydroclimatic trends. Quantitative hydro-limnological modelling can assist in disentangling these effects in high-resolution lacustrine records. Such modeling may reveal surprising climatic controls that can be missed when conventional sedimentary analyses are utilized.

Improving seismic imaging of the Jonah Ridge

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The Jonah high located ~80 km offshore Israel, buried by more than 4 km of sediments at its southern part has been the core of several research analyzing its origin and evolution, suggesting for an ancient (Late Paleozoic – Early Mesozoic) horst. Being deeper and narrower northward, it overlaps the Carmel's magnetic anomaly. Unlike the southern part of Jonah high, where sharp boundaries have been observed on seismic sections suggesting faults bordering its deeper parts, its northern edge lacks high quality imaging. Whether it terminate abruptly to the north or it prolongate in the deep subsurface remain obscure due to poor imaging. Furthermore, its northern edge trend to the north-east and approaches both the Carmel structure and the Israel continental shelf, rendering a complex structure encompassing a triangular shaped basin. The stratigraphic and structural relationship between the northern part of the Jonah high, the magnetic anomaly of the Carmel and the Israeli continental margin is a key for understanding magmatic and tectonic processes in the Levant.

We propose to improve seismic imaging of past and recent seismic surveys crossing the northern edge of the Jonah high, particularly to check the nature of the reflectors bordering the structure and to identify internal ones. We present preliminary results of seismic re-processing (of 2D and 3D data) comprising the application of CRS (common reflection surface) and other various algorithms, detailed velocity analysis and depth domain sections.

Mapping of the Sede Ya'akov fault

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The Sede Ya'akov fault is an assumed tectonic line suggested by basalt outcrops along the northwestern border of the Yizre'el Valley. This study aims at the verification, mapping and characterization of the Sede Ya'akov fault following recent subsurface analysis of the area bordering it and new $^{40}Ar/^{39}Ar$ dating).

Based on field mapping, cross sections, well data and magnetic field measurements along two cross-lines we suggest the location of this fault. The resulted fault line, alongside previous works enabled us to establish a normal sense of movement and a minimum vertical slip of >90 meters during the Lower Miocene. The faulting process caused the uplift of the Tiv'on block above the neighboring basins of Zevulun and Yizre'el. The Tiv'on block is part of the Gilboa-Carmel faulting array off the Dead Sea fault, a seismogenic branch cutting across the hilly Samaria-Galilee backbone. The Sede Ya'akov fault together with the Tiv'on block provide both the northwesternmost occurrence of the Lower Basalt formation in northern Israel and an eastern border for Pliocene-Pleistocene marine incursions. Further work may verify the assumed northern and southern extension of the fault, towards Alonim and Tel Kashish, respectively.

The recycling of the Ein Qedem brine - from Lake Lisan to large gypsum structures

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Radiometric dating (by 14C and 81Kr) of the hot-saline springs of Ein Qedem yielded ages that lie in the range of 35-16 ka. This age range, along with the chemical composition of the brine, suggest that the brine originated from the surface layer of the last glacial Lake Lisan. We provide a conceptual hydrological model for the long-term deep circulation in the marginal aquifers of the Dead Sea in which variations in lake levels are driving the brine flow into and out of the regional aquifer. During high lake stand of the last Glacial MIS2 period (e.g., ~170 mbsl, meters below mean sea level) the lake's upper brine layer recharged the marginal aquifer and sank through the marginal faults of the basin. During lake's low stand of the post glacial and Holocene periods (lake level of 400±30 m bmsl), the hydrostatic pressure of the lake's water column released, and the Ein Qedem type groundwater ascended from a depth of ~1 km and are currently discharging along the shores the of the lake. We suggest that Ein Qedem type brines precipitated the large gypsum structures (laminated mounds) recently exposed by the currently retreating Dead Sea at the Qedem shores as well as several other sites. These gypsum structures were deposited during times of lake level decline of the mid to late Holocene (e.g. ~ 3 ka), as determined by radiocarbon dating of organic debris and aragonite crusts that are contained in the structures. Thermodynamic calculations on the modern EQ brines and the composition of stable isotopes of sulfur and oxygen of the gypsum minerals ($\delta^{34}S$= 14-17‰ and $\delta^{18}O$ = 14.5-16.5‰) allowed us to estimate the composition of the ancient Ein Qedem brines and the geochemical conditions that led to the formation of these unique gypsum structures.

High resolution calcareous nannofossil chronology of the Eocene sequence in the southern Golan basin

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The southern Golan basin was drilled by six oil exploration wells that crossed through an extensively thick Eocene sequence. Here we present a detailed age model and basin wide correlation of the Avedat Group from the Taqiye, Adulam and Maresha formations. The Eocene sequence was found to be about 800m thick and spread between NP11 to NP17 of the calcareous nannofossil.

In the basin the Taqiye Fm is composed mostly of chalk and marlstone, the Adulam Fm is an alternating chalk with thin chert horizons and the Maresha is almost exclusively chalk. Both the Adulam and Maresha Fms contain about 2% organic carbon.

Cuttings were sampled by high resolution from the wells. Using Martini (1971) calcareous nannofossil biostratigraphic scheme and GTS2012 Geologic time-scale (Gradstein et al, 2012), an age model was constructed. A basin wide correlation was established and sedimentation rates were calculated across.

The calculated rates indicate high values above 100m/Myr which are at least 5-fold larger comparing to the values calculated at the Avedat Plateau and and resemble the rates calculated by Benjamini (1984) in the 'Arava Valley. The high sedimentation rates and the spatial variability in the basin may suggest mass movements and slides to local depocenters in the basin and also capture changes in productivity of the upper water body.

Rates of Seawater Circulation in Aquifers, using Radium Isotope Ratios

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Activity ratios of the long-lived ^{226}Ra and of ^{228}Ra to the short-lived isotopes ^{224}Ra and ^{223}Ra were studied in saline groundwater (90-100% seawater salinity) from the Quaternary coastal aquifer of Israel, up to 1 km from the sea. The aquifer consists of sands and calcareous sandstones of Nilotic origin. We identified no trend of increasing ^{226}Ra/^{224}Ra and ^{226}Ra/^{223}Ra with distance from the sea, and these ratios are low (e.g. ^{226}Ra/^{223}Ra mostly ≤3) in all sampled water, including deeper, confined sub-aquifers (down to 150 m below sea level). ^{224}Ra/^{228}Ra ratios are relatively high (activity ratios >3, far from secular equilibrium) up to 270 m from the sea, while ≤2 at 800 m. Together, these observations suggest that the residence times in the aquifer do not exceed a few hundred years, which means circulation rates of at least several meters per year.

Groundwater sampled from boreholes, <10 and 40 m from the sea at Dor Bay, showed different patterns in saline groundwater of two aquifer units. In the deeper, confined unit (roof at 27 m below sea level), water with seawater salinity mostly showed high ^{224}Ra/^{228}Ra activity ratios, which testifies to their young age, i.e. no more than a few years. On the other hand, water in an overlying, partly confined unit, with conductivity <40 mS/cm mostly showed activity ratios <2, which is interpreted as older water. This, together with significantly lower heads in the shallower unit, suggests that rates of circulation in this unit are lower than in the deeper one. It could also be that the differences are due to sampling of different parts of the circulation cell. While in the deeper unit we sampled seawater on its way landwards, the water of the shallow unit was sampled from the transition zone (mixed with overlying fresh water), which could have longer history in the aquifer and could represent water on its way back to the sea.

Radium isotope ratios were also measured in saline groundwater in the deeper, Cretaceous carbonate aquifer. In this aquifer, the interface is typically at 800-1100 m below sea level. Here, the activity ratios of long to short-lived isotopes are usually high, with ^{226}Ra/^{223}Ra mostly >20, (AR of ^{238}U/^{235}U = 21.7), which suggests that residence times in this unit are much larger than1000 years.

Carmeltazite, $ZrAl_2Ti_4O_{11}$, a new mineral from the volcanic rocks of Mt Carmel, northern Israel

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Studies of xenocrysts in upper Cretaceous volcanic tuffs on Mount Carmel, and in associated placer deposits in the drainage of the Kishon river, are producing a large range of exotic accessory minerals, ≥35 of which are previously unknown. Here we draw attention to the description of a new Zr-Al-Ti oxide, carmeltazite, with the simplified formula $ZrAl_2Ti_4O_{11}$. The crystal structure is orthorhombic, space group *Pnma*, with unit-cell parameters a = 14.0951 (9), b = 5.8123 (4), c = 10.0848 (7) Å, V = 826.2 (1) Å^3, Z = 4, and resembles a defective spinel structure. This new mineral has been named from Mt Carmel ("CARMEL") and from its major components, i.e. Titanium, Aluminum and Zirconium ("TAZ"). The mineral and its name have been approved by the IMA Commission on New Minerals, Nomenclature and Classification, under the number 2018-103. The full description is given by Griffin et al. (2018a).

Carmeltazite occurs in xenocrystic aggregates of corundum crystals (Carmel Sapphire ™), which crystallized from a magma, and trapped abundant pockets of their parental silicate melts. These melts appear to have evolved from primary mafic magmas that were progressively desilicated by the exsolution of immiscible Fe-Ti oxide melts and Fe-Ti-Zr-silicide melts (found also as inclusions in carmeltazite), and the crystallization of moissanite and khamrabaevite (TiC), at fO_2 = ΔIW-6 or less. The first phases to crystallize in the melt pockets are tistarite (Ti_2O_3) and a Mg-Al spinel; the tistarite is commonly resorbed and rimmed by euhedral crystals of carmeltazite, up to 80 µm in length.

The crystallization of Carmel Sapphire™ appears to have occurred near the crust-mantle boundary (ca 30 km depth), in the presence of excess volatiles. The abundance of carbon in the system (SiC, TiC and

amorphous C are widespread) and the low fO_2 required by the observed assemblages suggest that the volatiles were dominated by mantle-derived CH_4+H_2.

The mineral assemblages at Mt Carmel show several analogies with those in calcium-aluminum-inclusions (CAIs) in carbonaceous chondrites (CCs). Phases common to both assemblages include tistarite, hibonite, grossite and krotite, while carmeltazite resembles the Zr-bearing phases found in CC, such as panguite, kangite and allendeite. The inferred conditions of crystallization of the Mt Carmel assemblages are similar to those of the CAIs in terms of T and fO_2. These analogies suggest that the Mt Carmel system also formed in the presence of abundant $\mathbf{H_2}$ and carbon. This is suppported by the recent discovery of the first natural metal hydride ($\mathbf{VH_2}$) in hibonite-grossite xenocrysts from Mt Carmel.

A New Seismo-Engineering Ground-Motion Database for Israel

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The seismic activity in Israel and its surrounding neighbors originates mainly from the active Dead Sea transform. The historical and archaeological records suggest a recurrence interval of approx. 10^2 and 10^3 years, for earthquakes of M6 and M7, respectively. Despite the existing hazard, local advancements on this topic have been slow and incremental, partly due to objective challenges, such as the limited number of recorded significant earthquakes and a limited azimuthal coverage. Consequently, limited effort to date has been made to compile all of the available data into one standardized, open resource for the scientific and engineering communities. This project is a joint effort, aimed at standardizing the catalog and creating a publicly-available ground motion database for Israel. The database is compiled of three main branches: the event database, the ground motion recording database and the site database.

The event database is composed of over 400 events, and is a subset of the formal catalog published by the GII. We selected events with Md > 5.0 between 1983 and 2007, and Md > 3.0 since 2008.

The ground motion recording database is composed of over 3100 records having two horizontal components, and over 2900 records having all three components. The raw time-history data is processed following a protocol suggested by the Pacific Earthquake Engineering Research institute (PEER) and the Reference database for seismic ground-motion in Europe (RESORCE). Then the full Fourier Amplitude Spectra of the processed acceleration record is obtained at discrete frequencies, as well as peak values, such as PGA and PGV.

The station database compiles all available data regarding ISN station characteristics, as well as new field measurements collected systematically for the first time in the history of ISN. Surface - wave dispersion measurements allow us to obtain both the full shear-wave velocity (Vs) profile down to the available depth, as well as other proxies used for site response evaluation, such as the time-averaged shear wave velocity of the upper 30 meters, a parameter known as Vs30. At this point, we have a complete database for 23 out of 25 seismometer stations, and 29 out of 60 strong motion stations. This database is constantly growing as we continue to conduct field measurements at station locations.

Novel radon and CO2 monitoring technique in deep subsurface, as a proxy for investigating tectonic pre-seismic processes that occur before earthquakes

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Three multi-detectors monitoring stations of radon, CO_2, Relative Humidity and climatic parameters probes were installed in deep drilling along the Dead Sea Fault Zone (DSFZ).

The aim was to determine whether there is a link between radon and other gases anomalies at depth, and the pre-seismic process as accumulation and relaxation of lithospheric stress and strain.

The long-term monitoring in deep borehole method assumes that the climatic influence on physicochemical parameters is limited since its energy decreases with the increase in thickness of the geological cover. Hence, the natural gases monitoring of radon, CO_2 and other parameters above and below the water table in deep boreholes, enables to eliminate the climatic-induced periodic contributions, from the residual portion of the signals that are associated with the regional geodynamic processes, as have been proved by us recently.

The intention was to strengthen the contention that geo-physicochemical parameters under appropriate monitoring methods may be used as earthquake precursors, long before the main rupture occurs.

The main achievements can be summarized as follow:

(a) Radon in a rock porous media is driven by the surface temperature gradient ΔT, and moves down to a proven depth of 100 m, with the same daily cycle and a specific time lag. Radon in the open borehole air space is driven by the pressure variation ΔP. Therefore, radon may have daily and semidaily pressure periodicity.

(b) The high-resolution time interval (30 sec to 15 min) enables to distinguish between the diurnal periodical effect of the ambient temperature and the semidiurnal effect of the ambient pressure, on the radon temporal spectrum, and determination, for the first time, the radon movement velocity within rock layers at depths of several tens of meters, namely, 25 m/h on average.

(c) A very pronounced signal that became different in shape appeared during a day before the Nuweiba (in the Gulf of Eilat) M 5.5 earthquake of 27 June - wider than the expected width of the periodic signals appearing usually once or twice a day.

(d) This phenomenon repeats itself twice: on 16 May 2016, preceding by 12 hours the Nuweiba M 5.1 earthquake, and on 17 and 23 July 2016, two broadened radon anomalous signal appeared 7 and 2 days before new Palmyra Syria M 4.4 earthquake on 25 July 01:30.

(e) Radon and the CO_2 that emerge from the groundwater to the borehole airtight casing, are reveal the same daily & semi daily periodicity, under the same influence of the climatic driving forces and simultaneously parallel non-periodic broadening in time under the influence of tectonic driving forces.

Hence, the deep gas monitoring technology can become a useful tool as proxy for pre-seismic precursory before earthquakes.

Identification and Characterization of Phosphorus-Dust Sources Driven to Lake Kinneret, Israel

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Significant amounts of phosphorus in Lake Kinneret (LK) are suspected to be the cause for cyanobacteria blooms. Lake monitoring associates these phosphorus loads, to dust fluxes depositing over LK and contributing estimated amounts of 44-60 ton P year^{-1}, while 60% considered bioavailable P. The common assumption is that the summer's dominant westerlies are the driving force to most of the dust depositing in LK. New evidence, showing significant dust deposition rates all year round, raises new hypotheses regarding the sources and trajectories of dry deposition to LK. We hypothesize that: (i) different local anthropogenic sources cause phosphorus enrichment to dust (in varied levels of affect); (ii) Other wind directions may convey P-rich dust, in spite of the westerlies frequency and dominance; (iii) seasonal dust events, considered as major contributors to dust deposition, are not necessarily major contributors of phosphorus. An array of atmospheric dust collectors was located on the shores around the lake, in order to examine the dust falling over LK, and another array of horizontal mass flux samplers were stationed in LK surroundings. Then, a chemical, mineralogical and shape analysis of the dust samples was performed, combined with backward air trajectories and meteorological data. Mass flux samplers results show cattle farms and intensive pasture areas as more significant P contributors than open areas or agricultural lands (1650, 355 and 312 mean mg bioavailable P*kg^{-1} dust, respectively). It was shown that except the summer which is dominated by the western component, wind regime around LK is shifting throughout the year and has other components (eastern, southern and northern). Atmospheric dust collectors' results show variations in dustfall mineralogical composition between seasons, displaying higher dolomite and feldspar concentrations in summer, two minerals typical to local rocks around the lake. In addition, particles shape analysis and size distribution shows relatively coarse (up to 65% of all particles are greater than 10 µm) and poorly rounded particles. These findings might indicate number of contributors, possibly varying over the year, with emphasis on local deposition sources rather than long distance deposition route from the west.

Growth and Interactions of Subparallel Strike-Slip Faults in Post-Messinian Sediments, Levant Basin

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Studies of the growth and interaction of naturally occurring strike-slip faults are limited by the difficulty in evaluating the variability of slip across the fault plane. The Levant Basin post-Messinian interval serves us as a 'box model' for faults growth and interaction kinematics studies, being a relatively rapidly deforming finely layered brittle interval overlaying the ductile Messinian evaporitic interval and well imaged on 3D seismic data. Here we present a 3D seismic interpretation based study of two overlapping sub-parallel predominantly strike-slip faults in the SE Levant Basin with minor faults duplex development between them. Direct evaluation of the horizontal slip along segments of these faults is obtained through measurement of offsets on multiple avulsion channel packages crossed by the faults, aided by microscale fault interpretation, seismic attribute analysis and spectral decomposition. In conjunction, the dip-slip components of net-slip along the same fault segments were evaluated by measuring the offset of seismic interpretation horizons across these faults. Results display linear relationships between the dip-slip and the strike-slip, with the dip-slip constituting ~15% of the net-slip. These results corroborate that the two components developed simultaneously. Moreover, the linear relations imply that the dip-slip offsets, which are readily measurable, can serve as proxies for evaluating the predominant strike-slip across these faults. Thus, the dip-slip component of the offsets across the faults were measured on multiple interpretation horizons and used to produce continuous displacement maps of the fault planes, which we consider to represent net-slip across each major overlapping fault.

Findings show that breaching occurs progressively within the overlap zone due to faults interactions, with secondary normal faults initiation equally from the major faults on each of the sides. The secondary faults accumulated displacement and merged during their growth to develop a sigmoidal duplex. The duplex forms horst, graben and half-graben structures, indicating the prevalence of dilatational strain conditions.

Displacement maps of the major faults planes reveal highly segmented complex spatial patterns, with continuous segments observed in both the breached and the intact parts of the overlap zone. Analysis of displacement-distance plots show that areas of minor faults initiation in many cases coincide with the location of the initial paleo-tips of the fault segments. Moreover, the displacement profiles of each segment suggest that most of them formed after the sediment deposition, and propagated radially

during their growth. Additionally, segment complexity increases near the Top-Evaporites surface. Some of the segments appear to have nucleated close to the Top Evaporites horizon and likely propagated upward. The proposed methodology of identifying dip-slip and strike-slip relationships from 3D seismic data, can be used to: i) differentiate simultaneous from reactivated slip ii) distinguish strike-slip or dip-slip dominated segments; ii) examine weakness zones within strike-slip dominate faulting regimes.

Wave-cut surfaces south of the Be'er Sheva valley – A mirror image of its northern part

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Miocene-Pliocene wave-cut surfaces capped by marine and continental sediments were described all along the central mountain belts of Israel up to the Be'er Sheva valley, and were used to reconstruct their uplift history. Our current study identified those surfaces also across the lowland between the Be'er Sheva valley and the northern Negev anticlinal ridges. This region has been shaped by five rock cut surfaces, with eastward increasing altitude, which are separated by escarpments 30-40 m high. They are described below from the lower to the upper and from west to east.

1. A surface capped by shallow marine limestone and beach-rock of the Pliocene Pleshet Fm. located at an altitude of 260-270 m. It marks the coastline of the Pliocene sea that deposited the extensive clastic shallow marine sediments that mantles the Lower Shefela surface of the northwestern Negev, which was formed at the Middle Miocene.

2. A wide (3 km) surface at an altitude of 320 m capped by a fluvial conglomerate derived from the anticlines of the northern Negev. It is located at the same altitude as the Pliocene coast line north of Be'er Sheva, and therefore, it was also correlated with the Lower Shefela surface.

3. Shemen surface at an altitude of 360 m, where communication antennas (Giv'at Hablanim) are located. Several allochthonous clasts were found on the slopes of this surface.

4. Ar'ara surface at an altitude of 400-420 m, which extends up to the Dimona Anticline in the east and Hebron Mts. in the north, and is capped by conglomerate of local origin.

5. Kuseife surface, which extends eastward up to the regional water divide south of Arad, and is covered by the Heimar conglomerate in the east and the middle Miocene marine Ziqlag Fm. in Giv'ot Goral north of Be'er Sheva (the Upper Shefela surface). A new relic of a shallow marine to coastal sequence was found on this surface 13 km south east of Be'er Sheva at an altitude of 458 m, which is also the altitude of the Ziqlag Fm. at Giv'ot Goral, and therefore, it was correlated with the Higher Shefela surface.

The morphological positions of these five surfaces reflect an uplift of about 140 m during the Middle Miocene, an uplift of 30-40 m during the Pliocene and a post Pliocene uplift of about 250 m. As this tectonic scenario has been documented all the way to the Carmel fault, it is postulated that the entire mountains belt of Israel south of the Carmel fault, manifest the same episodes of tectonic uplift since the Middle Miocene.

Drivers and sources of lithogenic fluxes in the deep Levantine basin offshore Israel

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Automated sediment traps (conical, McLane type) were deployed for 18 months (Nov 2016 – May 2018) along the cable of the DeepLev mooring at the Levantine Basin, 50 km west of Haifa, at 1,500 m water depth. The automated traps were sampling sinking particulate matter (PM) at depths of 180, 280 and 1300 m with a temporal resolution of 11-12 days. To these, we added two couples of single-collection cylindrical traps at 810 and 1490 m. Here, we report particle composition and temporal variability of the obtained lithogenic fluxes and discuss their drivers and sources.

The particulate matter is predominantly comprised of fine-grained lithogenic material, mostly clays, with a minor marine biogenic component, i.e. organic matter and marine carbonates. Year-round average in the deep traps (810, 1300 and 1490 m) were similar, at ~270 mg m^{-2} d^{-1}. At the shallow traps (180 and 280 m), fluxes were significantly lower: ~160 mg m^{-2} d^{-1} for the 280 m and ~70 mg m^{-2} d^{-1} for the shallowest, 180 m trap. Therefore, we infer that considerable amount of the PM was introduced by intermediate lateral flow (i.e., nepheloid layers) between the 280 m and 810 m. The 18 month-long PM flux record shows good correlations with winter storms, including onshore-measured rainfall precipitation, stream discharge, and coastal waves. Although the rainy season in the Levant is short (roundly four months), the alluvial transport delivered during this period contributes up to two-thirds of yearly lithogenic flux in DeepLev site. PM flux peaks are also associated with the occurrence of seaward cross-shelf currents. On the other hand, there is weak correlation with dust in the air. The above suggests that modern sedimentation in the deep Levantine basin is controlled by the lithogenic input from a proximal land.

A giant delta interacting with a salt giant: the asymmetric circum-Nile deformation belt

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The relatively young and not deeply buried Mediterranean salt giant provides an opportunity to study the initial stages of salt tectonics, which are difficult to reconstruct in highly deformed salt basins. The circum-Nile deformation belt (CNDB) particularly illustrates the interactions between a giant delta and a giant salt body. The semi-radial shape of the CNDB is commonly interpreted as salt squeezing out from under the Nile delta. We demonstrate, however, that, in fact, the thickest part of the delta overlies a quite thin original salt section. Squeezing this salt would have had little effect on the regional picture. The only area, in which the squeeze-out model works, is the easternmost side of the delta towards the Levant Basin. In this area, differential loading over a few hundred meters thick salt produces a pressure gradient sufficient to promote salt flow, even upslope, against the elevation gradient. On the other side of the delta, towards the Herodotus Basin gliding of the sediment-salt sequence downslope is driven by the elevation gradient, enforcing contraction in the deepest part of the basin. A particularly interesting phenomenon is a 'salt glacier' gliding basinward over thick salt, filling preexisting valleys. The 15x40 km Palmahim disturbance offshore Israel and the 50x200 km Temsah Valley offshore Sinai, Egypt, are two such examples.

The future of Israel's marine sand resources supply

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Since 1964, when the Aswan High Dam practically cut off fresh Nilotic sand supplies to the Mediterranean, the huge volumes of sand that had previously accumulated in the coastal areas of the Nile Delta and its offshore are feeding the Nile Littoral Cell.

It is estimated that steady sand supply from these sources will last for at least hundreds of years before it will terminate due to continuous erosion. Moreover, the great amount of sand accumulated along northern Sinai beaches will continue to supply sand afterwards and insure the longshore sand transport toward Israel's shores.

The current study estimated that sand flux input from Gaza Strip to Zikim-Ashqelon is about 400,000 cubic meters, annually on the average. This volume is contributed by wave-induced longshore currents in the littoral zone (~ 300,000 m^3/year) and by wind-induced longshore currents beyond the breaker zone to about 30 m depth (~ 100,000 m3/year).

Assuming that the sand transport pattern during the last 5,000 years has not much changed the sand input into the Mediterranean coast of Israel totaled two billion cubic meters. The sand have mostly dispersed over the inner shelf, deposited on the beaches and blown inland as sand dunes on the coast and beyond. Some very fine sand escape seaward into the open deep shelf.

The principal mechanisms responsible for the redistribution of sand entering the Israeli inner shelf by longshore and cross-shore sediment transport are caused by breaking waves, winds and coastal currents, more specifically by undertow.

In conclusion, if the sand supply to the Mediterranean coast of Israel is cut off (because of large marine structures such as El-Arish and Ashdod ports, and Gaza seaport in the future etc.) very large sand reserves will still remain along the Israeli inner shelf and will be available for future exploitation. The national challenge will be how to exploit and manage this essential resource without harming the morphology of the coast and other values of nature.

צילום: אריה טננבאום, מתוך אתר פיקיוויקי