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נִיר עֶצִיּוֹן - 2022 - Nir Etzion



# נִיר עֶצִיּוֹן

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## חוברת תקצירים
















## Abstracts

**עריכה:** יהונתן קינן, נורית ובר ויהודית הרלבן

**Editors:** Jonathan Keinan, Nurit Weber and Yehudit Harlavan



# החברה הגיאולוגית הישראלית מודה למוסדות ולגופים הבאים על תמיכתם ותרומתם בשנים 2021-2022

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**חברי ועדת ביקורת**

שמעון פינשטיין, אנטון וקס וגל יסעור

## **Methane biogeochemistry in Ein Feshkha groundwater**

ביוגיאוכימיה של מתאן במי התהום של עין פשחה, ים המלח

Abu Ali H. (1, 2), Reznik I. (2), Bar Zeev E. (3), Rahav (4), Sivan (1)

1. Department of Geological and Environmental Sciences, Ben Gurion University of the Negev, Beer-Sheva, Israel
2. Geological Survey of Israel, Jerusalem, Israel
3. Department of Environmental Hydrology and Microbiology, Zuckerberg Institute for Water Research, Blaustein Institutes for Desert Studies, Ben Gurion University of the Negev, Israel
4. Israel Oceanographic and Limnological Research, National Institute of Oceanography, Haifa, Israel

abualihala@gmail.com

The occurrence and source of hydrocarbons in the groundwater along the Dead Sea Transform (DST) was previously documented, but the microbial activity and composition accompanying the anaerobic respiration processes at different water salinities and redox states have been barely investigated. In this study, groundwaters were sampled from nine boreholes drilled in the Ein Feshkha nature reserve at the north of the Dead Sea. Alkanes, dissolved inorganic carbon (DIC), and their isotopic composition were measured, in addition to other chemical and microbial parameters. The groundwater samples varied in salinity, redox state, sulfate and methane concentrations. Methane and DIC stable carbon isotopic composition, together with C1/C2 ratio and the microbial data show different sources of methane and dominance of different biogeochemical processes.

## Submerged Levant shorelines from glacial lowstands: Novel stratigraphic-tectonic markers in 3D seismic data from exploration

החופים הטבועים של הלבנט מהנסיגות בתקופות הקרח: סמנים סטרטיגרפיים וטקטוניים חדשניים  
בנתוני תלת מימד סייסמי

Algon R. (1), Mevedev B. (2), Agnon A., (1)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel
2. Schlumberger Petroleum Services

amotz@huji.ac.il

Modern petroleum exploration extracts 3D volumes of seismic data where certain curves can be drawn delimiting stratigraphic horizons. Such curves hold a promise as piercings for identifying tectonic offsets in 3D. Pinchout points on vertical sections connect with adjacent sections to form contours in 3D. Such a contour, showing quasi-uniform depth, may be considered a paleo-isobath. Here we focus on pinchout paleo-isobaths in the western shores of the Levant that might record ~120 m drop in sea level at the peak of late Quaternary glacials. We identified a pinchout isobath, ~15 km offshore, ~140 m below sea level. Water depth averages ~90 m, and sediment cover averages ~45 m. Allowing for isostatic adjustment, this is compatible with eustatic levels of the last two glacial maxima. We hypothesize that the contour mapped is closely related to the shoreline of one of the last glacial maxima. The pinchout pattern is continuous for ~25 km in the southern reaches of the survey area, at depths of  $137 \pm 2.5$  m, an isobath within the observational uncertainty. The isobath is lost for ~10 km in the central portion of the survey, north of which a slightly deeper isobath reappears for 7 km, until it disappears approaching a bathymetric trough. The deeper pinchout isobath reappears in the northernmost section of the survey, where it deepens by an average of 5–6 m relative to the southern part (from 137 m to 142 m). The deepening of the pinchout contour is consistent with massive sliding underlying the trough. Sliding here has been attributed to sediment load or salt tectonics, and has been recently associated with a local tsunami dating  $9.6 \pm 0.3$  ka. Recent work relocated the deepest earthquakes on the Levant southern shelf (depths circa 30 km) to the trough, with epicenters coinciding with the boundary faults. This may indicate an active deep-seated tectonic feature. Expressions of the contour outside the survey area will offer tests to our paleo-shoreline hypothesis. Additional pinchout isobaths and pinchout contours associated with earlier lowstands will help constrain tectonic rates as well as glacial eustatic levels and hydro-isostatic effects, with potential regional and global applications.

## Continental margin impact on C:N:P ratios in the southeastern Levantine Basin

השפעת מדף היבשת על יחסי פחמן/חנקן/זרחן במזרח הים התיכון

Alkalaya R. (1,2) Bar T. (1,3), Katzc T. (2), Herut B. (2), Berman-Franka, I. (3) Weinstein Y. (1)

1. Department of Geography and Environment, Bar-Ilan University, Ramat-Gan, 52900, Israel

2. Israel Oceanographic & Limnological Research Ltd., Tel-Shikmona, P.O.Box 8030, Haifa 31080, Israel

3. Leon Recanati Institute for Maritime Studies University of Haifa, Mount Carmel, Haifa 3498838, Israel

ronen.alkalay@gmail.com

Aspects of C export were studied in April 2018 along a transect from Haifa to the DeepLev station (50 km) aboard the R/V MED-EXPLORER. Water column profiles were sampled at four points: shelf break (water depth of 120m), mid-slope (680m), slope bottom (1000m) and DeepLev station (1500m). The slope part followed the route of a local submarine canyon. Concentrations of particulate organic Carbon and Nitrogen (POC, PON) decreased with distance from shelf and with depth. POC/PON and PON/POP ratios mostly decreased with depth in all deep stations, which is in disagreement with the common observations of increasing ratios due to the faster degradation of organic nitrogen and should be further studied. High turbidity observed at the shelf break and the slope with a peak at 500m, the turbidity decreased with distance.  $^{234}\text{Th}$  disequilibrium with its radioactive parent  $^{238}\text{U}$  is commonly used in oceanic studies as a proxy for particle scavenging, and accordingly for C export assessment.  $^{234}\text{Th}$  deficit is clearly observed in the euphotic zone (upper 180m), which indicates on particle transport from surface to the deep water, mainly related to primary production. On the other hand, a pronounced excess of  $^{234}\text{Th}$  was found at the base of the euphotic zone, down to 280m, as well as at 700 m at the open sea DeepLev station. This was accompanied by an elevated  $^{234}\text{Th}$  at 180 m at the slope station. We interpret this as an indication for a lateral input from the shelf, which is in accordance with sediment trap observations from DeepLev (Alkaly et al. 2020). The 700 m  $^{234}\text{Th}$  excess probably indicates on another lateral source at mid-slope depth, which is also supported by the high turbidity observed at this depth, and may be related to transport through submarine canyons in this area.

## **Shelf inhabiting foraminifera as a tool for understanding Late Quaternary slope mass transport processes in the Northern Gulf of Eilat/Aqaba, Red Sea**

פורמיניפרה ממדף היבשת ככלי להבנת תהליכי הובלת סדימנט במפרץ אילת/עקבה ברביעון

המאמר

Ash-Mor, A. (1), Almogi-Labin, A. (2), Ben-Avraham, Z. (1,3), Kanari, M. (4) Bookman, R. (1)

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

2. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

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

4. Israel Oceanographic & Limnological Research Ltd., Tel-Shikmona, P.O.Box 8030, Haifa 31080, Israel

ash\_anat@yahoo.com

The sedimentary records of steep continental slopes are sensitive to global and local processes, especially in tectonically active margins, such as the Gulf of Eilat/Aqaba (GEA). During the Late Quaternary, in addition to the repetitive seismic activity along the Dead Sea Transform, drastic changes in sea level, temperature and salinity occurred in the marine environment resulting in changes to the faunal community. In this study, a newly established approach, using shelf originated foraminifera to identify displaced sediment units, is utilized to reconstruct the events which occurred in this rapidly changing environment. A total of 11 units of displaced sediments and 3 temporally significant unconformities were identified based on foraminiferal assemblages and radiocarbon dating within two cores from the GEA northwestern slope at water depth of 300-400 m, covering up to 40 kyr BP. Two foraminiferal assemblages were identified corresponding with the changing salinity: 1) the 'Holocene assemblage' dominated by the stenohaline symbiont-bearing larger species *Operculina ammonoides*, *Amphistegina papillosa* and *Amphistegina bicirculata*; and 2) the 'Glacial assemblage' dominated by the hypersaline tolerant species *Elphidium* cf. *E. limbatum*, *Elphidium jensenii* and *Peneroplis planatus*. Both assemblages recorded the mass transport deposits with high precision, even when grain size showed no indication of coarsening, reinforcing shelf originated foraminifera as a reliable proxy for mass transport events. Unconformities were found to be associated with periods of rapid sea level changes and/or increased sedimentation rates, effecting sediment porosity and slope stability. Displaced shells of the 'Holocene assemblage' were dated to 12 kyr BP and believed to be the first recorded evidence for the post glacial re-settlement of this ecologically important group in the northern GEA.

## **The Nature of the Pumiceous Ash and Tuff used for the Construction of the Sebastos Harbor at Caesarea Maritima**

אופי הפומיס והטוף ששימשו לבניית הנמל בקיסריה ההרודיאנית

Asscher Y. (1)

1. Analytical Laboratory, The Artifacts Treatment, Conservation and Laboratories Dept., Israel Antiquities Authority, Har-Hotzvim, Jerusalem.

[yotama@israntique.org.il](mailto:yotama@israntique.org.il)

The most impressive structure built under the king Herod reign was the artificial harbor of the city Caesarea Maritima, named Sebastos in honor of the Emperor (Sebastos is Greek for Augustus). The structure was constructed on a shoreline devoid of any natural protective embayment, and given such unfavorable geomorphological conditions, the choice of innovative building materials and techniques was required to protect it from one of the Mediterranean's highest-energy wave environments. As thoroughly described by the 1st Century CE Roman Jewish historian Josephus Flavius, the construction of Sebastos Harbor "...was to be brought to perfection by materials from other places, and at very great expenses" (JA 15.9.332). These foreign materials were incorporated into large concrete blocks of the underwater foundations, described as "...this he effected by letting down vast stones of above fifty feet in length, not less than eighteen in breadth, and nine in depth..." (JA 10.334-336), and were recently identified as pumiceous ash and tuff sourced from the Phlegraean Fields volcanic district, Italy. Pumiceous ash and tuff are found to be the key ingredients in constructing underwater foundations, as they contain amorphous aluminosilicate compounds capable of reacting with lime and water to precipitate hydraulic insoluble phases with excellent mechanical properties. The specific chemical nature and mineralogical formation pathways of hydraulic reactions will be discussed here, and a new criteria will be shown for prescreening mortars for these materials based on X-ray powder diffraction (XRD), X-ray fluorescence (XRF) and Fourier transform infrared spectroscopy (FTIR) measurements. Scholars rely on the writings of Josephus Flavius as the starting point for information about Herod the Great. Recent geoarchaeological studies in Caesarea Maritima allowed archaeologists to find the links between historical texts and Roman concrete in the Sebastos Harbor.



## **Landscape evolution of the Sinai-Israel plate: a contribution for tracing Paleolithic sites in their geomorphological contexts in the Levant deserts**

התפתחות הנוף של לוח סיני-ישראלי: תרומה לחיפוש אתרים פלאוליתיים במדבריות הלבנט

Avni Y. (1), Barzilai O. (2)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

2. Archaeological Research Department, Israel Antiquities Authority, POB 586, Jerusalem, 91004, Israel

[yoav.avni2@gmail.com](mailto:yoav.avni2@gmail.com)

Landscape evolution stages of the Sinai-Israel plate are strongly associated with its tectonic development. After the Dead Sea Transform was initiated in the Early Miocene (18-16 Ma), the Sinai-Israel plate was uplifted, causing the development of drainage basins such as the Paran-Negarot basin in the Negev and the Watir and Naseb basins in Eastern Sinai. Toward the end of the Pliocene and during the Early Pleistocene (4-1.6 Ma), the rate of incision decreased enabling deposition of fluvial units within the drainage basins. At this stage, the Arava Formation was deposited in the Eastern Negev, while the Garof Formation and equivalent units were deposited in Eilat and in Eastern Sinai, all partly cemented with calcite cementation and associated with large-scale landslides. A regional tectonic phase, dated to 1.5-1 Ma, caused the re-uplift of the Sinai-Israel plate, combined with faulting and arching of the Negev toward the Arava Valley. This activity created re-organization of the drainage network, creating new drainage basins such as the Ashosh, Barak, Vardit and Hayyon. In the Eilat region, Nahal Gishron disconnected previous drainage lines feeding the Garof Formation. In Eastern Sinai, a new incision phase evolved, leaving remnants of Pliocene-Early Pleistocene conglomerates at elevation of 50-100 m above the drainage channels. As the rapid incision ceased, a series of alluvial terraces developed within the drainage basins, labeled as Q1, Q2 and Q3 surfaces, containing artifacts of prehistoric cultures. A geo-archaeological study in the framework of the ISF demonstrated that the Q1 surface is corresponding to the Lower Paleolithic, containing Acheulean handaxes. Q2 surface shows several terraces, comprising Early-Middle Paleolithic occurrences while the Q3 terrace contains the Middle-Upper Paleolithic transition. This new understanding of the link between landscape evolution and prehistory stages has great benefits for improving geo-archaeological surveys in the arid regions of the Levant.

## **Fault creep and salt ductility: analysis of borehole station data for the 2018 earthquake swarm in the Kinneret pull-apart basin**

זחילת העתק וזרימת מלח: אנליזה של נתוני קידוחים מנחיל הרעידות ב-2018 אגן הטנספורם אשר בכנרת

Barnea Cohen O. (1), Hofstetter R. (2), Hamiel Y. (3), Cesca S. (4), Dahm T. (4), Agnon A. (1)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel
2. Independent researcher
3. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel
4. GFZ German Research Center for Geoscience Potsdam, Telegrafenberg, 14473, Potsdam 6 14467, Germany

[osnat.barnea@mail.huji.ac.il](mailto:osnat.barnea@mail.huji.ac.il)

Kinneret (Sea of Galilee) area has recently made headlines following several earthquakes that were felt across the country. The noticeable activity started in October 2013 and continued in July-August 2018, and again this year. We present unpublished data from two near-source seismographs in boreholes (~530 m depth). According to our results, more than a thousand earthquakes ruptured during July-August 2018, while hundreds were recorded in the Israel Seismic Network. The earthquakes are of a swarm type, clustered in the northern reaches of the lake, the majority at  $\leq 6$  km depth. In this study, we sample the earthquakes from the two stations and analyze waveforms. By using cross-correlation coefficients, we expose the dominant location: a cluster in the center of the northern third of the lake. Our current study is based on our previous work (Barnea Cohen et al., submitted), and additional pieces to the puzzle. According to the hypothesis, the earthquakes could be induced by shallow creep on the plate boundary associated with a ductile buried salt unit. A recent gravity model (Rosenthal et al., 2019) suggests that an evaporitic formation, penetrated by a borehole, underlies the entire basin, at a few kilometers depth. We suggest here that the ruptured faults lie in the least stable region of the salt. It may be associated with an intrusion interpreted in seismic data (Reznikov et al., 2004) with normal faults and grabens. Another source of instability might be heating by a basalt flow (based on Ginzburg and Ben-Avraham, 1986 and Shalev et al., 2013), contributing to salt ductility. This could enable fault creep and stress concentration. Although there are several explanations for the seismicity “hot spot” at the northern reaches of Lake Kinneret, association with a ductile salt formation seems the most plausible.

## **Back to 'Ubeidiya: revisiting stratigraphy, chronology and paleoenvironments of the Fluvatile Inferior (Fi) cycle**

בחזרה לעובדיה: בחינה מחודשת של הסטרטיגרפיה, כרונולוגיה ופליאוכרונולוגיה בתצורת FI

Barzilai O. (1), Belmaker M. (2)

1. Israel Antiquities Authority, POB 586, Jerusalem, Israel

2. The University of Tulsa, USA

omryster@gmail.com

'Ubeidiya, located in the Jordan Valley is one of the earliest prehistoric sites outside Africa. Extensive excavations carried by several expeditions in the second half of the 20th century yielded important archaeological, paleontological, and geological data, which provided insights into early Pleistocene hominins expansion out of Africa. Since the early excavations, the lithics and faunal assemblages were revisited and studied using state of the art methods; however, the geology and stratigraphy were not reexamined. One of the primary descriptions of the site was its four cycles: Limnic inferior (Li), Fluvatile Inferior (Fi), Limnic Upper (Lu), and Fluvatile upper (Fu). In addition, a composite trench detailing the correlation on either side of the anticline summit. A composite stratigraphic column published has been extensively used as the model for the within site chronology. Furthermore, dating attempts at the site did not yield satisfactory results; and the current chronology is estimated based on biochronological markers only. Here we present preliminary field observations from a new excavation in 2021 at 'Ubeidiya. One of the main aims of the new project was sampling for dating and paleoecological methods which spanned the Li and Fi cycles. We identified several artifacts and faunal bearing strata in Trenches Ia and III; However, we could not confirm the previously published stratigraphic schema. We could not securely identify a correlation between strata on both sides of the anticline summit and between trenches IIa and Ia, which formed the basis for the famous stratigraphic diagram. This suggests that a detailed revision is warranted and that outstanding question such as the presence of early lithic industries and unique fauna in the Li cycle may need to be reexamined and will provide a better understanding of the how, what and where of the expansion of the early Acheulian from Africa to Eurasia.

## **Beachrock morphology along the Mediterranean coast of Israel and its significance for understanding beach evolution**

מורפולוגיה של סלעי חוף לאורך חוף הים התיכון של ישראל ומשמעותה להבנת התפתחות חוף

Bar A. (1, 4), Galili E. (2), Bookman R. (1) Zviely D. (3)

1. The Dr. Moses Strauss Department of Marine Geosciences, Leon H. Charney School of marine sciences. University of Haifa, Mt. Carmel, Haifa 31905, Israel.
2. Zinman Institute of Archaeology, University of Haifa, Israel.
3. Faculty of Marine Sciences, Ruppin Academic Center, Emek-Hefer 40250, Israel
4. Geomorphology and Portable Luminescence Laboratory, Leon Recanati Institute for Maritime Studies, U. of Haifa, Abba Hushi Ave., 199, Mt. Carmel, Haifa, 3498838, Israel.

hazirbar@gmail.com

This study presents the current state of beachrock morphology along the Mediterranean coast of Israel, based on field measurements and field relations interpretation, backed by petrographic and sedimentological data. The study focuses on beachrock beds formed since the sea level has reached the present level ~4 kyr ago, presents new typology of erosion patterns of beachrocks, and demonstrates the possible use of beachrock exposers as a marker for sea-level change. Beachrock is characterized by significant amounts of beachface associated particles (such as shells, sand), cemented with calcium carbonate. Beachrocks are formed in the intertidal zone, and therefore indicate the position of palaeoshorelines. In microtidal areas, like the case of the South East Mediterranean, they are considered as reliable indicators for sea-level changes. Although the Mediterranean coastline of Israel exhibits abundant beachrock occurrences, there is gap of knowledge regarding the deposition and exposure patterns, and its formation age. The study deals with the undisturbed in-situ beachrock outcrops along the Mediterranean coast of Israel, focusing on the Sharon and Carmel coasts. The methodology combines field measurements and sedimentological analysis including: thin section petrography, SEM-EDS, XRD, surface profile, bedding structures, sediment and cement texture, as well as, OSL ages and POSL analysis, aimed at dating and examining their formation process. The results indicate that massive sediment lens was present along the Sharon coastline some 1.3 ky ago, and that it has been eroded since. We show that occurrence of large beachrock blocks in few meters water depth is often associated with erosion and not necessarily indicates a lower sea level during their formation.

## **Influence of Dead Sea level changes on earthquake recurrence during the last two millennia**

השפעת שינויי מפלס ים המלח על חזרתיות של רעידת אדמה במהלך אלפיים השנים האחרונות

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

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

(2) The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel.

[mkukuliev@gmail.com](mailto:mkukuliev@gmail.com)

We explain the variability in paleoseismic rates of large strike-slip earthquakes by large-scale water level fluctuations in basins overlying faults. Reservoirs are known to induce seismicity: water level increase significantly affects effective stresses at seismogenic depths, generating immediate and delayed seismic responses, and accelerating seismicity. Our modeling manifests that fluctuations in water level in historic water bodies in the tectonic depression of the Dead Sea Basin could cause changes in paleo-seismic rates. This triggering is explored on a historical time scale of the period of two millennia, based on the data gathered on water level fluctuations and earthquakes in the Dead Sea Basin. The data regarding these two phenomena suffer from severe uncertainties due to their different nature, methods, and their inherent resolution. The correlation between the quasi-continuous record of historic Dead Sea level reconstructions and discrete seismicity patterns is considerably improved and novel scenarios for water level reconstruction are introduced, applying a numerical earthquake simulation algorithm. The results of the simulations show direct connection between water level changes and frequency of seismic events in the Dead Sea Basin for the period of two millennia; dates of numerically simulated quakes are also comparable with those from the literature sources. Our study demonstrates that incorporation of water level changes is essential for earthquake simulation, prediction, and mitigation in areas of lakes or reservoir.

## **Dissolved trace metals, rare earth elements and Pb isotopes in the eastern Mediterranean Sea**

מתכות מעבר, עפרות נדירות ואיזוטופים של עופרת במזרח הים התיכון

Benaltabet T. (1,2), Lapid G. (1,2), Alkalay R. (3,4), Weinstein Y. (3), Steffens T. (5), Achterberg E.P. (5), Torfstein A. (1,2)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel
2. Interuniversity Institute for Marine Sciences, Eilat 88103, Israel
3. Department of Geography and Environment, Bar-Ilan University, Ramat-Gan, 52900, Israel
4. Israel Oceanographic & Limnological Research Ltd., Tel-Shikmona, P.O.Box 8030, Haifa 31080, Israel
5. GEOMAR Helmholtz Centre for Ocean Research, Kiel 24148, Germany

tal.benaltabet@mail.huji.ac.il

Inputs from continental margins and anthropogenic activities exert strong controls over trace metal biogeochemical cycles with oceanic Pb being a primary tracer of anthropogenic inputs to the marine environment, and its isotopic composition widely used to distinguish and quantify its different sources to the marine environment. Here, we present high spatial resolution dissolved trace metal (Al, Zn, Mn, Fe, Ni, Cu, Co, Cd, and Pb), rare earth elements, nutrient (PO<sub>4</sub>, NO<sub>3</sub>, and SiOH<sub>4</sub>), and Pb isotope profiles sampled during two cruises carried out in April 2018 and June 2021 between the northern offshore of Israel and the deep and warm oligotrophic eastern Mediterranean Sea. The results display elevated concentrations of Zn, Mn, Co, Cu, and Pb at the coastal stations along the continental shelf, corresponding with Pb isotopic signals associated with terrestrial inputs. An enrichment in Zn, Cd, Ni and NO<sub>3</sub> and a depletion in Pb concentrations was observed along intermediate depths (~200-700 m), in tandem with terrestrial Pb isotopic compositions and a negative Ce anomaly. These imply that a shelf-break sourced intermediate nepheloid layer acts as both a source and a sink for trace metals through partial dissolution of, and scavenging onto, suspended particles. Open sea trace metal profiles suggest that the effects of the nepheloid layer may resonate further away to the remote Mediterranean Sea. The different trends in dissolved trace metal and Pb isotope distributions and concentration range observed between the two cruises emphasizes the dynamic nature of the continental margin environment as varying atmospheric, terrestrial and anthropogenic inputs may transiently alter elemental water column distributions and potentially impact open water biogeochemical cycles.

## **Dissolved aluminium in the Gulf of Aqaba, northern Red Sea: On the short- and long- term effects of daily time scale dust storms, wet deposition and sediment resuspension**

השפעת סופות אבק, גשמים והרחפת סדימנטים על אלומיניום במי מפרץ עקבה

Benaltabet T. (1,2), Lapid G. (1,2), Torfstein A. (1,2)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel

2. Interuniversity Institute for Marine Sciences, Eilat 88103, Israel

[tal.benaltabet@mail.huji.ac.il](mailto:tal.benaltabet@mail.huji.ac.il)

Dissolved aluminium (Al) is a primary tracer for evaluating atmospheric deposition fluxes to the open ocean. However, the impact of daily time scale environmental perturbations such as dust storms, sediment resuspension and rainfall events on the oceanic water column is poorly constrained due to the typically low temporal resolution of sampling in open ocean settings. The Gulf of Aqaba (GoA), northern Red Sea, is a highly accessible deep oligotrophic water body featuring exceptionally high atmospheric deposition rates, delivered primarily during discrete dust storms. Here, we report a highly resolved time series of vertical profiles of dissolved Al and silicate concentrations sampled during 2017 and 2018 in the GoA, with a particular focus on daily time scale dust storms, episodes of sediment resuspension and rain events. We evaluate the results in conjunction with high temporal resolution measurements of airborne aerosols and sediment trap based water column sinking particulate fluxes. Dissolved Al concentrations range between 22 and 91 nmol kg<sup>-1</sup>. Counter intuitively, mixed layer Al (AIML) inventories decrease with increasing aerosol loads, with dust storms promoting intense Al scavenging, abruptly driving down AIML by up to 14%. By contrast, wet deposition may enhance the soluble Al flux from dust by a factor of 13. Post dust storm AIML change rates decline linearly with increasing theoretical dissolution rates following the Dry Deposition Curve. Accordingly, low particle density driven by low magnitude dust storms and deep mixing depths will result in scavenging favoring conditions. In response to a sediment resuspension event, Al water column inventories decreased by 34% as dissolved Al was mainly scavenged onto resuspended sediments and only mildly (2-5%) incorporated into diatom frustules. The in-situ rates and insights presented here may be incorporated into atmospheric deposition models to better quantify and understand the short- and long-term impacts of abrupt environmental events on water column chemical compositions.

## Drivers of topographic asymmetry in the Antarctic Dry Valleys

מנגנונים להוצרות אסימטריה טופוגרפית בעמקים היבשים של אנטארקטיקה

Ben-Asher M. (1), Mushkin A. (1), Eppes M. C. (2), Lensky N. (1), Amit R. (1), Ming D. (3), Sletten R. (4)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

2. University of North Carolina Charlotte, Charlotte, NC, 28223, USA

3. NASA Johnson Space Center, Houston, TX 77058, USA

4. University of Washington, Seattle, WA, 98115, USA

[mushkin@gsi.gov.il](mailto:mushkin@gsi.gov.il)

Topographic asymmetry between north- and south-facing hillslopes is common across terrestrial landscapes. In the absence of structural, stratigraphic, or lithological forcing, asymmetric hillslope evolution is commonly attributed to insolation-dependent vegetation, fluvial, colluvial, pedologic, and frost-weathering processes that ultimately link to differential weathering and/or transport rates. Here, we show that topographic asymmetry in the Antarctic Dry Valleys (ADV) results from elevated rock-weathering rates on north- (equator) facing hillslopes although the region's hyper-arid, extremely cold and barren conditions effectively exclude mechanistic linkages described above. Diurnal surface-temperature oscillations due to insolation geometry during the transition seasons, excess moisture from snowmelt and cycles of salt deliquescence/efflorescence appear as the likely drivers for faster rock-weathering rates on the north-facing hillslopes of one of Earth's most slowly eroding landscapes. In a broader context beyond that of topographic asymmetry, we propose salt deliquescence as a potentially overlooked mechanism for effective conversion of atmospheric humidity to water available for rock-weathering processes in otherwise hyper-arid environments on Earth and possibly Mars.



## **The contribution of submarine groundwater discharge to the alkalinity budget of the Nature Reserve Reef, Hof Almog, Eilat**

התרומה של שפיעת מי תהום למאזן האלקליניות בשמורת חוף אלמוג, אילת

Ben David, A. (1,2), Silverman, J. (2), Alkalay R. (1), Weinstein, Y. (1)

1. Department of Geography and Environment, Bar-Ilan University, Ramat-Gan, 52900, Israel

2. Israel Oceanographic & Limnological Research Ltd., Tel-Shikmona, P.O.Box 8030, Haifa 31080, Israel

[alon26262@gmail.com](mailto:alon26262@gmail.com)

Total Alkalinity (TA) budgets have been used to estimate Net Community Calcification (NCC) in coral reefs. It has been previously shown that the NCC is negatively impacted by seawater acidification in response to increasing atmospheric CO<sub>2</sub>. In 2015-16, diel cycle measurements of TA in the Nature Reserve Reef (NRR), Hof Almog Eilat, revealed that maximum nighttime dissolution of CaCO<sub>3</sub> (D<sub>max</sub>) had increased 3-4 fold compared to previous measurements conducted during 2000-02. It was suggested that increased acidification of the waters in the Gulf of Eilat occurs in response to increasing atmospheric CO<sub>2</sub>, and that eutrophication during this period may have caused the increase in D<sub>max</sub>. Alternatively, changes in TA flux of Fresh and Recycled Submarine Groundwater Discharge (SGD = FSGD + RSGD) may have caused the increase in D<sub>max</sub>. Earlier studies showed that SGD is a significant source of TA to coastal waters and may have been overlooked in calculation of NCC in coral reefs. In March and October 2021 we conducted synchronous diel cycle measurements of TA, R<sub>n</sub> and R<sub>a</sub> in the NRR, adjacent offshore waters, pore waters of reef sediments and a nearby groundwater well, ca. 30 m from the water line. Preliminary results indicate that the nighttime TA in the reef in both studies exceeded the open sea baseline by 5-7 and 15 μmol/kg, respectively, while TA in the nearby groundwater well was 3700 μmol/kg and in reef sediment pore waters it was 2684 μmol/kg. These preliminary data, indicate that SGD could be a potentially important and previously overlooked component of the TA budget in the NRR. The measurements of R<sub>n</sub> and R<sub>a</sub> will be further used to assess on the SGD flux and its contribution the TA budget of the NRR.

## **A probabilistic approach for provenance studies of flint and their uncertainty in geoarchaeology**

גישה מבוססת הסתברות לאפיון מקורות צור ואי הוודאות הכרוכה בכך במחקר גיאוארכאולוגי

Ben Dor Y. (1), Finkel M. (2), Ben-Yosef E. (2)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

2. The Sonia and Marco Nadler Institute of Archaeology, Tel Aviv University, Tel Aviv 69978, Israel

yoav.bendor1@mail.huji.ac.il

Tracking the geological origin of raw materials and archaeological artifacts (provenance studies) is fundamental to understanding key aspects of ancient societies, including mobility and trade patterns. In this study, a novel probabilistic approach was developed and applied on datasets of trace element composition of flint (chert) from potential sources in the Negev desert (prehistoric Neolithic quarries and geological outcrops). After the structure of the data across the different labelling hierarchies is established, the robustness of the classification scheme is evaluated through a probabilistic framework using multiple classification metrics (e.g., accuracy, recall, etc.). The method developed in this case study is useful for estimating the level of confidence to which the provenance of artifacts can potentially be determined, and presents a quantitative framework for evaluating the confidence of classification at different hierarchies (e.g., geological era vs. sampling site). This approach reveals the power, the potential and the limits of supervised classification for different classification hierarchies, and also helps in estimating the required number of samples for distinguishing sources at different levels (e.g., era, age, geological formation and outcrop). Additionally, this approach facilitates the identification of artifacts of unknown origin through their comparison with an established dataset of provenance localities that is being continuously expanded.

## **Sequestration of greenhouse gases in deep geological and saline formations – design and execution of controlled CO<sub>2</sub> injection experiments at the Heletz site**

סילוק גזי חממה לשכבות גאולוגיות מליחות ועמוקות – תכנון וביצוע של ניסויי החדרה פד"ח  
מבוקרים בשדה חלץ

Bensabat J. (1), Niemi A. (2)

1. EWRE LTD, Yefe Nof St 97/A Haifa, Israel

2. Uppsala University, 752 36 Uppsala, Sweden

[jbensabat@ewre.com](mailto:jbensabat@ewre.com)

As part of a four-study project (MUSTANG, PANACEA, TRUST, CO<sub>2</sub>QUEST) funded by the EU Research and Development Fund, a site was set up to carry out carbon dioxide (CO<sub>2</sub>) sequestration experiments in the "Heletz sands" layer in the Heletz field. The target reservoir (Heletz sands) and the sealing layer above it were characterized, based on existing information, for selection of the experimental area. The H18A well was prepared for insertion of CO<sub>2</sub>, production, sampling, and monitoring, while the H18B well was prepared for production, sampling, and monitoring. The monitoring included measurements of pressure and temperature in two horizons and continuous measurement of temperature using optical fiber. The wells were designed so that there were at least two layers of safety: 1) a gasket above the target layer that can be closed at ground level; 2) Wellhead that creates a closed and sealed space, which withstands high pressures. At the ground level a system for inserting CO<sub>2</sub> was installed, as well as a field laboratory to which the information measured during drilling and operation was sent and stored, including chemical analysis, acidity measurements, and spectrometry. The insertion system included the possibility of injecting CO<sub>2</sub> together with other gases (nitrogen, sulfur dioxide, krypton, xenon, SF<sub>6</sub>). As a preliminary step, a pumping test was performed that can assess the hydraulic properties of the target layer. Core samples from the target layer were sent for determination of two-phase hydraulic parameters (water-CO<sub>2</sub>): capillary pressure and relative hydraulic conductivity. Several field experiments were performed to characterize residual trapping and the solubility of CO<sub>2</sub> under stratum conditions. These experiments were carefully designed using models before they were performed. The objectives of the experiments were achieved: controlled introduction of CO<sub>2</sub> through a set of experiments of a scientific nature.

## **Agricultural properties of Fazael Formation and their implication on deciphering the Neolithic agricultural revolution in the Jordan Valley**

התכונות החקלאיות של תצורת פצאל וחשיבותן למהפיכה החקלאית הניאוליתית בעמק הירדן

Ben Shalom Y. (1), Ben Dor Y. (2), Stein M. (1,2), Goring-Morris N. (3), Erel Y. (1)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of Jerusalem, 9190401, Israel

2. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

3. Institute of Archaeology, The Hebrew University, Jerusalem 9190501, Israel

yodfat.benshalom@mail.huji.ac.il

During the Neolithic agricultural revolution (NAR), which took place at the Pleistocene-Holocene transition, human societies developed agrarian lifeways in the Fertile Crescent, coupled later with the early domestication of crops, coinciding with the transition from the Natufian to PPNA (Pre-Pottery Neolithic A) cultures in the Levant. The Fazael Formation, which overlies the last glacial Lisan Formation accumulated during the Pleistocene-Holocene transition (~14-7 cal ka BP). It comprises fine, remobilized sediments from soils that developed on the carbonaceous Judea and Samaria Hills and material derived from basalts exposed along the upper Jordan Valley. The soil properties that were available for the early agriculturalists during this transition, and are part of the Fazael Formation, were studied in key settlements where the NAR was recorded in the lower Jordan Valley, including Jericho, Gilgal and Netiv Hagdud. Our current research aims to determine whether the transition of the Natufian people of the Jordan Valley into an agrarian (cultivation) lifeways of the PPNA was enabled by improved soil fertility. We analyzed soil and sediment samples of the Fazael Formation from several PPNA sites (where NAR took place) and compared them with samples from Natufian and other pre-NAR sites in the area, as well as Lisan formation samples using several fertility-related proxies, including soil texture, soil mineralogy, organic matter concentration, water content and retention, soil pH, exchangeable cations composition, and available phosphorus.

## **Sediment transport and channel morphology during an extreme flood event in Nahal Meshushim, Central Golan Heights and NE Sea of Galilee, Israel**

תנועת גרופת ומורפולוגיית האפיק במהלך שיטפון חריג בנחל משושים, מרכז רמת הגולן וצפון מזרח הכנרת, ישראל

Bergman, N. (1), Greenbaum, N. (1), Coren, L. (1), Glassman, H. (2)

1. Department of Geography and Environmental Studies, University of Haifa, Mt. Carmel, Haifa 3498838, Israel.

2. Israel Nature and Parks Authority, Am V'Olam 3, Giv'at Sha'ul, Jerusalem 9546303, Israel.

bergmannati@hotmail.com

During January 2020, an unusual rainstorm occurred in northern and central Israel. The storm generated large floods, inundation, casualties and massive damage to property and infrastructure. In the central Golan Heights in NE Israel, the rain amounts exceeded 100 mm for 24 hours and generated an extreme flood event in the basaltic boulder-bedded Nahal Meshushim (draining 160 km<sup>2</sup>) with a 1:20 recurrence interval. The middle peak of the 3-peaked flood hydrograph was 3.5-4.0 m high and had a discharge of 203 m<sup>3</sup>/sec, shear stress of 405 N/m<sup>2</sup> and maximum velocity of 6 m/s. This peak discharge was the third largest flood on record since 1969, and almost 4 times the bankfull discharge (53 m<sup>3</sup>/sec) for this stream. Using three acoustic Japanese impact plates embedded in the concrete weir of the official IHS hydrometric station, intense sediment transport was recorded of all grain size fractions available in the bed, including mass entrainment of boulders. The movement of the boulders (> 1 m), which control the channel structure and morphology suggested breakup of the armor layer and existence of equal mobility transport (EMT) conditions that are rarely measured and described in the field, as they often destroy the measuring equipment and pose a hazard to personnel present on-site. One of the most prominent results of the acoustic bedload system is regarding the existence of spatial EMT conditions: The momentary hydrologic conditions do not necessarily overlap with the concurrent sedimentologic conditions. Two main reasons can explain this unusual sedimentary pattern: 1. Boulders are not as abundant in the channel bed as smaller grain fractions and cannot satisfy the "demand". 2. The bed transport responds relatively slowly to the quickly changing discharge due to particle roughness and grain interactions and thus sediment motion of the coarse fraction is discontinuous. EMT conditions occurred at 2.3-4.5τ<sub>bc</sub>. Pre- and post- flood measurements demonstrated the extremity of the flood. These included substantial decrease of the armor ratio in the pool upstream of the measurement site by almost half from 19.1 to 10.5, removal and stripping of bank and floodplain riparian vegetation, exposure of bedrock along the banks and channel and sediment transport of gravel up to cobbles over the floodplain - 2.0-2.5 m above the channel bed.

## **Geomorphic changes of the Nahal Oz Reservoir dam-break flood landscape, NW Negev Desert, Israel - a 20 years after perspective**

שינויים גיאומורפיים בעקבות פריצת מאגר נחל עוז בפרספקטיבה של 20 שנים אחרי, צפון מערב  
הנגב ישראל

Bergman, N. (1), Sholker, O. (2), Greenbaum, N. (1) Roskin, J. (3)

1. Department of Geography and Environmental Studies, University of Haifa, Mt. Carmel, Haifa 3498838, Israel.
2. Shikma-Besor Drainage Authority, Hagoren 8, Omer Industrial Park, 84965, Israel.
3. Department of Geography and Environment, Bar-Ilan University, Ramat-Gan, 52900, Israel.

bergmannati@hotmail.com

Twenty years after the catastrophic Nahal Oz dam-break flood occurrence, we returned to the site of Nahal Yare'akh, a small loess tributary of Nahal Hanun, part of the larger Shikma drainage basin system. This 2.3 km long reach received and passed an enormous volume of  $3.5 \times 10^6$  m<sup>3</sup> of treated wastewater for 12 hours, with a peak discharge of about 1000 m<sup>3</sup>/sec, probably the largest anthropogenic-related flood that ever occurred in Israel. The goals of this research were to describe and document current valley and gully morphology in comparison to pre- and post-flood morphology using representative cross-sections, ground and aerial photos. Results showed there were many anthropogenic changes, such as new crossing paved roads or dirt trails, agricultural activity closer to the incised valley rims, and charred forest areas. Nevertheless, our main interest was the natural form of the scoured valley and channel. The morphology showed that most of the affected area has not recovered from the catastrophic flood and there is still clear evidence that was not erased by the natural loess erosion or even covered by the local eucalyptus and pine forest. The spillway is clearly a misfit valley with the active gully channel winding within it. The most striking evidence includes occasional steep valley vertical cutbanks. The valley cross-sections became more topographically complex, the most dominant processes in the valley walls are different mass-wasting processes. The internal small-scale active gully appears in a variety of channel forms and does not appear to follow a regular downstream hydraulic geometry pattern with the typical headcut erosion of loess gullies in the Negev Desert completely absent. We therefore suggest that the preservation of the catastrophic flood features will probably last for centuries unless human intervention assists the slow natural recovery.

## **The hydrologic and geomorphic outcomes of a small dam-break flood, Kfar Yehoshua C Reservoir, NW Jezreel Valley, Israel**

ההשפעות ההידרולוגיות והגיאומורפיות של פריצת מאגר קטן, מאגר כפר יהושע ג', צפון מערב עמק יזרעאל, ישראל

Bergman, N.

(1) Department of Geography and Environmental Studies, University of Haifa, Mt. Carmel, Haifa 3498838, Israel.

bergmannati@hotmail.com

Kfar Yehoshua C Reservoir in NW Jezreel Valley is a small agricultural reservoir capturing the flood waters of Nahal Bethlehem, a small tributary of Nahal Kishon, designed to enhance the dry summer irrigation season of local crops. In April 2019, human-related overfilling of the reservoir created internal piping in the western dike that slowly developed into a full breach that released a total volume of 150,000 m<sup>3</sup>. The floodwaters flowed into a 30 m long, newly-formed channel cut into the local alluvial soil. A peak discharge of 17 m<sup>3</sup>/s was reached 2 hours after the initial piping process, with a week-long recession. Daily observations of the breach and channel development was followed by field survey and sampling: 1. Cross-sections to characterize the topography of the new channel. 2. Hydraulic modelling using HEC-RAS program. 3. Grain size textural surveys in the field and laboratory, and 4. Soil samples were taken for laboratory geotechnical tests. At the cohesive and consolidated breached dike's toe, only minimal erosion was documented, whereas downstream, where the floodplain sediments of Nahal Kishon were not cohesive, a 2 m high vertical waterfall marked the main knickpoint of the longitudinal profile separating the reach into 2 distinct segments. The outflow was cone-shaped, narrow at the base of the breached dike (3 m width) and expanding to 53 m at the entrance into the Kishon River. Near the confluence, a small fan formed over an area of 15 m<sup>2</sup>. Most of the fan was made of newly transported fine sediments derived from the local soils with some cobbles and boulders originating from the breached dike's riprap. The amount of sediments eroded from the breached dike was estimated at 246 m<sup>3</sup>, compared to only 4 m<sup>3</sup> at the alluvial fan (1.6%), suggesting that most of the sediments entered the main Nahal Kishon and transported downstream. The HEC-RAS modelling showed that near the main waterfall, the maximal water depth was 3 m, but it was usually around 1 m or less. The peak flow velocity was 2 m/s at the dike's toe but reached 5.7 m/s at the waterfall. The maximal shear stress ranged 100-200 N/m<sup>2</sup> at the upper segment and 400-500 N/m<sup>2</sup> at the downstream segment. The soil strength tests showed marked difference between the upper and lower segments. The results of the small dam-break flood suggest that unusual point hydrological events have limited impact, in terms of the eroded sediment volumes and the

resulting morphology. Furthermore, it is highly probable the newly formed morphology will not be preserved for a long time, due to larger floods in the main Kishon channel.



## Significant geological outcrops attached to the Roded and Shelomo faults, Elat sheet

מחשופים בעלי משמעות גיאולוגית בסמוך להעתקים רודד ושלמה בגליון אילת

Beyth, M., (1) Calvo, R. (1) and Katz, O. (1)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9371234, Israel

[mbeyth@gsi.gov.il](mailto:mbeyth@gsi.gov.il)

Both faults Roded and Shelomo have normal and sinistral displacement suggested by Eyal and Garfunkel. Nuriel and co-authors dated their horizontal displacement between 15.71 - 17.16 and 13.65-15.83 Ma, respectively. We present maps and photos of five significant outcrops, which were mapped in the 1:50,000 Elat Sheet, partly revised 2021, providing additional evidence for the normal and sinistral displacement.

1. The folds, Shehoret east and Shehoret west mainly synclines, trending oblique to both fault planes, indicating the maximum horizontal shortening direction of NW-SE and hence in accordance with the sinistral displacement along both faults at N. Shehoret.
2. The abrupt change of ~90 degrees of the course of N. Roded at the junction with the Roded Fault, along a small valley, may indicate a sinistral displacement of around 1 km. This valley is a west tilted block between both faults.
3. Oblique and horizontal slickensides on the Roded and Shelomo fault planes at N. Shehoret Coord. 192855/394974 and N. Gishron Coord. 189451/382450.
4. Listric fault in the base Amudei Shelomo Formation along the embryonic Roded Fault, N. Netafim Coord 190479/390018.
5. Major Landslide of limestone of Gerofit Formation sliding from west to east across the Roded Fault above the lubricant shales of the Ora Formation, triggered by displacement/earthquake (?) of the Roded Fault, upper N. Amir, Coord. 193/395.

## **Exhumation-related deformation affects the development and architecture of the thin-skinned Naukluft Nappe Complex**

דינמיקה בין מעוות משיח לפריך משפיעה על ההתפתחות והמבנה של הרי הנאוקלופט, גלישון

טקטוני בנמיביה

Boianju I. (1), Faber, C. (2), Rowe, C. (1)

(1) Department of Earth and Planetary Sciences, McGill University, H3A 0E8, Montreal, Quebec, Canada

(2) Department of Geosciences, UiT The Arctic University of Norway, Tromsø, Norway

[inga.boianju@mail.mcgill.ca](mailto:inga.boianju@mail.mcgill.ca)

Continental thrust systems are responsible for mountain building and the associated earthquake hazards. Earthquake ruptures and seismic hazards are affected by fault/fold architecture and the links between brittle and ductile structures. These are controlled by the balance between ductile deformation at depth and brittle deformation near the surface, over geologic time. To understand the interplay between brittle and ductile deformation, we investigate the architecture and deformation history of an extremely well-exposed klippe, the Cambrian Naukluft Nappe Complex (NCC). The NCC is exposed in the Naukluft mountains of Namibia, comprised of stacked Neoproterozoic sedimentary and metasedimentary units that underwent a displacement of 50 - 80 kilometers. We aim to investigate how changes in fault strength contributed to larger scale architectural evolution of the fold and thrust belt. Ductile shearing is facilitated by crystal plastic deformation, leading to grain size reduction, and grain boundary sliding. Brittle deformation is recorded by localized brecciation and the development of discrete faults. Field relations, Scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS) reveal syn-kinematic sequential transitions between distributed folding and shearing, from development of localized mylonites, to embrittlement recorded by the brecciation of mylonites and development of discrete faults. We show that the ductile phase precedes the brittle phase, both accommodating the displacement, as the nappe stack propagates. This work shows how brittle and ductile behaviors interplay and accommodate mountain building.

## Who controls iron cycling in the Southeastern Mediterranean Sea methanogenic sediments?

מחזור הברזל בסדימנט המתאנוגני במדף היבשת של דרום מזרח הים התיכון

Bosco-Santos A. (1), Sivan O. (1), Herut B. (2)

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

2. Israel Oceanographic & Limnological Research Ltd., Tel-Shikmona, P.O.Box 8030, Haifa 31080, Israel

[icebosco@gmail.com](mailto:icebosco@gmail.com)

Microbial metabolisms that attain close together different biogeochemical cycles, such as Fe, C, and N, introduce complexity to the traditional redox electron acceptors cascade in sediments, leading to spatial overlap between geochemical gradients. A good example of overlap when considering Fe geochemistry is the oftentimes peaks in porewater dissolved  $\text{Fe}^{2+}$  observed below the sulfate-methane transitional zone (SMTZ) in the methanogenic zone of different environments. While anaerobic methane oxidation mediated by Fe reduction (Fe-AOM) might explain the feature in deep lacustrine sediments, our preliminary data indicate that Fe-AOM is not significant in oligotrophic marine sediments. We described Fe speciation, nutrients, and microbiota composition in various sedimentary profiles from the Levantine Basin, Eastern Mediterranean Sea (Israel) and observed coupled Fe and N cycling. In the ammonium-rich (2 mM) deep methanogenic sediments, a strong positive correlation between dissolved  $\text{Fe}^{2+}$  and  $\text{NO}_2^-$  (and/or  $\text{NO}_3^-$ ) is observed probably via microbe-mediated ammonium oxidation coupled to Fe(III) reduction (Feammox). In this environment, the deep availability of  $\text{Fe}^{2+}$  favors precipitation of authigenic Fe minerals below the SMTZ.

## **Magnetic surveys to detect suspected landfills of metal waste**

סקרים מגנטיים לאיתור ומיפוי אתרים החשודים כמטמנות של פסולת מתכתית

Bronshtein N., (1)

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

[nadav@gii.co.il](mailto:nadav@gii.co.il)

Landfills are the classical solution for waste disposals in the past and present. Historic industrial landfills were undocumented and established with no concern on the environmental effect. During the last years there has been a growing concern about the effect of these landfills on the environment due to contamination of the ground and nearby aquifers by leaching water. These concerns along new sites designated for residential neighbourhoods or industry zones raise the necessity to locate, confine, and excavate or sample these landfills. Geophysical surveys are increasingly filling this need and successfully applied to investigate landfills. Waste of metal bodies such as pipes, industrial parts or liquids barrels are sources of high magnetic intensity and are easily revealed by the magnetic method. The magnetic method is frequently used in studies over landfills where buried magnetic materials are present and is considered successful in detection the geometry of waste deposits in a faster, cheaper, and non-destructive way. The disadvantage of the magnetic method is the high sensitivity of the sensor to magnetic noise stems from surface man-made sources such as roads, buildings, electric lines, and fences, thus it works best in open areas with little or non-existence magnetic noise. Here, The Geophysical Institute of Israel present magnetic gradient surveys in various locations suspected as historic landfills. Some of the surveyed areas were excavated according to the results of the magnetic survey within the area of high intensity anomalies accumulation characterized by metals and other man-made materials. These excavations revealed high content of metal waste and delivered satisfy results with confining the landfill area.

## Multi-scale aeromagnetic UAV-based survey for detecting magmatic and tectonic feature

מיפוי מגנטי מבוסס רחפן ממספר גבהים באזור נבי-הודא

Buzaglo-Yoresh E. (1), Agnon A. (1), Gavazzi B. (2,3)

1. Neev Center for Geoinformatics, Fredy & Nadine Herrmann Institute of Earth Sciences, the Hebrew University of Jerusalem, 91904, Israel

2. School & Observatory of Earth Sciences, the University of Strasbourg, Strasbourg, France

3. ENEREX, Nancy, France

[eldar.buzagloyor@mail.huji.ac.il](mailto:eldar.buzagloyor@mail.huji.ac.il)

Following technological advances in recent years, unmanned autonomous vehicles (UAV's) are used for airborne magnetic surveys, filling the gap between aircraft-based and ground-based surveys. An innovative multi-scale aeromagnetic study in the Nabi-Huda vicinity (the eastern Hula Valley), explores the geological characteristics of the transition zone between the Hula Valley and the slopes of the Golan Plateau on both sides of the 'Azaz fault. We focus attention on the Nabi-Huda site because of several interesting geological types. The main and most prominent is the 'Azaz Fault, a secondary branch of the Dead-Sea Fault. Two short spalls of 'Azaz Fault uplift prominent hills on the Golan Plateau. The fault uplifts the Cover Basalt, including the Ein-Zivan Basalt. A flow belonging to that formation flowed in a ravine incised in the undivided Cover Basalt, (part of which still drains runoff) and is not exposed west of the fault. The sensor was first flown at a height of 100 m to obtain a preliminary map of the magnetic field in the area, and have an overview of the main geological features. In the second stage, the area was mapped from a height of 50 m to get more details of the magnetic anomalies. At this stage, preliminary data processing allowed us to identify several points of interest. Additional extensive data processing might allow us to the following: delineate the contact between the basalt flows on the raised block (Golan Plateau), to pinpoint the locations of the faults, and then to estimate the location of the Ein-Zivan flow that was shifted and is now presumably buried by Hula Valley sediments.

## **A tool for carbon sequestration: automated rock image analysis through machine learning**

Carbonari R. (1), Emmanuel S. (1)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of Jerusalem, 9190401, Israel

[rolando.carbonari@mail.huji.ac.il](mailto:rolando.carbonari@mail.huji.ac.il)

The global energy sector is dependent on the reliable characterization of rocks in the subsurface, and such characterization plays a central role in carbon storage and sequestration. One aspect of this characterization is digital rock analysis, which helps quantify rock porosity, permeability, and mineralogical composition. This process requires the visual interpretation of huge amounts of digital data, which is time consuming and costly. For this reason, in recent years automated image processing techniques have been proposed to reduce the manual intervention and speed-up the whole image analysis. So far, existing algorithms and currently available commercial software often provide unreliable results. To solve this problem, we initiated a project aimed at developing an automatic image analysis tool that will rely on the application of Deep Learning (DL) and Machine Learning (ML) methods. Both Deep and Machine learning proven effective in image analysis, and their application is now ubiquitous in every branch of image processing, from object detection to face recognition. The present project consists of several steps: (i) data gathering and collection from more than 60 rock samples from around the world; in this phase of the project electron microscope, energy dispersive spectroscopy, and cathodoluminescence images will be collected; (ii) definition of a data collection and ingestion protocol; and (iii) development and testing of different existing deep and machine learning methodologies for image rock classification. At present, we have tested machine and deep learning techniques on a small number of few rock images. The preliminary results show that these techniques can provide a high accuracy even with a small number of samples.

## Deciphering the Influential Parameters for Benzene Transport in the Unsaturated Zone Using Global Sensitivity Analysis

חילוץ הפרמטרים המשפיעים על תנועת בנזן בתווך הלא רווי בעזרת אנליזת רגישות גלובלית

Cohen M. (1), Schwartz N. (2), Rosenzweig R. (3)

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

2. Department of Soil and Water Sciences, The Robert H Smith Faculty of Agriculture, Food and Environment, The Hebrew University of Jerusalem, Rehovot, 76100, Israel.

3. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

[meirav@adssc.org](mailto:meirav@adssc.org)

One of the greatest threats to groundwater is contamination from fuel sources. Modeling transport of fuel constituents in the unsaturated zone can provide insight into the likelihoods for groundwater contamination. Yet, environmental models typically entail high uncertainty due to large number of unknown parameters. Therefore, in most environmental models sensitivity analysis (SA) is required for the determination of the contribution of individual input parameters to the total model uncertainty. Environmental models are usually multidimensional, nonlinear and contain high number of uncertain parameters, thus requiring complicated SA methods. Consequently, global sensitivity analysis (GSA) methods in environmental modeling are gaining increased attention in recent years. In GSA methods, unlike local SA methods, the input parameters are changed over the whole sampling space, and the variance of the output is tested, rather than the derivative, producing parameters influence ranking, and interactions data. Here, the transport of benzene in the unsaturated zone of the coastal plain aquifer was simulated by HYDRUS-1D. Benzene is the most mobile fuel constituent and one of the most prevalent groundwater contaminants. First a simple GSA 'Morris' screening method was used for parameters importance ranking in a homogenous sandy vadose zone. Then, a more computationally-demanding 'Sobol' variance-based GSA was run on the most influential parameters for an elaborated quantitative analysis of input parameters influence and interactions. Finally, the two methods were tested in a heterogeneous medium containing clay layers. The study results found benzene degradation rate ( $\lambda_k$ ) as the utmost influential parameter controlling benzene mobility, followed by the aquifer depth (z). When the system was introduced with clay layers, parameters order of influence was very similar, though z was moderately influential, together with the clay layers parameters. The study demonstrates that GSA is an important tool for transport models and emphasizes the significance of  $\lambda_k$  in predicting aquifer contamination.

## **GPR as a practical tool in archeology: The case of the Byzantine church of Ashdod-Yam**

ראדר חודר ככלי מעשי בארכיאולוגיה: הכנסייה הביזנטית באשדוד-ים

Darvasi Y. (1), Agnon A. (1) Fantalkin A. (2)

(1) The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of Jerusalem, 9190401, Israel

(2) Institute of Archaeology, Tel Aviv University, Israel.

[yaniv.darvasi@mail.huji.ac.il](mailto:yaniv.darvasi@mail.huji.ac.il)

Ground Penetrating Radar (GPR) is a non-destructive electromagnetic geophysical technique for mapping the shallow subsurface. The GPR method can image buried archaeological features such as walls and strata. Being inexpensive and featuring high-resolution imaging of relatively large-scale areas, it is becoming a standard tool in archaeology. Ashdod-Yam, which is located in the southern coastal area of Ashdod, was one of the most important cities on the Israeli coast during the Byzantine period. We tested the GPR method on the backfilled archeological site, after the first excavation season revealed remains of chapels, related to a Byzantine church. The aim was to locate additional anomalies which may point to a continuation of the archeological complex. The remains of a spectacular three-aisled basilica style church with decorated mosaic floors were found, together with elaborate chapels and additional structures by its northern and western sides. An unusual number of dated inscriptions, incorporated into the mosaic floors along with coins, suggest that the complex was used between ca. 400 – 600 CE. Devastation, with roof tiles directly impacting mosaic floors, testify that the rather feeble structure withstood the 419 CE event in Palaestina Prima. The excavation strategy has been designed based on the GPR images obtained before the recent excavation. The GPR images implied the existence of the central nave with an apsis and two flanking aisles. This prediction was strikingly verified in the recent excavation season. This case study is a significant example of how the GPR method can assist before and during an archaeological excavation.



## **Normal faults linkage and landscape evolution: an example from the Bet–Kerem fault system, Northern Israel.**

התחברות העתקים נורמלים והתפתחות הנוף : דוגמא ממערכת ההעתקים בית הכרם

Dawood R. (1,2), Siman-Tov S. (2), Matmon A. (1)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel.

2. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel.

[dawoodrawi@gmail.com](mailto:dawoodrawi@gmail.com)

Normal fault systems frequently tend to be initially expressed at the surface as an organized array of subparallel short segments that may link with time to form a continuous fault. This linkage of segments is known to increase fault slip rate, which in turn affects the landscape. In order to gain a better understanding of how segment linkage affects the landscape, we investigate The Bet-Kerem fault system, Northern Israel, which provides an exceptional opportunity to understand the interplay between fault segment linkage and landscape evolution. During the early history of this system, slip rates were very low and only stratigraphic throw was accumulated along the segments. Segment linkage was followed by slip rate increase and the growth of the present steep escarpments. Absolute stratigraphic and topographic throws and their ratio were estimated for four segments along the fault system. The most eastern investigated segment shows the highest throw values. Values westward suggesting that either segment formation developed westward (i.e. a temporal gradient scenario), or that all segments have formed simultaneously, but slip rate decreased from east to west (i.e. slip gradient scenario). Regardless the specific scenario, the eastern segments of the system linked first, resulting in an increase of the slip rate at those and forming the initial escarpments. The linkage of segments migrated with time westward towards the edge of the system, increasing throw rates and forming young escarpments. This spatiotemporal pattern of fault slip along the Bet Kerem fault system is also reflected by the escarpment present morphology and its relations with drainage systems that cross it.

## Long-term anthropogenic influence on molluscan assemblages from the Israeli Mediterranean

השפעה אנטרופוגנית ארוכת טווח על מאספי תמותה של רכיכות מים התיכון הישראלי

Koral H. (1,2), Edelman-Furstenberg Y. (1) Abramovich S. (2)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

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

[yael@gsi.gov.il](mailto:yael@gsi.gov.il)

The Eastern Mediterranean is a naturally oligotrophic environment with its main source of nutrients and sediment input from the Nile River. However, changes over the last decades, namely the opening of the Suez Canal that connected the Mediterranean to the Indian Ocean, and the damming of the Nile River have had a strong impact on the biota. Identifying the drivers of these faunal changes remains challenging, because most scientific studies began after the onset of local human stresses and because we lack data on key components of the system, most notably macrobenthos from periods before the opening of the Suez Canal and human influence in general. We used the shells of mollusks from sedimentary cores to evaluate the (paleo) ecological history over the last ~ century and a half of increasing human stress on the Eastern Mediterranean. Mollusks are sensitive recorders of seafloor conditions and generate a rich fossil record. Skeletal death assemblages are typically time-averaged, which smoothes short-term fluctuations but retains a memory of populations that inhabited now-vanished environmental conditions. Using large-volume box cores, from 60m water depth, enabled to assess down-core changes in mollusk death assemblages, using <sup>210</sup>Pb to establish a chronology of sediment accumulation. Over 6000 individuals of bivalves and gastropods were examined, yielding 92 species of which 8 were alien. The bivalve assemblage demonstrate a change in feeding mode over time, characterized by disappearance of deposit feeders, associated with the damming of the Nile and the following nutrient depletion. The gastropods demonstrate a change from dominance of the indigenous carnivore *Tritia varicose* before the opening of the Suez Canal, to dominance of the alien *Varicopeza pauxilla* exhibiting 83% of the gastropod assemblage today. Variations in the relative abundance and community structure of the molluscan assemblages captured the long-term environmental change the eastern Mediterranean is undergoing.

## **The influence of polygonal faults on gravity flow depositional systems: example from the Guyana-Suriname Basin margin**

השפעתם של העתקים פוליגוניים על מערכות השקעת סדימנט מבוססות זרמי כבידה: דוגמה

משולי אגן גיאנה-סורינאם

Elad M. (1,2), Hartman G. (2), Cronin B.T. (3), Makovsky Y. (1,4)

1. The Hatter Department of Marine Technologies, Leon H. Charney School of marine sciences, University of Haifa, Mt. Carmel, Haifa, Israel

2. Ratio Petroleum Energy, 85 Yehuda Halevi St., Tel Aviv, Israel

3. Tullow Oil Plc, Building 9, 566 Chiswick Hugh Road, London W4 5XT, England, United Kingdom

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

[matanlad@gmail.com](mailto:matanlad@gmail.com)

Continental slope topography has a significant influence on subaqueous sediment gravity flows and their associated depositional products, such as turbidites and debris flow deposits, on a variety of scales. Numerous examples of predominantly fine-grained continental slopes and basin-floor environments are host to polygonal fault systems (PFSs), which may exert a considerable impact on seafloor topography. A high-quality 3D seismic dataset from the western Demerara Rise margin, offshore Suriname, is used to investigate the impact of PFSs on the architecture of gravity flow depositional systems. Two stratigraphic intervals within the Neogene clastic sequence are analyzed. The Pliocene interval is characterized by a substantial slope failure that gradually transitioned downslope into genetically related turbidites. We use seismic attribute analysis to demonstrate how the spatial configuration of the Pliocene depositional system was controlled by the intra-channel faults. High amplitude anomalies, likely linked to coarser-grained sediment, appear to be bounded by these faults, highlighting the potential for sand-prone ponding along their hanging walls. The upper Miocene interval comprises several channelized fairways that terminate downslope in lobes of different morphological character. Elongated depositional lobes are interfingered with a more radial, proximal lobe complex, in which the individual lobes have a wider fan-shaped geometry. While the downdip terminus of the radial lobes is constrained by the faults, the elongated lobes further downslope appear to be less affected by them. Furthermore, the geometrical differences may suggest that coarser-grained sediment was deposited updip, like the Pliocene system. Our results suggest that the topography created by PFSs can significantly constrain the presence and stratigraphic architecture of gravity flow depositional systems through (1) formation of intra-slope accommodation space and (2) decreasing of flow energy to enable coarse sediment deposition.

## Setting and timing of copper mineralization in the Timna igneous complex

תנאי ההיווצרות והתזמון של מינרליזציית הנחושת בקומפלקס המגמתי בתמנע

Elhadad A. (1), Vapnik Y. (1), Haviv I. (1), Elisha B. (1), Golan T. (1, 2), Katzir Y. (1)

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

2. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

[alonelh@post.bgu.ac.il](mailto:alonelh@post.bgu.ac.il)

Copper mineralization, hosted in felsic to intermediate rocks of the Timna igneous complex, is considered to be of low-temperature (150-170°C) hydrothermal origin, as evident by the occurrence of secondary Cu-sulfides altered to malachite, atacamite, and chrysocolla. Associated with the Cu-bearing minerals are aggregates of unusually coarse zircon and rutile (100-500µm), providing a rare opportunity to track ore evolution in time. Likewise, ore precipitating solutions may be trapped in fluid inclusions hosted in igneous and gangue quartz. Fresh subvolcanic quartz porphyry stock is the major ore-bearing rock. It hosts disseminated sulfides in the form of chalcocite-covellite lamellae, engulfed by copper hydrates. Reflected light and electron microscope study reveals relics of primary sulfide mineralization including pyrite, pyrrhotite, galena, and chalcopyrite sheltered in goethite and quartz. Microthermometry of quartz-hosted fluid inclusions indicates two main fluid assemblages affiliated to copper mineralization: (1) Secondary, phenocryst-copper hydrate veinlet interface assemblage characterized by low salinity (0-11 wt% NaCl) and low-moderate homogenization temperatures ( $T_h = 115-256^\circ\text{C}$ ); (2) pseudo-secondary assemblages, some containing immiscible fluid pairs, comprising a high salinity (30-35 wt% NaCl) aqueous fluid trapped at 130-270°C, and a low-density CO<sub>2</sub>-rich fluid with  $T_h = 260-327^\circ\text{C}$ . Concordant U-Pb ages of the gangue minerals yielded slightly older cores of  $610-620 \pm 5$  Ma and younger rims of  $605 \pm 5$  Ma in zircon, along with  $605 \pm 6$  Ma rutile. U-Th/He thermochronology of rutile indicates that first cooling below  $\sim 260^\circ\text{C}$  occurred at  $605 \pm 6$  Ma, similar to its crystallization age. Zircon cooled below  $\sim 170^\circ\text{C}$  at either 400-300 Ma or  $\sim 170$  Ma and apatite cooled below  $\sim 90^\circ\text{C}$  at 10-11 Ma. The occurrence of primary sulfides and immiscible high-salinity fluids and the similarity of U-Pb ages in ore-associated zircon and rutile to the East-African crystallization ages of the Timna igneous complex suggest that copper mineralization is magmatic-hydrothermal in origin.

## **Man and rock Geo-location relationship - the role of rock formations in determining the location of historic settlements in Israel**

אדם ומסלע - תפקידו של גורם המסלע בבחירת מיקום יישובים בתקופות עבר

Elinson R (1)

1. Department of Geography, The Hebrew University of Jerusalem, Israel

[rotkes7@gmail.com](mailto:rotkes7@gmail.com)

The relationships between mankind and their physical environment is a long studied research subject in Israel and worldwide. Throughout history mankind utilized the physical environment for their needs, among these the establishment of settlements. The choice of settlement locations required many considerations. Notably, Lithology and the associated pedology could play a main role as each rock type has its unique characteristics. In limestone bedrocks of the Judean mountains in Israel, for example, there are often perennial springs that allowed a year-round supply of freshwater, while the softer chalk bedrock allowed quarrying of cisterns, caves and building materials, but usually does not contain springs. In this study, we examine the relationships between the lithology and the location of settlements during the British Mandate in Palestine using GIS, combining historical and modern databases. For the analysis, we used settlement locations from the village statistics survey of 1945, which was created for tax calculations between the 1930-1945 period, alongside current geological formation layers (assuming that the rock does not change). We performed two GIS analyses to determine the geological formations that each settlement was located on, once for the entire area of the modern state of Israel with about 700 settlements, and second for a regional analysis of the Jerusalem hills. We found that in the area of Israel, there is a striking preference for locating settlements on the chalky Mount Scopus group, and to a lesser degree on alluvial soil. In the Jerusalem hills area on the other hand, it seems that most settlements were located on hard limestone formations, which can be explained by proximity to perennial springs that are also located on these rock formations. These findings shed light on one of the parameters that shaped the map of settlement in Israel throughout history.

## A radically different way to mineralize carbon

שיטה חדשה לקיבוע פחמן במינרלים

Emmanuel, S., (1), Grayevsky, R. (1), Reiss, A. G. (1)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel

[simon.emmanuel@mail.huji.ac.il](mailto:simon.emmanuel@mail.huji.ac.il)

Carbon mineralization could play a key role in limiting global atmospheric CO<sub>2</sub> emissions. However, the standard methods, which aim to form stable carbonate minerals by reacting CO<sub>2</sub> directly with silicate phases, are extremely slow, so that storing significant amounts of carbon may take years or decades. Our recent work demonstrates the feasibility of a completely different approach: reacting minerals with a highly concentrated carbon-rich fluid. Our results show that the reaction can reach high levels of efficiency within days, and that it can even be used to convert building waste and other industrial materials into carbon storage material.

## **Implementing deep neural network-based seismic arrival time picking method for the 3.6 Mw January earthquake sequence south to Lake Kinneret (Sea of Galilee)**

רשת עצבית עמוקה לאיתור אירועים סייסמיים: יישום לסדרת הרעידות מינואר האחרון במגניטודה עד 3.6 מדרום לכנרת

Engelberg S. (1), Agnon A. (1), Wetzler N. (2)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel

2. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

[shakedeng@gmail.com](mailto:shakedeng@gmail.com)

Two M3 earthquakes occurred between 22/01/22 - 23/01/22 at the northern segment of the Dead Sea fault. The sequence was located 10 km south to the Lake Kinneret (Sea of Galilee) at depths up to 5 km. The Geological Survey of Israel detected 30 individual earthquakes with a magnitude range between 1.3 Mw – 3.6 Mw. Here we use deep learning algorithms, also named deep neural networks, to detect more events from this seismic activity and expand its catalog.

We activated the Phasenet algorithm, which was trained on the California seismic network, on the abovementioned 2022 January earthquakes sequence south of Lake Kinneret (sea of Gallilee). Phasenet detected dozens of P and S arrivals that are associated with new undetected events. The algorithm was able to recover a more extensive catalog with a magnitude range reaching below the completeness magnitude of the Israeli seismic network. With a larger catalog, the method can lead to better understanding of the last January sequence. Moreover, these findings show that Phasenet and similar algorithms can expand the Israeli catalog in general.

## The importance of implementing geomorphological principles in the interface of alluvial streams and infrastructure - examples from the Dead Sea area

החשיבות של יישום עקרונות גאומורפולוגיים בתכנון תשתיות בממשק עם נחלים אלוביאליים -

דוגמאות מאזור ים המלח

Eyal H. (1,2), Armon M. (3), Enzel Y. (1), Lensky N.G. (1,2)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel

2. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

3. Department of environmental systems science, ETH Zurich, Universitätstrasse 16, 8092 Zürich, Switzerland

[haggai.eyal@mail.huji.ac.il](mailto:haggai.eyal@mail.huji.ac.il)

Wind-driven storm waves result in transport and sorting of coarse gravel along coasts. Understanding the link between wave storms and the synoptic-scale hydroclimatic forcing is important for the ability to decipher hydroclimatic conditions encapsulated in coastal landforms and for the protection coasts against wave flooding and erosion. The physical link between waves and atmospheric circulation patterns (CPs) is complex since it involves processes occurring over a range of spatial and temporal scales. This link is also hard to observe, because of the scarcity of simultaneous measurements of coastal sediment transport, waves, wind, and detailed atmospheric CPs datasets. Here, we explore this link by using (i) longshore sediment transport measurements of varied-mass, 'smart' and marked boulders deployed along the Dead Sea shores under storm waves, (ii) continuous, ~4.5 years, high resolution wind-wave record, and (iii) synoptic-scale circulation conditions provided by ERA5 reanalysis model. We find that sediment transport along the Dead Sea shores occurs during the winter, driven by high-energy, long-duration, wind-wave storms with southerly wind dominance. Windstorms, blowing over the ~40 km lake fetch, produce wave storms ranging between several hours to ~4 days, similarly to the duration of the windstorms. Wind speed and maximum wave height can reach 20 m/s and ~4 m, respectively. The governing atmospheric CPs (~90% of CPs population) generating these conditions are eastern-Mediterranean lows on their passage from around Cyprus to Syria-Iraq, producing regional western/southern-western air flow. The orographically elongated Dead Sea funnels the synoptic airflow into surface winds with southern directionality during storms. The deeper the low is, the higher is the energy of the wind-wave storms it produces, and therefore, the larger are the transported gravels and the longer are the longshore distances they move. The southern directionality of winds and waves imposed by the atmospheric CPs and orographic configuration along the Dead Sea rift is reflected in the northern Dead Sea in formation of northward-extending coarse clastic beach berms and sediment accumulation northern of channel mouths, i.e., the synoptic conditions are reflected in the coastal geomorphology. Understanding the conditions of Dead Sea wave-producing CPs can be used to predict high-energy storm waves and coastal erosion



and sediment transport in the lake. Pleistocene deltas located at the foot of the Dead Sea western escarpment suggests that also during the Pleistocene the major deltaic sedimentary volumes were accreted northward of the channel mouths, implying that similar directionality of atmospheric CPs and their resulting sediment transport had affected this region.

## **Geochemistry and source characterization of late Pleistocene aeolian deposits in Dolni Vestonice, Central Europe (Czech Republic)**

גיאוכימיה ואפיון מקורות של משקעים איאוליים מהפלייסטוקן המאוחר בדולני וסטוניצה, מרכז  
אירופה (צ'כיה)

Faershtein G. (1), Rousseau D. (2), Kiro Y. (1)

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

2. Geosciences Montpellier, University Montpellier, CNRS, Montpellier, France.

[galina.faershtein@weizmann.ac.il](mailto:galina.faershtein@weizmann.ac.il)

Dust deposits hold an important record of present and past climate and environmental changes. Hence, identifying dust sources and spatial distribution is useful in reconstructing past climate conditions and atmospheric circulation. Dust provenance can be traced by its chemical composition and changes in radiogenic isotopes such as Sr, Nd, and Pb. During Marine Isotope Stage (MIS) 5 two types of peculiar aeolian deposits were identified in central Europe: so-called "aeolian silts" (ES) and "marker silts" (MS) sharply situated on top of soil units and are correlated with climate records that represent abrupt cooling such as cold stadials in the  $\delta^{18}\text{O}$  Greenland record. The formation of these silts and their source is not clear yet and should be further investigated. This study aims to characterize their provenance and trace possible atmospheric circulations responsible for their deposition. We investigated the chemical (major and trace element) and radiogenic isotope (Pb, Nd, Sr) composition of a continuous sedimentary succession in Dolni Vestonice, Czech Republic, which spans the last 110 ka and contains the silt units of interest. The different geochemical analyses were performed on different grain fractions (<5, 5-20, 20-63, >63  $\mu\text{m}$ ) in order to distinguish between proximal and distal material sources. Here we present preliminary results of major and trace elements of the bulk samples and the <5 and 5-20  $\mu\text{m}$  grain size fractions along with Pb and Nd radiometric composition of the bulk samples. Our results indicate different chemical compositions for the bulk sediment and fine fraction. The radiogenic isotopes data suggest that the ES and the MS are different from each other, implying that different climate dynamics are responsible for the formation of these layers.

## Environmental history of the last interglacial MIS5e Levant

היסטוריה סביבתית של התקופה הבינקרחונית האחרונה בלבנט

Frumkin A. (1), Stein M. (1, 2)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of Jerusalem, 9190401, Israel

2. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

[amos.frumkin@mail.huji.ac.il](mailto:amos.frumkin@mail.huji.ac.il)

The southern Levant region at the fringe of the Saharan-Arabian deserts is particularly vulnerable to warming and desertification. Thus, reconstruction of the hydroclimate conditions of this region in the past could have important implications for understanding of the future of the southern Levant. Here we report on high temporal resolution  $87\text{Sr}/86\text{Sr}$ ,  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  isotope data of a stalagmite from the Har Nof cave in Jerusalem, demonstrating a vulnerable environment during the last interglacial MIS5e between ~ 134-116 ka. We combine also data from other caves in Israel and the Dead Sea deep-drilled core. The following unstable paleoenvironmental history is observed: At 131-127.5 ka, Jerusalem was under moderate Mediterranean climate conditions. Desert dust accumulated above the cave, while salt deposition occurred in the Dead Sea. At 127.5-122 ka, across the MIS5e insolation peak and Sapropel S5 interval in the Mediterranean, highly negative  $\delta^{18}\text{O}$  indicate on both Mediterranean and southern (tropical) derived rains. Surface cover diminished, and by 122 ka the  $87\text{Sr}/86\text{Sr}$  and  $\delta^{13}\text{C}$  values indicate complete soil removal above the cave. Very high temperatures and intensive fires caused the removal of C3 vegetation. Rainfall season shifted from winter to summer with tropical-sourced precipitation. At 122-120.5 ka, the  $87\text{Sr}/86\text{Sr}$  ratios indicate contribution of sea salts. Extremely high  $\delta^{13}\text{C}$  values indicating no vegetation. At ~ 120.5-118 ka higher rainfall and lower temperatures, associated with re-establishment of vegetation, including savannah-like C4 pioneer grasses which appeared on soil patches. At 118-116 ka, the sedimentation rate of Har Nof AF12 stalagmite is extremely low, indicating regional aridity, coinciding with massive salt deposition in the Dead Sea.

## Evolution of a large normal fault along the margins of a deep subsiding basin: Example from the Dead Sea Basin

התפתחות העתק נורמלי גדול בשולי אגן שוקע: דוגמא מאגן ים המלח

Gabrieli T. (1, 2), Hatzor Y.H. (1), Sagy A. (2)

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

2. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem, 9692100, Israel.

[tom.gabrieli@gmail.com](mailto:tom.gabrieli@gmail.com)

We studied the structure and geometry of the Western Margins of the Dead Sea Basin (WMDS) to understand the development of fault-controlled margins of a deep subsiding basin, from initiation to current deformation mechanisms. The typical structure of the margins consists of several wide (>100 m) synthetically tilted blocks of mostly undeformed stratified rocks bordered by normal faults. The bordering faults exhibit distinct domains of fault rocks with damage intensity decreasing from the main slip surface, that are governed by brittle fracture and mechanical degradation of surrounding rocks. The main slip surfaces display oblique-normal abrasive striations but also larger scale, striation-parallel waviness. Dating of carbonate sheared deposits indicates continuous faulting activity, at least up to the Late Pleistocene. Measurements of normal-to-slip surface roughness at eight orders of length scale magnitudes combined with directly obtained fault dips and slip orientations suggest that at a length scale higher than ~102 m, the dominant geometry of the faults changes from wavy to distinct zigzag pattern. We relate these two types of geometries to different scale-dependent mechanisms; the former represents mechanical wear, and the latter represents a pattern created during faulting under 3D strain conditions. We utilize the numerical, discrete element method of Discontinuous Deformation Analysis, which solves deformation in a rock-block mesh, to explain the formation of the margins structure. Our results suggest that the upper 2 km of the basin margins deform as a system of uniformly sized blocks, gravitationally collapsing eastward due to minor East-West extension and major subsidence of the underlying basin block. These conditions explain many of the structures observed, such as synthetic tilting of marginal blocks, local flexures, and a km wide extensional deformation zone. We quantify the rate of rotation of marginal blocks and use it to date the deformation of the WMDS, which fits current estimates.

## **Dead Sea Stromatolite Reefs: Testing ground for automated detection of life forms and their traces in harsh environments**

שוניות סטרומטוליטים בים המלח: אתר מבחן לזיהוי אוטומטי של צורות חיים ועקבותיהן בסביבות חיים קשות

Gedulter N. (1), Thomas C. (2), Ariztegui D. (2), Torfstein A. (1,3), Levin N. (4), Agnon A. (1), Darvasi Y.

(1), Francos N. (5)1. Neev Center for Geoinformatics, The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, Israel

2. Department of Earth Sciences, University of Geneva, Rue des Maraichers 13, 1205 Geneva, Switzerland

3. Interuniversity Institute for Marine Sciences, Eilat, Israel

4. Department of Geography, The Hebrew University, Jerusalem, Israel

5. The Remote Sensing Laboratory, Department of Geography and Human Environment, Tel-Aviv University, Tel Aviv, Israel

[nuphar.gedulter@mail.huji.ac.il](mailto:nuphar.gedulter@mail.huji.ac.il)

The Dead Sea is one of the most saline lakes on Earth, and only few organisms manage to survive in this harsh environment. However, at some locations of the current Dead Sea shore, active and diverse microbial communities flourish. In the geological past, similar microbial-rich environments had left their marks under the form of stromatolites. Stromatolites are thoroughly investigated to understand the appearance of life on Earth and potentially on Mars and other planets. Currently, the main practical attraction revolving around these stromatolite textures is possible analogies with potential microbialites and fossils on Mars: they may be the Martian equivalent of the ancient, heavily weathered and contentious Archean stromatolites on Earth. In this research, we examine fossil stromatolites in order to create a spectral classification scheme for detection of their structures and explore the possibility to upscale the mapping using airborne and satellite imagery. This study evaluates point spectroscopy and remote sensing technologies in order to classify stromatolite fossils in a selected study site near the Dead Sea. Since the pioneering studies of Buchbinder and others, new research horizons have opened. The Dead Sea stromatolites offer a prism for better understanding the evolving of life in extreme environments. We are interested in the interface between biology and geology, with a reference to the way primitive forms of life could have been preserved as fossils. Geoinformatics studies have encouraged us to use remote sensing techniques as well as creating classification methods in this region of research. Our innovation includes integration of remote sensing and in-situ hyperspectral technologies for characterization of bio-signatures inherent to stromatolites, and development of spectral detection methods for automated mapping.

## Earth Science matters on the table of Hevel Eilat Regional Council

סוגיות בתחום מדעי כדור הארץ על שולחן המועצה האזורית חבל אילות

Ginat H., (1)

1. Dead Sea and Arava Science Center

[ginathanan@gmail.com](mailto:ginathanan@gmail.com)

The Hevel Eilat Regional Council covers an area of 2630 km<sup>2</sup>, 13% of the territory of the State of Israel. This area includes a very diverse range of rocks and landscapes, including the Dead Sea rift in the eastern part of the council. Because the area is hyper-arid, the rocks are completely exposed. There are twelve settlements within the regional council; the local economic endeavors are primarily based on agriculture, tourism and renewable energy. Several Earth Science matters are on "the table" of Hevel Eilat Regional Council, including: 1.

1. Renewing copper mining in Timna;
2. Oil and gas exploration near Yotvata Salt Flat;
3. Quarries in the region for construction materials;
4. Site planning considering flood hazards;
5. Intelligent management of groundwater;
6. Earthquake preparedness;
7. Promotion of renewable energy in high solar radiation area;
8. Educating residents and youth about local challenges.

These topics and others are some of the discussions and decisions currently on the table of the regional council. For each topic, detailed data is collected, and planning and implementation options are considered. Economic factors are weighed alongside sustainable components, aiming to achieve a balance between development and conservation in our wilderness landscapes. It is our right and duty to continue living and developing our region, while protecting its virgin landscapes.

## **Detrital zircon evidence for exotic elements in the southern Neotethys: A provenance study of Triassic-Eocene rock units in the Kyrenia terrane, Northern Cyprus**

עדות להמצאותם של מרכיבים אקזוטיים בניאותרטיס הדרומי: מחקר איתור מקורות הסדימנטים של יחידות סלע מגיל טריאס עד אאוקן החשופות בטרין הקירניה, צפון קפריסין

Glazer A. (1), Avigad D. (1), Morag N. (2), Güngör T. (3), Gerdes A. (4)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel
2. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel
3. Department of Geological Engineering, Dokuz Eylül University, Izmir, Turkey
4. Institut für Geowissenschaften Petrologie und Geochemie, Goethe-Universität Frankfurt, Frankfurt, Germany

[adar.glazer@mail.huji.ac.il](mailto:adar.glazer@mail.huji.ac.il)

Situated between Africa and Eurasia in the eastern Mediterranean, the island of Cyprus has developed on the northern margin of the southern Neotethys by the accretion of three terrains, the Mamonia complex, the Troodos ophiolite, and the Kyrenia terrane. The Kyrenia terrane comprises a tectonic stack of Triassic to Eocene rock units interleaved with basic and acid volcanics and minor metamorphic inliers, alongside an Oligocene-Miocene flysch. Our U-Pb-Hf detrital zircon investigation in the Kyrenia Triassic to Eocene section reveals large amount of Neoproterozoic zircons (950-600 Ma), alongside Silurian (~430 Ma), Carboniferous (~300 Ma), Triassic (~240 Ma), and Upper Cretaceous (~85 Ma) zircons. The Precambrian age profile of all three studied units resembles that of Paleozoic sandstones of the Tauride Block, as well as that of Paleozoic and Mesozoic sandstones found across North Africa. It is interpreted as reflecting the reworking of Paleozoic sandstone units from the Taurides or other peri-Gondwanan source. The presence of a substantial proportion of ~300 Ma zircons, as early as in Triassic sediments of the Kyrenia, is of significant interest because Carboniferous magmatism is confined to the Paleotethyan realm which is traced north of the Taurides. Deposition of the Kyrenia sequence closer to a Northern Tethyan province would better fit its detrital zircon signal. The detrital signal of the Kyrenia, indicative for Eurasian terranes north of the Mediterranean, also differs significantly from that of the Mamonia Complex (SW Cyprus) in which only Afro-Arabian sources are distinguished. Thus, in view of its unusual detrital zircon content, the Kyrenia sequence stands out in the Eastern Mediterranean as an exotic rock pile that cannot be straightforwardly correlated with its neighboring geologic environment.

## **The pollution event in Ashalim Wadi: discrete morphologies and leachable heavy metal content**

זיהום נחל אשלים; זמינות שיחרור מתכות לפאזה המימית

Golan R. (1), Nachshon U. (1), Katzir R. (1), Sharabi G. (2), Gavrieli I. (2)

(1) Soil, Water and Environmental Sciences, Agricultural Research Organization - Volcani Institute

(2) Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

[rotemg@agri.gov.il](mailto:rotemg@agri.gov.il)

On June 2017, estimated 250,000 m<sup>3</sup> of slurry composed of concentrated acids and phosphogypsum drained from an industrial pond of the ICL-Rotem phosphorous industry, into Ashalim stream, southern Judean desert, leaving behind dead animals and plants, as well as acidic ephemeral ponds and polluted soil. The present work focuses on sediments from the upper Ashalim stream, characterized by sandy alluvial riverbed derived from the Hazeva Formation. The pollution event left several new morphological features, including white phosphogypsum, consolidated crusts and whitish sands. Previous work indicated that the main contaminants in the stream are F<sup>-</sup>, SO<sub>4</sub><sup>2-</sup>, PO<sub>4</sub><sup>3-</sup>, and Na<sup>+</sup> along with heavy metals. The present work seeks to find whether these are associated with the phosphogypsum or are more dispersed in the natural sediment. Repeated leaching processes with distilled water (DDW) were carried out on two representative samples from each defined polluted morphology. The experiments were done at soil:DDW ratio of 1:1, in vials mounted on a rotating apparatus, and sampled at designated time-steps. The results are in agreement with previous data and emphasize that the sediments contain high levels of water soluble F<sup>-</sup>, SO<sub>4</sub><sup>2-</sup>, PO<sub>4</sub><sup>3-</sup>, and trace metals. The leachate has lower pH and is significantly more saline as compared to leachates from reference soils. A pronounced decoupling between the phosphogypsum and fluoride is clearly observed. Nearly all trace metals have elevated concentration in the first 24-hour leaching cycle of all the contaminated morphologies, with highest elevation in the deposited phosphogypsum samples. The concentrations in all contaminated samples decline during the following leaching cycles, with the Cd and Ni concentrations roughly stabilizing by the 4th to 6th cycle, though still at levels that are somewhat higher than in the reference samples. Overall, most trace metals are only partly associated with the phosphogypsum, implying the presence of other phases of pollution.



## Rapid conversion of olivine into carbon storing minerals

הפיכת אוליבין למינרלים מכילי פחמן באמצעות ריאקציה מהירה

Grayevsky R. (1), Reiss A G. (1), Emmanuel S. (1)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of Jerusalem, 9190401, Israel

[roni.grayevsky@mail.huji.ac.il](mailto:roni.grayevsky@mail.huji.ac.il)

Mineralization is often proposed as a method to store carbon, and typically involves reacting CO<sub>2</sub> directly with silicate minerals, such as olivine, to form carbonate minerals. However, this reaction is extremely slow under standard conditions, so that sequestering significant amounts of carbon could take years or decades. Here, we demonstrate the feasibility of using a reaction between carbon-rich fluids and olivine, to create stable mineral phases. We performed a series of batch experiments on olivine grain sizes to quantify the rate and efficiency of the reaction. Our results demonstrate that high levels of conversion of olivine to carbon-bearing minerals can be achieved within days.

## **Oxygen, Carbon and Clumped Isotope compositions of Detrital Carbonates: A New Combined Proxy for Quantifying Relative Sediment Fluxes in Carbonate Terrains**

איזוטופי חמצן, פחמן ואיזוטופים מצומדים בקרבונטים דטריטים: שילוב גישות להערכה וכימות שטפי סדימנטים יחסיים במערכות ניקוז וסביבות קרבונטיות.

Hagbi R. (1), Goren L. (1), Ryb U. (2)

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

2. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel

[ravidha@post.bgu.ac.il](mailto:ravidha@post.bgu.ac.il)

At steady-state, sediment fluxes out of a drainage basin (flux per area unit) equal its average erosion rate. Quantifying relative sediment fluxes is therefore key in estimating spatial erosional variability and the associated landscape evolution. Traditional approaches to quantify such fluxes in drainage basins include using the mineral and elemental compositions of sediments as markers for the relative contribution from sub-catchments. Such approach may fail to distinguish among bedrock sources, and have been shown to suffer from transport-related biases. Here, we aim to test and explore the combination of these traditional approaches together with oxygen, carbon and 'clumped' isotope analyses of detrital carbonate as a novel combined proxy for relative sediment fluxes in carbonate-dominated drainage basins. Because isotopic values potentially vary between same carbonate minerals that form in different environment, they can provide a sensitive indicator of sediment provenance. We test this approach at the Hatrurim Basin in southern Israel, as it comprises un-metamorphosed rocks of the Judea Gr., as well as Hatrurim Fm. rocks who have experienced different grades of combustion-metamorphism, and are therefore expected to have registered a wide range of isotope values together with distinctive carbonate mineral assemblages – allowing for using both 'traditional' and isotope-informed approaches. We collected bedrock and sediment samples from the Morag catchment in the Hatrurim Basin, and analyzed their mineral and isotope compositions in bulk and grain-size fractions. Our preliminary results show: (a) Hatrurim Formation's bedrock samples have a wide range of mineral and isotope values consistent with two main assemblages – high temperature metamorphic carbonates, and low temperatures re-crystallize carbonates. (b) Fine grain sediment fractions (<2mm) show binary mixing between un-metamorphosed Judea Group and Low-T Hatrurim end-member sources. Coarser sediment fraction show deviations from a binary mixing, which we associate with significant contribution from a High-T Hatrurim third source.

## **The 27 September 2021 Mw6 Crete (Greece) earthquake and implications to regional tectonics**

רעידת האדמה החזקה בכריתים (ב- 27 בספטמבר 2021) והשלכותיה לטקטוניקה האזורית

Hamiel Y. (1), Piatibratova O. (1), Ganas A. (2)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel
2. Institute of Geodynamics, National Observatory of Athens, Greece

[yariv@gsi.gov.il](mailto:yariv@gsi.gov.il)

On 27 September 2021, a strong earthquake ( $M_w=6.0$ ) struck central Crete (Greece), causing damage to the town of Arkalochori and surrounding villages, but without any clear evidence for surface rupture. The mainshock was preceded by foreshock activity lasted for ~4 months and followed by aftershock activity that still continues. The ruptured area is characterized by the presence of the normal Kastelli Fault striking NNE-SSW and dipping towards WNW. The surface exposure of the Kastelli Fault is only several kilometers long and at its southern tip is truncated by the sub-perpendicular Nipiditos fault. We use both ascending and descending interferometric Synthetic Aperture Radar (InSAR) and Global Positioning System (GPS) observations to analyze the coseismic deformation due to the earthquake. A maximum surface subsidence of ~20 cm was revealed by the InSAR data and of ~14 cm was recorded by the nearby ARKL GPS station in Arkalochori. The slip model produced from the inversion of both InSAR and GPS observations suggests a normal fault length of 13 km with a maximum coseismic slip of 1.2 m occurred at depths of 4-6 km and negligibly small surface rupture. Our results indicate the continuation of the Kastelli Fault farther south and highlight the WNW-ESE extension of central Crete, sub-perpendicular to the Hellenic arc and the main compression direction.

## Millennial-scale Divide Migration Dynamics from Abandoned Terraces in the Negev Desert

מה יכולות טראסות נטושות בנגב ללמד על הדינאמיקה של קו פרשת המים ?

Harel E. (1), Crouvi O. (2), Porat N. (2), Shelef E. (3), Ginat H. (4), Goren L. (1).

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

2. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

3. Geology and Environmental Science, University of Pittsburgh, 4107 O'Hara Street, Pittsburgh, Pennsylvania 15260- 3332, United States

4. Dead Sea and Arava Science Center, Kibbutz Qetura, Hevel Eilat 88840, Israel

[Elhanan02@gmail.com](mailto:Elhanan02@gmail.com)

Observations from around the globe show that drainage divides can migrate through time. Divide migration is highly consequential for landscape evolution because changes in the divide location modify the distributions of water discharge, sediment flux, and erosional power across the basins that share the divide. Despite its importance, field-based evidence of divide migration dynamics are exceptionally rare, most likely because geomorphic markers are often erased as part of the migration process. We identified a unique study area in the southeastern Negev highlands, Israel, where westward divide migration generated fill terraces along a ~500m channel, whose flow direction reversed from west to east, toward the Arava valley. The preserved terraces accompany the reversed channel, but uniquely, they grade westward, toward the divide, and opposite to the current flow direction. Consequently, we interpret these terraces as remnants of the antecedent west-flowing channel bed. We hypothesize that the abandonment age of each terrace reflects the timing at which the paleo-divide migrated past the location of the terrace, promoting the incision of the reversed channel that generated the terrace by disconnecting it from the current drainage. Accordingly, the abandonment ages of the terraces are expected to increase with distance away from the divide eastwards and to inform us about the timing and dynamics of divide migration. Absolute ages of terrace abandonment were constrained by luminescence dating, with complementary relative ages inferred from the chronosequence of reg soils that developed on the terraces. In agreement with the hypothesis, we found that the soils are more developed, and the abandonment ages are older, with distance from the divide eastwards. The oldest terraces are ~ 200ka, and the divide age is 24-34ka, which is consistent with luminescence ages of other divides in the region. The uniformity in the divide ages likely indicates episodic divide migration with recent migration stalling, governed by regional climatic conditions.

## Compatible and updated array of geology and vegetation habitat in the southern Lower Galilee

הגליל התחתון הדרומי מערך גיאולוגי עדכני ומגוון בתי הגידול של הצומח בהתאמה

Herr N. (1), Wald R. (2), Talmon I. (3)

1. Nirforestecosoil, Alon Hagalil 17920

2. Israel Chemicals Ltd., R&D Institute, P.O. Box 10140, Haifa Bay 2611101.

3. The Open Landscape Institute, Steinhardt Museum of Natural History, Tel Aviv University, Tel Aviv 6997801

[nir.herr@mail.huji.ac.il](mailto:nir.herr@mail.huji.ac.il)

The southern Lower Galilee, extending from the northern border of Yizre'el Valley to Bet Qeshet fault in the north is a unique geosystem, bridging over a range of geological units exposed mainly due to recent tectonic activity. Rock variety leads to different habitats promoting a diversity in vegetation formations accordingly. Updoming as part of a regional "Syrian Arc" folding system and Dead Sea fault transcurrent slip is evidenced by older Judea Group (Cenomanian-Turonian) outcrops along the fold axis and younger Avedat (mid-late Eocene) and Mount Scopus Group (Coniacian-Maastrichtian) outcrops on the flanks. Neogene basalt was emplaced via normal fault planes bordering subsiding basins. Marl and chalks (upper Miocene-Pliocene) denote a marine ingression. Our geophysical, geological, and ecological results enabled the characterization of the Galilee array via comparative analysis and ordinations. Results point to a rock-vegetation connection. *Quercus ithaburensis* woodland develops in calcrete soil pockets found among chalks at Alonim and Bet Qeshet, west and east of the dome axis, respectively. *Quercus calliprinos* maquis grows in two different habitats providing deep-root-space: soft chalks and karstic voids. *Ziziphus spina-cristi* savanna-like sparse wood and *Ziziphus lotus* garigue grow on basalts. Sparse *Pistacia atlantica* grows on marly chalks. *Sarcopoterium spinosum* bathas and other low shrubs grow on chalks, and perennials herbaceous are growing on limestones and shallow basaltic soil. Our recent study analyses the Galilee rock mosaic considering geo-botanic processes evolvement. The vegetation reflects environmental conditions in which water balance has main impact. Chalk pore water content within the vadose zone and their slow diffuse movement into the roots play a key role at improved habitats. Larger water volumes in the system lead to higher vegetation formations. Potential vertical rooting at certain localities enables maquis development. Soil pockets provide woodland development. Other conditions enable bathas and garigue development while dry habitats grow merely herbaceous.

## Establishing baseline assessment levels for monitoring coastal heavy metals using foraminiferal shells: A case study from the Southeastern Mediterranean

ניטור זיהומי מתכות כבדות בסביבה החופית באמצעות שלדי פורמפיפרים ע"י קביעת ערך ייחוס

Hoober L. (1), Titelboim D. (2), Abramovich S. (1), Herut B. (3), Teutsch N. (4), Benaltabet T. (5,6), Adi Torfstein A. (5,6)

1. Ben-Gurion University of the Negev, Beer Sheva, Israel
2. Department of Earth Sciences, University of Oxford, Oxford, UK
3. Israel Oceanographic and Limnological Research, Haifa, Israel
4. Geological Survey of Israel, Jerusalem, Israel
5. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of Jerusalem, Israel
6. Interuniversity Institute for Marine Sciences in Eilat, Israel

[hoober.lin@gmail.com](mailto:hoober.lin@gmail.com)

One of the challenges in monitoring the marine coastal environments is quantifying the magnitude and duration of pollution events. This study introduces a new concept of defining heavy metal (HM) baseline assessment levels (BAL) in coastal environments using foraminiferal shells. We demonstrated the potential of this approach by examining a nature reserve along the Mediterranean coast of Israel. Our previous investigation of this site in 2013-2014 using foraminiferal single chamber LA-ICPMS created a large dataset consisting of HM measurements of two species, *Lachlanella* and *P. calcariformata*. This database was used to establish the BAL of Zn, Cu and Pb, associated with anthropogenic sources. In February 2021, a significant oil spill event affected the entire Mediterranean coast of Israel, and included a considerable out wash of tar onto the shore. The event provided a unique opportunity to test the applicability of foraminiferal BAL by revisiting the previously studied site. Our strategy was to compare whole shell ICP-MS measurements of the two species collected shortly after the event and six months later, and compare them with the established BAL values. Our results revealed a significant increase (2-20 folds) in Zn/Ca, Cu/Ca, Pb/Ca ratios between 2013-14 and 2021. Among these, the increase in Pb/Ca is the most substantial and observed in both species. This implies a possible linkage between the oil spill event and the substantially elevated metals/Ca ratios measured by the foraminifera in 2021. Our study also demonstrates that bulk ICP-MS analyses will most likely yield similar ratios as those of average values of single chamber LA analyses of shells from the same location and period. This observation confirms that once BAL values are established, the analysis of bulk shell ICP-MS is effective for monitoring HM contamination of coastal environments.

## Live and dead deep-sea benthic foraminifera define biohabitats in the Levantine Basin, southeastern Mediterranean Sea

מאספי פורמיניפרה בנתוניים (חיים ומתים) את קרקעית הים העמוק של ישראל, דרום  
מזרח הים התיכון

Hyams-Kaphzan O. (1), Gefen I. (1), Zolotarevsky S. (1), Kitin M. (1), Lubinevsky H. (2), Tom M. (2),  
Herut B. (2), Katz O. (1), Almogi-Labin A. (1)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

2. Israel Oceanographic & Limnological Research Ltd., Tel-Shikmona, P.O.Box 8030, Haifa 31080, Israel

[orithy@gsi.gov.il](mailto:orithy@gsi.gov.il)

Benthic foraminifera (BF) constitute an important part of the meiofauna of deep water environments, including the Mediterranean Sea. In order to establish a reference baseline for studying future seafloor changes that might arise due to increasing activity of gas/oil companies in Israel, we conducted a quantitative survey of live and dead BF assemblages from the deep (100–1900 m) southeastern Levantine basin (LB) (33.4°–31.7 °N, 31.3°–34.9 °E). The aims were to determine biotopes based on foraminiferal assemblages composition and correlate the biotopes of the live assemblages to prevailing environmental conditions. Box corer samples were collected at 50 sites in summer 2013. The foraminiferal macrofauna (> 250 µm) were identified to species level. Overall, 100 species of living BF and 197 species of dead BF were identified, many of them for the first time in this region. Based on cluster analyses of the live foraminiferal assemblages, six biotopes were identified: the shelf margin (SM), two upper continental slopes (UCS1 and UCS2), the lower continental slope (LCS), the eastern bathyal plain (EBP) and the western bathyal plain (WBP). The dead assemblages were divided into four biotopes, compatible with the live ones, excluding the UCS2 and the EBP. Species richness in dead assemblage varied between 65 in the SM to 16-30 in the bathyal. The highest abundance of live BF at UCS1, correlates with high organic carbon and low oxygen content. In deeper water >1100 m, a sharp decrease in local species diversity was detected, especially in the dead assemblage, when the agglutinated species made the majority of the BF. Those species were associated with the commonly occurring aragonitic pteropods shells, which provide a unique firm substrate in the bathyal. Increasing ocean acidification might eliminate this BF-pteropoda association in deep-water environments and change this biotope in irreversible way.

## Eolian dynamics in Uvda valley, southern Negev, during the late Quaternary

דינמיקה איאולית לאורך הרביעון העליון בבקעת עובדה, דרום הנגב

Jacobi Y. (1), Harel E. (1,2), Porat N. (1), Teutsch N. (1), Goren L. (2), Shelef E. (3), Ginat H. (4), Crouvi O. (1)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

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

3. Geology and Environmental Science, University of Pittsburgh, 4107 O'Hara street, Pennsylvania 15260-3332, United States

4. Dead Sea and Arava Science Center, Kibbutz Qetura, Hevel Eilat 88840, Israel

yael.ja@gsi.gov.il

Aeolian sediments serve as excellent archives of paleoclimate conditions. Such archives were extensively studied in northern Negev, providing valuable information of late Quaternary climate. However, aeolian archives were rarely explored in hyperarid southern Negev. Here we study the accumulation of aeolian sediments in the vicinity of Uvda Valley (southern Negev), an elongated (15x5 km) structurally controlled valley filled with alluvial sediments, mainly sand, that gradually thicken to the north. In the northeastern part of the valley, sand dunes (named 'Kasuy') are widespread, composed of quartz and calcite. This unique environment enables us to examine the importance of proximal dunes relative to distal aeolian sources, in supplying eolian sediments to the landscape and soils. Moreover, archives of aeolian deposits can shed a light on the evolution of the Kasuy dunes. Sediments sections and soil profiles were sampled in natural traps (bedrock cracks and reg soils developed on alluvial terraces) located at different distances/directions from the dunes. All sites are located on carbonate bedrock that contrasts the silicate-rich aeolian sediments, and are characterized by negligible fluvial/colluvial input. The sediments were described and analyzed for particle size distribution (PSD), chemical composition and OSL dating. The PSD of all samples is polymodal and varies between sites and with depth. Three main PSD end members were identified at the very fine sand (~105  $\mu\text{m}$ ), coarse-medium silt (~35  $\mu\text{m}$ ) and clay (~4  $\mu\text{m}$ ) fractions. In all sections/profiles located downwind of the dunes, the sand fraction gradually increases upwards, reflecting an increased contribution of sediments from the dunes with time. The chemical analyses support the PSD results and reveal that the Kasuy dunes are a dominant source, together with regional, Saharan/Arabian atmospheric dust (4  $\mu\text{m}$ ) and coarse silts (35  $\mu\text{m}$ ) that are most likely related to the loess in the northern Negev.



## **Turbidity Currents and more: Insights from Two Years of in situ measurements in a Small Submarine Canyon Offshore Northern Israel**

זרמי כבידה ועוד: תובנות משתי עונות מדידה בקניון תת-ימי מול חופי צפון ישראל

Jaijel R. (1,2), Biton E. (1), Weinstein Y. (2), Ozer T. (1), Katz T. (1)

1. Israel Oceanographic & Limnological Research Ltd., Tel-Shikmona, P.O.Box 8030, Haifa 31080, Israel

2. Department of Geography and Environment, Bar-Ilan University, Ramat-Gan, 52900, Israel

[roiijel@gmail.com](mailto:roiijel@gmail.com)

Submarine canyons are considered to be major conduits for turbidity currents carrying water and sediment (and sometimes contaminants) to the deep sea. In Israel, Mediterranean submarine canyons are only found to the north of Atlit and they are generally small (5-20 km long) and dissociated from major coastal rivers. If and how these canyons serve as pathways for turbidity currents that carry sediment to the deep Levantine basin was unknown. To answer these questions, two moored stations (landers) with measuring instrument arrays were placed at 350 and at 710 m depth along the thalweg of "Bat-Galim" submarine canyon, offshore Haifa. The landers were deployed from October 2019 to June 2020 and from Sept 2020 to May 2021. In both deployments, the landers registered winter turbidity currents, characterized by turbid water progressing down canyon at high speed near the seabed. These turbidity currents occurred only when significant rain events (several tens of mm) were accompanied by >4 m high waves. During these events, warm and saline shelf water were gravitationally forced to plunge underneath colder water. Expectedly, this led to later convection through the water column once sediment-settling relived the otherwise buoyant, warm water of its ballast. Mean sediment fluxes in the canyons during these deployments were extraordinarily high compared to both the shelf and the deep sea suggesting major sediment transport. Our observations indicate that much of the accumulated sediment during these events are later transported seawards via other physical mechanisms. These results show that the Bat-Galim and most probably other submarine canyons in northern Israel are active pathways for annually occurring turbidity flows. They also highlight the potential importance in sediment transport of the numerous and grossly under studied small submarine canyons in the ocean and point to a novel, turbidity flows driven mechanism for water column convection.

## Origin and kinematics of a basin-scale, non-polygonal, layer-bound normal fault system in the Levant Basin, eastern Mediterranean

גיאומטריה, קינמטיקה ומקור אפשרי של העתקים ליניאריים המעתיקים את חתך האוליגוקן-מיוקן  
באגן הלבנט

Joffe A. (1), Jackson CAL. (1,2), Steinberg J. (3), Bell R. (1), Makovsky Y. (4)

1. Basins Research Group (BRG), Imperial College, Prince Consort Road, London SW7 2BP, UK
2. Department of Earth and Environmental Sciences, The University of Manchester, Manchester, UK
3. Ratio Oil Exploration, Tel Aviv, Israel.
4. The Dr. Moses Strauss Department of Marine Geosciences, Leon H. Charney School of marine sciences. University of Haifa, Mt. Carmel, Haifa 31905, Israel

[amir.joffe18@imperial.ac.uk](mailto:amir.joffe18@imperial.ac.uk)

Layer-bound normal faults, characterised by a well-defined polygonal pattern map-view, can extend over very large areas (>2,000,000 km<sup>2</sup>) of sedimentary basins. Typically best-developed in very fine-grained rocks, these faults are thought to form during early burial in response to a range of diagenetic processes, including compaction and water expulsion. Deviations from this idealised polygonal pattern are common, being locally developed around channelised depositional systems, salt diapirs, or pockmarks, or due to local changes in the dip of the faulted host rock. However, how and why such deviations in map-view pattern may occur at the basin-wide scale are not well-documented and accordingly, understood. In this study we use 3D seismic reflection, biostratigraphy, and well-logs from the Southern Levant Basin, offshore Israel, to develop an age-constrained seismic-stratigraphic framework for the sub-evaporite strata and determined the geometry and kinematics of basin-scale, non-polygonal, layer-bound normal faults. The faults tip-out downwards along the Eocene Unconformity, but unlike those in the Northern Levant Basin, they do not reach the base-Messinian evaporites, instead tipping-out upwards at the Top Langhian. On average, the faults in the Southern Levant Basin are 6.3 km long have an average throw of 116, and consistently strike NW. Throw-depth plots, accompanied by thickness changes in host rock strata, indicate the faults nucleated in a mudstone-dominated unit, reaching the seafloor to act as syn-depositional faults, and are kinematically associated with a WSW-striking strike-slip fault. Unlike true polygonal faults, they were able to propagate through a ~2 km-thick sandstone-dominated sequence. Whereas previous studies from the Northern Levant Basin associate fault nucleation and growth with early, burial-related diagenesis, previous studies also argue the Oligocene-Miocene host-rock comprises relatively coarse-grained strata unlikely to have undergone a similar diagenetic process. Using our age-constrained seismic-stratigraphic framework we highlight potential thick-skinned tectonic events that occurred during and may have triggered thin-skinned extension. Our model thus suggest that basin-scale, non-

polygonal, layer-bound faults did not develop in accordance with the diagenetic model proposed for some other polygonal faults systems. Layer-bound normal faults thus should be looked at in the geodynamic and structural context of the basin in which they formed.

## **Measuring water velocity by LSPIV for accurate determination of water discharge and roughness coefficients in representative ephemeral channels**

מדידה של מהירות מים, ספיקת מים ומקדמי חספוס בשיטת LSPIV בתחנות נבחרות של השרות ההידרולוגי

Kaholi T. (1), Babad A. (2), Halfi E. (2), Laronne B. J. (3)

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

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

3. Department of Geography & Environmental Development, Ben Gurion University of the Negev, Beer Sheva 8410501, Israel

[tomkah@post.bgu.ac.il](mailto:tomkah@post.bgu.ac.il)

In arid regions, such as Israel, surface hydrology is characterized by flash floods which are usually intensive, rapid and responsible for the most fluvio-morphological changes. Water discharge ( $Q$ ) is one of the key parameters needed for characterized and understanding the dynamics of the stream environment.  $Q$  could be calculated by multiplying the wetted cross-sectional area by the mean flow velocity. Using direct and intrusive measuring instruments for determining the flow velocity (e.g., mechanical current meter and ADCP) is very common. However, these instruments required being inside the flow, hence safety and logistic issues limit the applicability of measuring intensive flows. Consequently, estimation for discharge is based mainly on hydrological models. These models, such as Manning, have a significant inaccuracy derives primarily from the velocity component and the difficulty in accurately determining the roughness coefficient. Our research objective is to improve both the accuracy of discharge estimation and the ability to monitor flash floods. For this reason, we are measuring the stream flow velocity by remote sensing method named LSPIV (Large Scale Image Velocimetry). This method is based on 3 main principles: (1) Recording the flow as video, (2) Orthofying the photographs and (3) identify pixel patterns (such as boils, vegetation debris, etc.) on the water surface and determine their displacement between successive video frames. The product is a two-dimensional velocity field of the water surface. Four LSPIV stations were installed adjacent to IHS stations, at streams with wide range of bed roughness. The streams, from the smoothest to the roughest are Shiqma, Zin, Ramon and Arugot. During the current winter we managed to record and analyze a flash flood event in Arugot. By knowing the wet cross-sectional area of the stream, we calculated the discharge. We also made and empirical estimation for Manning roughness coefficients as a function of water stage.

## Flood Characterization and Hydrological Modeling in the Ze'elim Basin

אפיון שיטפונות באגן נחל צאליים ובניית מודל הידרולוגי

Kallush A.(1), Haviv I. (1), Zoccatelli D. (2), Halfi E.(3), Laronne J.B. (1)

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

2. Department of Civil and Environmental Engineering, University of Wisconsin-Madison, Madison, WI 53706, USA

3. Dead Sea & Arava Science Center, Mount Masada, Israel

[amitkall@post.bgu.ac.il](mailto:amitkall@post.bgu.ac.il)

Flash floods are quick, decisive, and devastating phenomena in which ephemeral channels rapidly start flowing due to rainstorms generating steep hydrograph rises. The recessions initially decrease slowly with altogether short durations. Due to the required high temporal resolution and many relevant variables, there are considerable uncertainties for modeling and forecasting flash floods. In this study, a network of rain gauges and water level sensors deployed in the semi-arid to hyper-arid Ze'elim Basin in the Judean Desert, southeast Israel. The Ze'elim is not only the largest watershed in the Judean Desert, but it is also hydrologically, economically, and in part environmentally the most important. The deployed rain gauges will be used to verify and calibrate radar backscatter data that will be used to determine the spatial and temporal variation of rain intensity. Data from the water level sensors monitoring runoff in the main tributaries will be used to calculate water discharge based on one of several roughness equations. The rainfall-runoff database in conjunction with topography, geological background, and land use will be used to understand the dominant rainfall-runoff processes. The available database will be used to calibrate and validate an existing hydrological model to be chosen at a later stage of this study.

## **Anthropogenic changes in waterways produce “drought-like” layers in shelf sediments**

שינויים אנתרופוגניים בנתיבי מים הנשפכים לים יוצרים שכבות סדימנט "בצורתיות" במדף היבשת

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

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

(2) Israel Oceanographic & Limnological Research Ltd., Tel-Shikmona, P.O.Box 8030, Haifa 31080, Israel

(3) Interuniversity Institute for Marine Sciences, Eilat 88103, Israel

(4) Department of Oceanography and Marine Sciences, Dalhousie University, Halifax, NS, Canada

[koss.kalman@gmail.com](mailto:koss.kalman@gmail.com)

A primary component of the global sediment cycle is the delivery of sediment from rivers to the sea, an input that fluctuates in magnitude and frequency owing to changes in precipitation. Some of these fluctuations can be recognized in the sedimentary record on the continental shelf and used to reconstruct past climatic conditions. Today, many coastal rivers have been heavily altered by dam construction, flood control, harbors, irrigation canals, and other human activities; thus also changing the volume, location, and arrival intervals of sediment discharge into the shallow marine shelf. In this study, we examined the inner continental shelf sediments in the northern Gulf of Aqaba-Eilat (GAE) and the Israeli coast of the Mediterranean Sea to determine how they were impacted by 20th century anthropogenic alterations of incoming rivers. In the GAE, a drought-like upper sediment layer appeared where floods are no longer reaching the sea because of river channel diversion. This horizon contained microplastics, timing it to after the foundation of the city of Eilat. These markers are disassociated from recorded rainfall and flood events and were not replicated where floods continued to reach the sea. In the Mediterranean, the observed drought-like changes in the sediment corresponded with the damming of the Nile. Our results show that in both cases, anthropogenically reduced load of fine alluvial (mostly flood) particles and continued winnowing caused sediments to coarsen and become more sorted with higher concentrations of larger foraminifera tests. These sedimentological markings resemble those reported for prolonged droughts, but can be differentiated by discrepancies to recent climatic records. Considering the alterations of waterways worldwide, this sedimentological mismatch may constitute a new proxy of the Anthropocene and highlights the way that human activities are altering the sediment cycle.

## **Spatial mapping of seafloor comet structures at 90-120m water depths along the Israeli shelf reveals trends in sediment transport forces**

מיפוי מבני שביט ברצועת העומקים 90-120 מ' במדף היבשת מעיד על מגמות במערכת הובלת הסדימנט לאורך המדף

Kanari, M.(1), Giladi, A. (1)

1. Israel Oceanographic & Limnological Research Ltd., Tel-Shikmona, P.O.Box 8030, Haifa 31080, Israel

[mor.kanari@ocean.org.il](mailto:mor.kanari@ocean.org.il)

Multibeam and backscatter bathymetry from several sites covering ~110 km along the Israeli continental shelf at water depths 90-120 m reveals over 90 comet structures: exposed sandstone knolls surrounded by unstable soft-sediment scouring at their base, providing conditions for hard bottom insular habitats, proven to host diverse ecological niches and unique faunal communities in previous studies. With soft-sediment scouring at their base, these rocky knolls create comet-like 'head and tail' structures, ranging in diameter between 15-140 m, with relative elevation from their surroundings varying between 3-36 m. Analysis of these comet geometries yields a distinct dominant orientation of their tails around 8-12 degrees. We observe a correlation between the latitude and the diameter of the knolls: they are smaller in size to the north. However, there is a relatively constant ratio between the tail length and the diameter of the knolls. We suggest that the constant orientation shows single dominant sediment transporting force in the North direction, which matches well with the Levant Jet System (LJS) currents detailed in literature to be diminishing northward. The study supports previous suggestions about the LJS having a dominant direction from south to north. The reduction in exposed knoll diameter northward leads to infer that the LJS current is stronger in the south and goes weaker with the latitude further north. However, direct observation for that is yet to be obtained. The comets appear at 90-120 m water depths belt, which is also the coastal shoreline/cliff at LGM times, leads to hypothesize that these structures were exposed to sub-areal fluvial systems during sea-level low-stand periods. In high-stands, when the shelf is submerged, the persistent current transports sediment from south to north, forming these distinct comet structures in the dominant direction of the LJS to the north.

## Anthropogenic mediated shift in the Levantine basin silica cycle

שינויים תלויי פעילות אדם במחזור הסיליקה באגן הלוונט

Katz T. (1), Bookman R. (2) Sisma-Ventura G. (1)

1. Israel Oceanographic & Limnological Research, Haifa, 31080, Israel

2. Department of Marine Geosciences, Leon H. Charney School of Marine Science, University of Haifa, Haifa 3498838, Israel

[timor@ocean.org.il](mailto:timor@ocean.org.il)

Diatoms that constitute almost half of the primary productivity in the ocean require dissolved silica to construct their opaline (biogenic silica) skeletons. While constituting the dominant group of phytoplankton in nutrient and silica replete waters, diatoms are much less abundant in oligotrophic, low silica conditions such as in the Eastern Levantine Basin (ELB), in the Mediterranean Sea. Although the ELB has been oligotrophic for millennia, prior to the damming of the Nile in the 1960s, summer floods that carried large quantities of dissolved silica (and other nutrients) to the sea were shown to support offshore diatom growth. This silica discharge was greatly reduced following the construction of the Aswan high dam and did not recoup thereafter. In this research we show evidence from the water column and from deep-sea sediment cores that the damming of the Nile, possibly with the contribution of anthropogenically induced climate change, caused a shift in the Si cycle offshore Israel in the ELB. This shift, which included reduction in dissolved silica concentrations and diatoms abundance in the surface water culminated by a drop in biogenic-silica accumulation rates at the seafloor, along the mesoscale trajectory of the Nile plume. During the last 100 years, massive damming of rivers worldwide greatly reduced dissolved silica discharge from the land to the sea. Considering this and enhanced water column stratification owing to sea temperature warming, we suggest that the shift in the silica cycle observed offshore Israel in the ELB, might present a preview for other areas of the ocean.



## Hybrid turbidite-contourite sediments transport system in the Eastern Mediterranean upper continental slope

מערכת הסעת סדימנט משולבת של טורבידיטים וקונטוריטים במדרון היבשת העליון של מזרח הים

התיכון

Katz O. (1), Ashkenazi L. (1, 2), Abramovich S. (2), Almogi-Labin A. (1), Makovsky Y. (3), Gadol O. (3), Kanari M. (4), Hyams-Kaphzan O.(1)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

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

3. Charney School of marine sciences. University of Haifa, Mt. Carmel, Haifa 31905, Israel

4. Israel Oceanographic & Limnological Research Ltd., Tel-Shikmona, P.O.Box 8030, Haifa 31080, Israel

[odedk@gsi.gov.il](mailto:odedk@gsi.gov.il)

Nile derived sediment is the main source for sedimentation along the Levant continental margins. The sediment is transported via jet and longshore currents, mainly operating along the shelf. Yet, the cross shelf component of sediment transport, conveying sediment towards the upper slope, is less known. To better understand the cross-shelf vs. the longshore components of sediment transport, we studied two ~5.5 m piston-cores: DOR280 and DOR350, sampled on the upper continental slope at 280m and 350m water depth, respectively. We analyzed the particle size distribution (PSD) as well as the benthic-foraminiferal assemblages and their shells taphonomy, for documenting both the source and the transport mechanism of the upper continental-slope sediment. The radiocarbon sediment age at the DOR280 core-base is  $\sim 660 \pm 70$  Cal Yrs. B.P., indicating an exceptionally-high average sedimentation rate of  $\sim 800$  cm/kyr. DOR280 consists of alternating two sedimentary facies: (1) Laminated (L) intervals with bimodal PSD and high ratio of allochthonous vs. autochthonous (allo/auto) foraminiferal species, characterized by a high percentage of benthic-foraminiferal broken and poorly preserved shells, indicating contribution of transported sediment originating from mid-shelf habitats. (2) Non-laminated (NL) intervals with unimodal PSD, low allo/auto ratio and low percentage of broken shells, indicating mostly in-situ deposition. The L intervals are interpreted as numerous centimeters-thick turbiditic-events revealing grain-size grading and discontinuous eroded lower stratigraphic-contacts. Sedimentation rate calculated only for the NL intervals is still exceptionally high, excluding hemipelagic sedimentation as the sole deposition. Thus, a contour bottom-current transported component is suggested for the NL sediments of DOR280 (i.e. contourites). DOR350 reveals higher sedimentation rates and presents mostly of the L facies. Hence, the sediment of DOR350 mostly consists of transported (by turbidities) sediment with only minor contribution of hemipelagic sedimentation or contourites. We conclude that a hybrid contourite-turbidite system actively prevails along the Levant upper continental slope offshore Israel.

## **Incised Meanders along the Soreq Channel and the Judean Mountains and their Implications for Palaeo-Drainage across the Dead Sea Transform**

פיתולים חתורי סלע לאורך ערוץ נחל שורק והרי יהודה ומשמעויותיהם לגבי עבר אגני הניקוז מעבר לטרנספורם ים המלח

Kellum A. (1), Haviv I. (1)

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

[kellum@post.bgu.ac.il](mailto:kellum@post.bgu.ac.il)

River meanders constitute a ubiquitous planform in alluvial channels but are also quite common as incised meanders in bedrock channels. Meanders morphologic characteristics (wavelength, amplitude, and channel sinuosity) are known to be influenced by hydraulic parameters such as discharge, drainage area as a proxy for discharge, and channel gradient. It was previously argued that the Soreq channel, one of the largest channels which drains the Judean Mountains towards the Mediterranean Sea, is characterized by large, atypical meanders - but this argument was never demonstrated in a quantitative manner. In this project we characterize the morphology of the Soreq meanders and compare it to 16 nearby channels which are incised into identical hard-carbonates lithology and discuss potential triggers for the observed morphology. We utilize a 25x25 m digital elevation model (DEM) of the Judean Mountains in order to quantify channel sinuosity, meander amplitude and wavelength, as a function of drainage area, channel gradient, channel steepness index and precipitation. We restrict our analysis to channel reaches which are incised into hard carbonates of upper Cretaceous age (Judea Group). Our results delineate unusually high values of channel sinuosity (~2 vs. 1.5) and meanders amplitude (~800 m vs. ~250 m) along the Soreq channel relative to other channels with similar drainage area. Such values would be expected if the Soreq drainage area was ~450-750 km<sup>2</sup> larger than it is today. This disparity could be reconciled if the paleo Soreq channel used to drain a large area extending farther to the east across the left-lateral Dead Sea Transform plate boundary.

## Ni-rich inclusions in diamonds and the enrichment of nickel in the Earth's mantle

אינקלזיות עשירות ניקל מתנתי ביהלומים והעשרה של ניקל במעטפת

Kempe Y. (1), Remennik S (2), Navon O. (1), Tschauner O. (3) Weiss Y. (1)

1 The Freddy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem 91904, Israel

2 The Harvey M. Krueger Family Center for Nanoscience and Nanotechnology, The Hebrew University of , Jerusalem 91904, Israel

3 Department of Geoscience and High-Pressure Science and Engineering Center, University of Nevada, Las Vegas, NV 89134, USA

[rael.kempe@mail.huji.ac.il](mailto:rael.kempe@mail.huji.ac.il)

The redox state and oxygen fugacity of the deeper mantle play an important role in defining the geochemistry of different mantle reservoirs. Experimentally based thermodynamic calculations show a general trend of decreasing  $fO_2$  with depth and predict that  $Ni^{2+}$ , mainly in olivine, will be reduced to form Ni-rich metal along the Ni-Precipitation Curve (NiPC). At the conditions and Ni concentrations of the upper mantle, the NiPC is crossed and Ni-rich metallic melt forms somewhere between 8-14 GPa, shallower than the precipitation of iron melt, which dominates deeper zones. However, to date, no geological evidence has been found to corroborate the thermodynamic calculations. Here we present evidence for the presence of  $NiCO_3$ , Ni-rich alloy,  $CO_2$  and molecular  $N_2$  micro and nano-inclusions in two sub-lithospheric diamonds from the Voorspoed mine, South Africa. We argue that the high  $Ni/(Ni+Fe) \sim 0.8$  in the carbonate and alloy can be explained only by formation of Ni-rich metallic phase. We interpret the carbonate as a later reaction of the alloy with  $CO_2$  or a carbonate-rich melt. One diamond showed mineral inclusions identified as coesite, olivine, NaAl-pyroxene and possibly a NAL phase (1-20  $\mu m$ ) associated with sub-lithospheric mineral assemblage. An array of pressures obtained from the coesite, nitrogen and NAL phase ranges between  $\sim 8-16$  GPa at mantle conditions, in agreement with the predicted pressures for the NiPC. These samples may be the first geological evidence for the formation of nickel-rich alloys in the deep upper mantle. They contribute to our understanding of the stability of metal-rich phases in the sub-lithospheric mantle, with direct implications to the deep carbon and nitrogen cycles, magmatic processes, and the redox state of the Earth's deep mantle.

## Geochemical evolution of Lake Lisan brine from interstitial soluble salts

שחזור הרכב תמלחת ימת הלשון והשינויים בה בעזרת הרכב המלחים המסיסים המצויים בחללי המשקעים

Khalifa O. (1,2), Lazar B. (1), Stein M. (1,2)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of Jerusalem, 9190401, Israel

2. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

[omri.khalifa@mail.huji.ac.il](mailto:omri.khalifa@mail.huji.ac.il)

Located on the transition between the climatic belts of the hyperarid Sahara to the subtropical Mediterranean and being a terminal lake, the hypersaline Lake Lisan, the last glacial precursor of the Dead Sea, has been in the focus of extensive paleoclimate research during the past several decades. The sediments deposited from the lake comprise the Lisan Formation which consists mainly of sequences of laminated primary aragonite, silty detritus, and occasional gypsum. Samples were taken from the marginal terraces of the modern Dead Sea where the Lisan Formation is exposed and from sediments cores from the deepest and unexposed point of the lake recovered during the Dead Sea Deep Drilling Project held by the ICDP. Thus, the sampling provides information on the lake in the deep and shallow limnological environments. Here, we report on the chemical compositions of interstitial soluble salts extracted from the sediments. The soluble salts represent the composition of the lake's brines. The measured ions are  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{K}^{+}$ ,  $\text{Na}^{+}$ ,  $\text{Sr}^{2+}$ ,  $\text{Cl}^{-}$ ,  $\text{SO}_4^{2-}$ ,  $\text{Br}^{-}$ ,  $\text{NO}_3^{-}$ , and  $\text{HCO}_3^{-}$ . We emphasize several ion ratios that correlate well with pore fluids composition extracted from the same section in the DSDDP deep core, such as  $\text{Na}/\text{Cl}$  and  $\text{Mg}/\text{Cl}$  (in eq). The  $\text{Na}/\text{Cl}$  gradually increases from 0.3 at the beginning of the last glacial period (~95 ka) up to 0.7 during the Younger Dryas and sharply drops back to 0.3 during the shift to the Holocene. The  $\text{Mg}/\text{Cl}$  shows a mirror pattern (with max values 0.5 and min of 0.2 respectively). These temporal changes reflect the gradual freshening of the deep hypolimnion along the last glacial period. The deep brine shows relative stability along the last glacial period compared with the shallow epilimnion composition that variates in response to short-term and secular climatic changes, such as Heinrich events and marine isotope stages.

## Sea level change in Israel and in the Mediterranean

שינויים בגובה פני הים בישראל ובים התיכון

klein M. (1)

1. Department of Geography and Environmental studies ,Univ.of Haifa

[mklein@geo.haifa.ac.il](mailto:mklein@geo.haifa.ac.il)

In the State of Israel, there are two government agencies that conduct measurements for the purpose of monitoring sea level. The first is the Survey of Israel (SOI), which is the body authorized for geodesic measurements in the country. The second institution is Israel Oceanographic and Limnological Research (IOLR). SOI has been measuring sea level since 1958; IOLR has been doing so since 1991. In the period during which sea level was measured by both agencies, i.e. between the years 1991 and 2020, the respective sea level measurements of both institutions are in very good accordance. It can be concluded that the measurement methods of SOI and of IOLR reflect accurate data. An analysis of the data obtained by SOI indicates that since 1958 there has been an increase in sea level, of 0.8 mm per year. Measurements along the Mediterranean Coast. The station where the surface height of the Mediterranean Sea has been measured for the longest period of time is the port of Marseille in the south of France. A recent study analyzing the measurement data at the Marseille station reports an average increase of 1 mm per year over the last 170 years, at a fairly constant rate. Assuming the same rate, over the next eighty years until 2100 the sea level will rise by 8 cm.

## **The geological history of the Permian sequence in south Israel as reflected by direct evidence from boreholes - lithology, biostratigraphy, microfacies**

ההסטוריה הגיאולוגית של הרצף הסדימנטרי מגיל פרם בדרום ישראל כפי שנלמד ישירות מחומר קידוחים - ליתולוגיה, ביוסטרטיגרפיה ומיקרופציאסים.

Korngreen D. (1), Orlov-Labkovsky, O. (2), Stephenson, M.H. (3)

1 Geological Survey of Israel, 32 Yesha'yahu Leibowitz St., Givat Ram, Jerusalem 9371234, Israel

2 Steinhardt Museum of Natural History in Tel Aviv University, 12 Klouzner St., Tel-Aviv 69978, Israel

3 Stephenson Geoscience Consulting Ltd, Keyworth, United Kingdom

[mikepalyno@me.comdoritk@gsi.gov.il](mailto:mikepalyno@me.comdoritk@gsi.gov.il)

The Permian sequence in the Israeli boreholes contains good potential source rocks for hydrocarbons. However, seismic surveys fail to distinguish it from the Triassic sequence, therefore, it is usually included in a comprehensive 'Permo-Triassic' succession category. This prevents monitoring of its regional tectonic context, assessment of sedimentary systems trends, and its correlation with the Permian formations in the Arabian Plate that constitute reservoir or self-sourced rocks. Beyond that, as one of the most important periods of distinct global earth-life events, it deserves special attention. The purpose of this talk is to bring insights from an up-to-date Negev and Jordan Palynological-age review from latest works that confirm Wuchiapingian-Changhsingian (Late Permian) age to the whole sequence (Saad, Arqov, Shezaf, Umm-Irna Fms) and to compare it with benthic foraminifera-based ages obtained from the Coastal Plain-Hashfela (SW-NE line) boreholes. In the last, the base of Arqov Fm is attributed to the Middle-Late Permian transition, the entire Arqov Fm - to the Wuchiapingian and the overlain Shezaf Fm to the Changhsingian. Thus indicating southeastward diachronic sedimentary progress of marine transgression over a peneplain slightly sloping northward (0.1-0.2%). Faults with westward downfaulted blocks indicate that the marine transgression phases relate to the faults activity during the Middle-Late Permian. The half graben pattern of Saad Formation indicates initial stages of crust-extension as a mirror of the NeoTethys opening dynamics. The east to west differential cessation of the fault activity indicates that the main activity of the crust-extension located and migrated westward, in parallel to the heritage peneplain slope. Although the eastern fault activity ceased, the marine transgression continued southeastward during the Changhsingian, indicating a global sea level rise then. The SW-NE line exhibit similar sedimentary facies evolution indicating similar location on a common peneplain slope. All indicates spatial thickening and sedimentary environments trends in the subsurface.

## **Late Quaternary evolution of the Yesha Valley (Naftali Mountains): a tectonic and paleoenvironmental study**

טקטוניקה ושחזור סביבת ההיווצרות של בקעת ישע (הרי נפתלי) ברביעון המאוחר

Kranenburg H. (1) Shtober-Zisu N. (1), Waldmann N. (2), Porat N. (3), Greenbaum N. (4)

1. Department of Israel Studies, University of Haifa, Mt. Carmel, Haifa 3498838, Israel.
2. The Dr. Moses Strauss Department of Marine Geosciences, Leon Charney School of marine sciences. University of Haifa, Mt. Carmel, Haifa 3498838, Israel.
3. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel.
4. Department of Geography and Environmental Studies, University of Haifa, Mt. Carmel, Haifa 3498838, Israel.

[kranenburgia@gmail.com](mailto:kranenburgia@gmail.com)

The Yesha valley is an elongated (1.8 km) and narrow (<0.1 km), N-S trending tectonic depression in the Naftali mountains. It follows the marginal faults of the Hula pull-apart basin and is incised into the Dir Hannah Formation. It is drained eastward by 3 slope-channels and the Nahal Kadesh stream to the south. The Yesha Valley serves as an active subsiding local base level and a disturbance for channel flow and sediment transport to the Hula valley. Sediments that accumulate in the valley include mostly reddish clays of Terra Rossa origin and aeolian dust. The aim of the study is to analyze the sedimentary sequence in order to reconstruct the regional paleoenvironment and the later tectonic phases along the Yesha marginal fault. A 20 m long core of reddish clay sediments was extracted, down to the underlying limestone at the bottom of the valley. The analyses comprise magnetic susceptibility, sedimentological description, grain-size, mineralogy, and chemistry (XRF, XRD, FTIR and TOC). Chronology is based on luminescence dating. Four different sedimentological units were described (from the top): Unit A - 4.1 m thick, composed of dark reddish clay, where the uppermost 3 m are significantly affected by agriculture. Unit B - 2.4 m thick, dated to about  $85 \pm 4$  ka, composed of brownish clay, rich in organic material, possibly implying moist environment. Unit C - 8.5 m thick, composed of relatively uniform reddish brown quartz-rich sediments dated to between  $271 \pm 18$  and  $767 \pm 65$  ka with relatively constant rate of accumulation of about  $0.02 \text{ mm yr}^{-1}$ , suggesting similar rates of tectonic subsidence (creep). The high Si suggests large aeolian dust contribution. Unit D - 4.5 m thick, comprised of 5 well-cemented calcrete horizons older than  $767 \pm 65$  ka. These calcic horizons indicate periods of tectonic quiescence, stability and calcic pedogenesis in somewhat drier climate conditions.

## The listric faults bounding the Dor Disturbance from the southeast: indications for recent major seabed ruptures

השברים הליסטיים התוחמים את הפרעת דור מדרום-מזרח: אינדיקציות לקריעת פני שטח רצנטית בקרקעית הים

Laor M. (1,2), Gvirtzman Z. (1,2), Katz O. (1), Gadol O. (3), Hyams-Kaphzan O. (1), Makovsky Y. (3)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

2. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel

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

[may.laor@mail.huji.ac.il](mailto:may.laor@mail.huji.ac.il)

The faults bounding the Dor disturbance (offshore Israel) from the southeast are exceptional relative to other faults nearby. 1) Whereas most of the faults are aligned along the base of the continental slope, these faults are located in the upper slope; 2) Whereas most of the faults are salt-related, these faults are located east of the salt wedge; 3) Unlike the salt-related faults that displace the entire Pliocene-Quaternary section and reach the Messinian salt, these faults die out at a relatively shallow depth and do not reach the Pliocene section; 4) Whereas the salt-related faults are dipping 45° on average, the upper slope faults are listric with an average dip of 30°; 5) Compared to the salt-related faults, the upper slope listric faults have larger recent displacements with larger seabed scarps. The exceptionally high fault bathymetric scarps are particularly interesting, considering that this specific area has the largest sedimentation rate, four times larger than the displacement rate. This apparently indicates that displacements occur by rupture events rather than by continuous creep. To better understand the formation of these listric faults and assess the hazard they pose, we performed a high-resolution, multi-channel, seismic reflection survey south of the Dor Disturbance. We map three unconformities on and off the shelf and date them, using sequence stratigraphic principles and a global sea-level curve. Considering the dated seismic reflectors, we measure fault offsets and calculate the displacement rates throughout the history of the fault. In this talk, we will present the preliminary results and discuss their implications.



# **The (234U/238U) compositions and trace element concentrations of sequential leachates of atmospheric dust collected in the northern Red Sea between 2009-2019**

איפיון יסודות קורט ואיזוטופים של אורניום בפאזות שונות של אבק ממפרץ אילת בין השנים 2009-2019

Lapid G. (1,2), Torfstein A. (1,2)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel

2. Interuniversity Institute for Marine Sciences, Eilat 88103, Israel

[gil.lapid@mail.huji.ac.il](mailto:gil.lapid@mail.huji.ac.il)

Atmospheric dust plays a key role in shaping global climate by affecting radiation budget, modulating precipitation, and serving as a significant source of limiting trace metals to the oceans. At present, the primary source of atmospheric dust in the world is the Sahara-Arabia desert belt. The mineral composition of dust varies both spatially and temporally, but can be generally divided into water labile, Ca-carbonates, Fe- and Mn- oxides, Mg-carbonates and silicate phases. Here, we report (234U/238U) compositions and trace element concentrations in five sequentially leached phases of 20 dust samples collected in the Gulf of Aqaba, northern Red Sea, between 2009-2019. The sampling site is located between the Sahara and the Arabia Deserts and is exposed to frequent dust storms, whose source is identified through air mass back trajectories. The (234U/238U) ratio is sensitive to the weathering history of the samples, which reflects the combined effects of their provenance, transport pathways and chemical weathering rates. The sequential leaching steps included water, followed by 0.1N HNO<sub>3</sub>, hydroxylamine hydrochloride, 3N HNO<sub>3</sub>, and a mixture of concentrated HNO<sub>3</sub>-HF. These leachates successfully extracted the water labile, Ca-carbonates, Fe- and Mn- oxides, Mg-carbonates and silicate phases. The water labile phase displays the highest (234U/238U) values between 1.11-1.32, roughly corresponding with seawater composition (~1.14). The Ca-carbonate and silicate phases, which incorporate most of the U content, display an overall (234U/238U) range of 0.93-1.03, and the Mg-carbonates and Fe-Mn oxides display values of 0.97-1.09 and 0.95-1.08, respectively. This is the first report of the uranium isotopic composition of atmospheric dust from the Arabian and eastern Saharan Deserts. Coupled with trace element abundances in the different mineral phases, the results allow us to reconstruct the geochemical history of different dust sources, and determine aeolian trace element fluxes in this region.

## Tracking particle flux dynamics in the eastern Mediterranean using dissolved $^{230}\text{Th}$ and $^{232}\text{Th}$

איפיון שטפי חלקיקים במזרח הים התיכון בעזרת איזוטופים של תוריום

Lapid G. (1,2) , Benaltabet T. (1,2), Alkalay R. (3,4), Weinstein Y. (3), Adi Torfstein A. (1,2)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel
2. Interuniversity Institute for Marine Sciences, Eilat 88103, Israel
3. Department of Geography and Environment, Bar-Ilan University, Ramat-Gan, 52900, Israel
4. Israel Oceanographic & Limnological Research Ltd., Tel-Shikmona, P.O.Box 8030, Haifa 31080, Israel

[gil.lapid@mail.huji.ac.il](mailto:gil.lapid@mail.huji.ac.il)

Marginal oceans are a unique environment within the land-ocean continuum. The proximity to land results in high influxes of terrestrial material, i.e. runoff, dust, nepheloid layers, as well as water-sediment interactions. These processes play a prominent role in the temporal evolution of chemical and isotopic composition of seawater, but their quantitative impact is not well constrained. This can be achieved based on the dynamics of thorium isotopes. Dissolved  $^{230}\text{Th}$  concentrations, which increase with depth, reflect scavenging in shallow waters and remineralization at depth, coupled with dissolved  $^{232}\text{Th}$  concentrations which reflect terrigenous inputs, can be used to quantify fluxes and sources of particulates in the oceans. Here, we present results from two cruises performed in April 2018 and June 2021, where vertical seawater profiles were collected along a transect between the Haifa Bay area and the deep Levant Basin, eastern Mediterranean. These transects span the continental shelf, slope, and the abyssal plain of the eastern Mediterranean. The first order fluxes of terrestrial particulates (e.g., dust), scavenging, and remineralization processes across the water column, are quantified based on the distributions of dissolved  $^{230}\text{Th}$  and  $^{232}\text{Th}$ . The results yield an a-priori residence time ranging between ~5 years in the upper water column, and ~15 years at 1600 m depth, with an apparent vertical lithogenic flux range between 0-23 g m<sup>-2</sup> y<sup>-1</sup>. In general, the vertical lithogenic fluxes decrease with increasing distance from shore. In addition, a change in scavenging intensities observed at intermediate depths indicates the occurrence of nepheloid layers originating from the continental shelf. These results are coupled with corresponding dissolved trace element concentrations and Pb isotopic compositions, and provide for the first time a detailed description of the spatial and vertical dynamics and rates of biogeochemical cycles between the continental shelf and the deep water column of the eastern Mediterranean.

## UAV Based Remote Sensing for Locating and Mapping Archaeological Features Beneath Vegetation and Sub-Surface

שימוש באמצעי חישה מרחוק על גבי רחפן באיתור ומיפוי אלמנטים ארכיאולוגים מתחת לצמחייה  
ובתת-הקרקע

Laugomer B. (1), Shicht I. (1)

1. Enso Geospatial - Ein Vered 4069600, Hayuval 6 St. P.O.B 520, Israel

[ben@ensogeospatial.com](mailto:ben@ensogeospatial.com)

Locating previously unknown archaeological features under vegetation and below the surface presents a challenge, especially over large and/or densely vegetated landscapes. While satellites are able to cover large areas, they lack the resolution that is sometimes needed to see smaller features, and completely lack the ability to penetrate vegetation. We present a workflow based on accessible sensors mounted on UAV platforms and sophisticated analysis of the derived data in a GIS based environment to locate and map different archaeological features, both under vegetation and the shallow subsurface. Examples from the sites of Legio, Abu-Shusha and more show that the use of such workflows allow for better and cost effective planning, as well as the ability to map and gain insights in areas that prevent accessibility challenges or the ability to map larger areas in high resolution.

## Using machine learning to test the Jurassic 'Boreal spread' hypothesis of nerineoidean gastropods

Leshno Afriat Y. (1,2), Edelman-Furstenberg Y. (1), Rabinovich R. (2)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

2. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel

[yaeleshno@gmail.com](mailto:yaeleshno@gmail.com)

The opening of the North Atlantic during the Middle Jurassic enabled Arctic currents to reach Western Europe. As a result, the biogeographic distribution of shallow, warm-water fauna from the northern Boreal Realm shifted southward. This southward 'Boreal spread' has been suggested for several groups, including nerineoidean gastropods. However, the magnitude and extent of the shift have not been quantitatively evaluated. The Nerineoidea, a group of extinct gastropods, were one of the most abundant and diverse groups in Mesozoic shallow marine environments. Internal spiral folds that are viewed in polished cross-sections characterize the group and form the basis of their classification. Recent development of a geometric morphometrics protocol to differentiate groups of nerineoideans based on their internal whorl-outlines minimizes the inconsistency and difficulty of comparing identifications between authors. Here, we utilize the development of the method to an automated classification system by using convolutional neural networks (CNNs) to test for the Boreal spread of nerineoideans. We compiled a large image database of nerineoidean cross-sections from various sources and used the CNN to validate the inclusion and classification of newly compiled images from published literature into three predefined groups: Ceritellidae, Ptygmatididae, and a combined group of Nerinellidae+Eunerineidae+Nerineidae. Our results support a southward expansion of nerineoideans from the Boreal Realm of the Early Jurassic to the Tethyan Realm of the Middle Jurassic. The variation in the relative abundance of the nerineoidean groups probably reflects their adaptation to the different paleoecological settings.

## Can Electrical Resistance Tomography (ERT) detect cavities?

האם ניתן לאתר חללים בעזרת טומוגרפיה גיאושמלית (ERT)?

Levi E. (1)

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

eldad@gii.co.il

Geophysical methods are widely used for near surface engineering (studies) during the first stage of the site investigation, one of its aims being cavity detection. The Electrical Resistance Tomography (ERT) method, the results of which create a 2D resistivity cross section or 3D subsurface image with high lateral resolution, have become very popular for cavity detection. Cavities are usually filled with air, which has very high resistivity compared to soil and surrounding rocks. Hence, it is considered as easily identified high resistivity anomaly. An ERT 2D survey above a well mapped cave near Beit Govrin found that the Wenner-Schlumberger array gave the best detection results compared to others arrays, and a 3D survey at the same location/site shows that the orientation of the survey line in relation with the geometry of the cavity effect its detectability. Since cavity detection in field conditions using ERT can be non unique and have limited success, it is recommended to combine it with others geophysical methods in order to improve detectability.

## **Petrological and chemical characterizations of pristine and reworked phosphorites from Negev, Israel: insights into industrial usage**

איפיון כימי ופטרולוגי של סלעי פוספט ראשוני ושניוני מהנגב, ישראל: תובנות לגבי השימוש התעשייתי

Levy A. (1,2), Schneider Mor A. (1), Gelman F. (1), Kamyshny A. (2)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

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

[bensamit@post.bgu.ac.il](mailto:bensamit@post.bgu.ac.il)

Phosphorites are essential natural resource for producing phosphoric acid, phosphate fertilizers, and phosphate-based products. The detailed characterization and right assortment of the phosphate resources are necessary for the identification of rocks chemically suitable for the phosphate industry. In the frame of Ph.D. project, we investigated the chemical composition and petrographic characteristics of phosphorites from three phosphate fields located in the same syncline, Zin, Negev, Israel. In each site, the succession of pristine and reworked phosphorite layers along 10 m of section was observed. Based on the chemical and petrographic analysis of phosphorites, it can be concluded that even though all the studied phosphorites were deposited in the same basin under suboxic conditions, sedimentary settings varied at each site. These variations resulted in differences in morphology and chemical composition including the concentrations of major and trace elements as well as the abundance of the organic matter (OM) fractions. In all studied samples, a decrease in total organic carbon (TOC) and redox-sensitive trace elements (RSTE) was observed upon the transition from a pristine to a reworked phosphorite phase, while the relative abundance of organic matter fractions remained similar. The results of the present study agree well with the previous studies, suggesting that phosphorites deposited with the slow sedimentation rate are more likely be suitable for industrial application. However, in phosphates, where humic substance (HS) represents the main fraction of OM and is located mainly inside carbonate-fluorapatite (CFA) grains, difficulties in the separation of OM from CFA grains during the production process cannot be excluded.

## Towards global quantification of seawater circulation in coastal aquifers

כימות גלובלי של שטפי סירקולציית מי ים באקוויפרים חופיים

Levy Y. (1), Kiro Y. (1)

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

[yehuda.levy@weizmann.ac.il](mailto:yehuda.levy@weizmann.ac.il)

Submarine groundwater discharge (SGD) is significant to coastal water chemistry and ecology. Nonetheless, the majority of SGD flux to the ocean comprises circulated seawater. This study deals with seawater circulation in coastal aquifers on a global scale in order to assess solute fluxes through SGD into the ocean. While the circulated seawater does not affect the water budget, it has a much higher impact on the ocean solutes budget due to water-rock interactions. We present a global assessment of saline SGD mechanisms' role using numerical simulations and analytical calculations. The numerical model simulates three main circulation mechanisms in coastal aquifers: density-driven circulation (long-term), tidal-driven nearshore circulation, and tidal pumping (short-term), while we calculate the wave-driven benthic exchange flux analytically using the same settings of the numerical model. The model tests the typical range of the different geohydrological parameters. Our results revealed that: (1) increasing hydraulic conductivity increases the density-driven and decreases the tidal-driven nearshore circulations; (2) increasing the hydraulic gradient (or freshwater recharge) has no significant effect on the density-driven circulation while it slightly decreases the short term nearshore circulation; (3) tidal pumping fluxes are relatively large of the overall SGD flux (30%-60%). Together with global hydraulic parameter distributions, the model results enable assessing the global SGD component of seawater circulation. Preliminary results reveal that the total density-driven SGD is about 0.5-1% of the river fluxes to the oceans. Based on the enrichment of calcium in the long-term SGD component, our global assessment of the calcium flux through density-driven flow may reach the same calcium flux through rivers into the ocean.

## Imaging an Underwater Basin using Optical Fiber Distributed Acoustic Sensing

דימוי אגן דימנטרי תת ימי באמצעות סיבים אופטיים

Lior I. (1), Diego M. (2), Rivet D. (3), Sladen A. (3) and Ampuero J. P. (3)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel

2. CEREMA, équipe REPSODY, Sophia Antipolis, Valbonne, France

3. Université Côte d'Azur, CNRS, Observatoire de la Côte d'Azur, IRD, Geoazur

[itzhak.lior@mail.huji.ac.il](mailto:itzhak.lior@mail.huji.ac.il)

Distributed acoustic sensing (DAS) is an ideal tool for ambient noise tomography owing to the dense spatial measurements and the ability to continuously record in harsh environments, such as underwater. While the fine spatial sampling of DAS facilitates the imaging of small-scale lateral velocity heterogeneities, efforts relying on dispersion-based ambient noise tomography are hampered by the underlying premise of negligible lateral variations across the segment used for dispersion curve extraction. To image small-scale structures, this method should be augmented with objective and independent approaches that are not scale-limited. Here, we show that power spectral densities (PSD) and auto-correlations (AC) of DAS data reveal extremely detailed frequency-dependent resonance and wave propagation characteristics. These observations contain crucial information on lateral and vertical wave propagation. We use these methods to demonstrate the ability to image a complex underwater basin using ambient noise recorded on a fiber deployed offshore Greece. A two-dimensional shear-wave velocity model was derived by analyzing Scholte-wave dispersion. PSD and AC reveal significant lateral variations across the short 2.5 km long fiber segment, including basin edge effects and scattered waves. These were used to further constrain and modify the velocity model. The modified model is supported by waveform simulations that qualitatively reproduce PSD and AC observations. Our results demonstrate the advantages of incorporating PSD and AC observations into ambient noise-based imaging. The spatially continuous observation of resonance modes across the basin highlights the benefit of DAS acquisitions for ground-motion estimation.



## **Dust as a foliar fertilizer in an elevated CO<sub>2</sub> conditions**

אבק כדשן אטמוספירי על עלים בתנאי פחמן דו חמצני גבוה

Lokshin A. (1), Avner G. (1), Palchan D. (2)

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

2. Department of Civil Engineering, Ariel University, Ariel 40700, Israel.

lokshinanton@gmail.com

Dust as a foliar fertilizer in elevated CO<sub>2</sub> conditions Desert dust serves as an important source of macronutrients such as P and K and micronutrients such as Fe, Mn, Zn, and others. Studies showed that plants, which grow on infertile soils and had evolved in dusty ecosystems, will optimize their nutrient acquisition mechanisms either through the roots or via foliar nutrient assimilation (i.e., from dust settled on the leaves). This mechanism may serve plants in a future world, where atmospheric levels of CO<sub>2</sub> will rise and soils are expected to lose fertility (i.e., their nutrient storage). Such a world may hamper basic plants processes such as photosynthesis and, in turn, the global continental carbon sink. A recent study had shown that foliar uptake of nutrients may be significant and an alternative nutrient acquisition pathway for plants in nutrient deficient soils, and in future high CO<sub>2</sub> atmospheric levels. We aim to investigate the proportion of foliar assimilation of nutrients in varying levels of atmospheric CO<sub>2</sub>. In our experiment, we apply desert dust directly either on leaves or on roots in ambient (400 ppm) and elevated (850 ppm) CO<sub>2</sub> levels. We study dry biomass of the roots and the foliage, bioavailable P concentration, leaves pH, and the photosynthesis rate. Preliminary results show that the dry biomass of foliage chickpea varies between 6-11.5 gr for plants that received the full spectrum of fertilization and between 0.8-3 gr for plants that received P deficient fertilization. The biomass of plants fertilized by dust applied on either leaves or roots varies between 1-3 gr. In the future, the application of dust separately on leaves and roots will allow us to quantify the relative nutrients assimilation achieved by means of Nd and Sr radiogenic isotopes. This will enable us to quantify the nutrient assimilation mechanism from roots and foliage.

## **AxUV surveying of seepage edifice at the seafloor of western Palmahim Disturbance – developing innovative methodologies for deep sea environmental assessment and monitoring**

סקר כשב"מ של מוקדי נביעות בקרקעית הים במזרח הפרעת פלמחים - פיתוח שיטות חדשניות  
להערכה סביבתית וניטור בים העמוק

Makovsky Y. (1,2), Bialik O. M. (1), Meilijson A. (1), Neuman A. (1), Lawal M. (1), Kanari M. (3), Giladi A. (2), Antler G. (4,5), Suma B. (6), Ebinger C. (7), Rubin-Blum M. (2)

1. The Dr. Moses Strauss Department of Marine Geosciences, Leon H. Charney School of marine sciences. University of Haifa, Mt. Carmel, Haifa 3498838, Israel.
2. The Hatter Department of Marine Technologies, Leon H. Charney School of marine sciences. University of Haifa, Tel-Shikmona, Haifa 31080, Israel.
3. Israel Oceanographic & Limnological Research Ltd., Tel-Shikmona, P.O.Box 8030, Haifa 31080, Israel.
4. Interuniversity Institute for Marine Sciences, Eilat 88103, Israel.
5. Department of Earth and Environmental Sciences, Ben Gurion University of the Negev, Beer Sheva 8410501, Israel.
6. Department of Computer Science, Tulane University, 6823 St Charles Ave., New Orleans, LA 70118, USA.
7. Earth and Environmental Sciences Department, Tulane University, 6823 St Charles Ave., New Orleans, LA 70118, USA.

[yizhaq@univ.haifa.ac.il](mailto:yizhaq@univ.haifa.ac.il)

The deep sea is the largest habitation space on Earth, an important source for resources and a major control of climatic changes. However, it poses a challenging management environment. It is therefore imperative to derive innovative quantitative methodologies for investigation and monitoring of the deep sea. This presentation summarizes the context, results and analysis of an AUV survey that was carried on January, 2021, in the western part of Palmahim Disturbance (PD). The AUV data are utilized for quantitative estimations of habitat and seepage on the deep seafloor, testing our 3D-seismic based mapping of potential seepage locations and intensities and the validity of our modelled distribution of rare seafloor habitats on PD for the purpose of marine protected areas planning. The AUV SAS backscatter and multibeam bathymetry data are corroborated with visual ROV surveys, and used to outline seafloor pockmarks, carbonate rock groups and stretches of enhanced bioturbation. Manual outlining of these seafloor features corroborate that our 3D-seismic potential seepage predictions robustly detect medium to high intensity seepage sites (>80% confidence), while providing a broad indication to the presence of lower intensity seafloor seepage. This is probably associated with the previously underestimated presence of gas bearing intervals tens of meters beneath the seafloor, as marked by high amplitude seismic reflectivity. The observed distributions of pockmarks and carbonates correlates in general with our modeled distribution of rare seafloor habitats. An enhanced distribution of these features at medium probabilities may reflect the association of higher seepage intensities with stronger focusing of the PD

seepage system. A more robust estimation of the distribution of seafloor features through machine learning methodologies is currently under development. Our results highlight the potential of AUV SAS surveying for quantitative assessments of the deep sea environment, and in particular monitoring of seafloor and infrastructure leakages.

## **Massive westwards Oligo-Miocene sediment transport to the subsiding Levant basin and its exploration significance**

הסעת סדימנטים מאסיבית אל אגן הלבאנט השוקע ומשמעותה לחיפושי הידרוקרבונים

Mart, Y. (1)

1. Leon Recanati Institute for Maritime Studies University of Haifa, Mount Carmel, Haifa 3498838, Israel

[yossimart@gmail.com](mailto:yossimart@gmail.com)

Seismic reflection profiles shot along the Levant Basin and its margins show considerable thickening of the Oligo-Miocene sequence compared with overlying and underlying strata. Numerous erosional channels flow from east to west, their dimensions vary, as they form a dense submarine sediment-transport system. These channels differ from the erosional channels that developed during the latest Miocene, which are fewer, but very large, entrenched deeply into their substrate. These latter sedimentary channels seem subaerial, and were probably developed due to the Messinian desiccation, while the previous ones are probably marine. The evident reconstruction of the late Miocene drainage system indicates that the flow of the sediments was then mostly from east to west, unlike the present depositional system which derives most of its sediments from the Nile River and flows northwards. Modeling the paleogeography of the Levant in the Oligo-Miocene suggests that its position at that time was at latitudinal range of 10o-15o N, where the present East African mantle plume has been active since. Previous numeric modeling of that plume indicated that the Oligocene crustal uplift of the Arabo-Nubian Massif due to that plume was accompanied by surrounding basins, one of them seems to be the marine basin that underlies the SE Mediterranean, where the extensive Oligo-Miocene sediment deposition took place. That sediment transport system across the continental slope to the marine basin of the SE Mediterranean Sea serves as a guideline to the contemporaneous catchment and storage of sand from source to sink and enhances fruitful search and discovery of new hydrocarbon reservoirs.

## Verification of numerical model of methane bubble growth in aquatic sediments

אימות מודל מספרי של גידול בועות מתאן במשקעים מימיים

Meena M.K. (1), Katsman R. (1)

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

[manishkumarmeena49@gmail.com](mailto:manishkumarmeena49@gmail.com)

Methane (CH<sub>4</sub>) is a greenhouse gas that affects the greenhouse gas budget and can increase a global warming in the atmosphere. The greenhouse warming potential of methane is several times more than the Carbon-di-oxide (CO<sub>2</sub>) gas. Produced by methanogenesis in sediments, the CH<sub>4</sub> emission from aquatic systems to the atmosphere is usually dominated by gas ebullition. In shallower lakes, around 2% of CH<sub>4</sub> originates with dissolution while around 98% comes out from the bubbles. To study the CH<sub>4</sub> flux coming out from the aquatic environment, the study of CH<sub>4</sub> bubble dynamics in muddy aquatic sediment is quite important. The Linear Elastic Fracture Mechanics (LEFM) model is used to model CH<sub>4</sub> bubble growth and migration caused by bubble solute uptake in muddy sediment: elastic bubble expansion and discrete differential fracture over the bubble front helps to track the shape and size of the growing bubble. Starting from the initial penny-shaped bubble configuration, the final mature CH<sub>4</sub> bubble gains an inverted-teardrop shape, just before the beginning of its rise towards the water column. Our model was extensively tested and verified by comparison to the available analytical solutions. The comparison of bubble size, bubble opening, stress intensity factor difference between the bubble head and its tail to the available analytical solutions demonstrates a convincing agreement. Further calculations with the reliable model will allow estimating the CH<sub>4</sub> flux coming out from the aquatic sediments with higher accuracy.

## Characterization of seafloor gas emanations and their potential linkage with sub-sea reservoirs in the Levant Basin

אפיון שפיעות גז בקרקעית הים והקשר האפשרי שלהן למאגרים תת-ימיים בלבנט

Meilijson A. (1), Reznik I. J. (2), Rosenberg Y. O. (2), Pape T. (3), Bohrmann G. (3), Bialik M. O. (1), Kanari M. (4), Giladi A. (4), Ozer T.4, Bronstein O. (5), Sisma-Ventura G. (4), Antler G. (6,7), Berman-Frank I. (1), Herut B. (4), Rubin-Blum M. (4), Makovsky Y. (1)

1. The Dr. Moses Strauss Department of Marine Geosciences, Leon H. Charney School of marine sciences. University of Haifa, Mt. Carmel, Haifa 31905, Israel
2. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel
3. MARUM - Center for Marine Environmental Sciences and Faculty of Geosciences, University of Bremen, Bremen, 28359
4. Israel Oceanographic & Limnological Research Ltd., Tel-Shikmona, P.O.Box 8030, Haifa 31080, Israel
5. School of Zoology תל אביב University, Tel Aviv, 69978.
6. Department of Earth and Environmental Sciences, Ben Gurion University of the Negev, Beer Sheva 8410501, Israel
7. Interuniversity Institute for Marine Sciences, Eilat 88103, Israel

[ari@yamyabasha.space](mailto:ari@yamyabasha.space)

This study aims to characterize the dynamics of seafloor gas leakage in the Levant Basin and determine in detail the nature of the seeping compounds. We aim at building local capacities required for future detection of leakage, estimation, and monitoring of the sealing capacity of potential carbon sequestration or hydrogen fuel storage within sub-sea reservoirs. Novel and state-of-the-art methodologies were employed for geophysical identification of seepage localities and estimation of bubble fluxes, followed by seepage sampling for geochemical and petrophysical analysis. We address the origin and source of emerging gases, the interconnectivity of reservoirs in the Levant Basin, and their environmental impact. We present results from a hydroacoustic autonomous-underwater-vehicle (AUV) based synthetic aperture sonar (SAS) seafloor imaging, and remotely-operated-vehicle (ROV) visual seafloor inspections and sampling at water depths of ~1150m in the Palmachim Disturbance (PD), ~60km offshore Israel. SAS surveying at the PD detected and mapped gas bubbles rising from the seafloor, authigenic carbonates and pockmarks. ROV surveying confirmed the presence of unique combined gas seepage and related features including brine pools, carbonates, and chemosynthetic biology. Numerous deep-sea sharks use this habitat as a nursing ground. Gas samples were collected from several sites, stored under in-situ hydrostatic pressure that prevented admixing with environmental gases and fluids, and subsampled on deck. Samples were analyzed for their molecular compositions of light (C1-C6) hydrocarbons, CO<sub>2</sub>, and stable C and H isotopic compositions of methane. C<sub>1</sub>/C<sub>2</sub> values in the range of 640-690 along with δ<sup>13</sup>C and δ<sup>2</sup>H values of 64‰ V-PDB and 190‰ SMOW, respectively, indicate a predominant microbial source of methane, with some potential admixing with secondary microbial and/or thermogenic hydrocarbons. Future analyses include PVT analysis and noble

gas concentrations and isotopes which may help to categorize gas reservoirs and provide time constraints for the gas source.

## **A new chronostratigraphic framework and depositional model for the offshore Mesozoic sequence in the Levant Basin with a focus on organic-rich deposits**

מודל כרונסטרטיגרפי וסדימנטולוגי חדש לחתך המזוזואי באגן הלבנט עם דגש על שכבות עשירות  
בחומר אורגני

Meilijson A. (1), Bett W. (1), Funaro E. J. (2,3), Hirsch S. (3), Sagy Y. (3), Reznik I. J. (3), Benjamini, C. (2), Feinstein S. (2), Rosenberg Y. O. (3), Ashckenazi-Polivoda S. (4)

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

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

3. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

4. Dead Sea and Arava Science Center, Central Arava Branch, Hatzeva 86825, Israel

[ari@yamyabasha.space](mailto:ari@yamyabasha.space)

Exploration efforts for hydrocarbons throughout the Levant Basin are ongoing. Defining and characterizing the properties and distribution of local source rocks is a major component of hydrocarbon exploration and is in the center of modeling efforts for predicting the likelihood of hydrocarbon reservoirs in the deeper Mesozoic section of the Levant. In this work we focus on providing an updated chronostratigraphic depositional model of the offshore Mesozoic deposits based on a section of 10 offshore wells, that places potential source rock intervals within this framework. Biostratigraphic reevaluation resulted with 30 faunal datums which are age indicative, and 25 datum levels which are correlatable but do not have a designated age. The model tests our hypothesis that Arabian Plate-wide maximum flooding surfaces (MFS) have controlled sedimentation patterns in the Levant during the Mesozoic, and that basin-wide correlation should be attentive to the Arabian Plate sequence stratigraphy. Furthermore, regional deposits with elevated organic content, i.e., potential source rocks, should be considered in relation to the MFS of the Arabian Plate. Our model places regional geological formations and potential source rocks within a chronostratigraphic framework which appears to comply with this hypothesis. We report on the possible identification of the following intervals containing a regional increase in organic content: Upper Cretaceous Maastrichtian Ein Zeitim Fm (MFS K180;71.7-67 Ma); Upper Cretaceous Ein Zeitim Fm/Campanian Mishash Fm (78.3-72.1 Ma); Upper Cretaceous overlying the Mishash Chert (MFS K170;79 Ma); Upper Cretaceous Turonian Daliyya Fm (MFS K140;93 Ma); Lower Cretaceous Aptian at the base of the Yavne Fm (MFS K80;116 Ma); Lower Cretaceous Barremian Gevar'am Fm (MFS K50;125 Ma); Lower Cretaceous Valanginian Gevar'am Fm (MFS K30;136 Ma); Upper Jurassic Tithonian Yam-Ashkelon Fm (MFS J110;145 Ma); Middle to lower Upper Jurassic Callovian to Oxfordian Kidod Fm (MFS J40;161 Ma); Middle Jurassic Bajocian-Bathonian Barnea Fm (MFS J30;168 Ma).





## **The interaction of slab-derived silicic fluid and harzburgite - metasomatism in the sub cratonic lithospheric mantle**

האינטרקציה של נוזלים סיליציים מהלוח הנוחת להרצבורגיט - מטסומטיזם של הליתוספירה הסאב קרטונית

Meltzer A.,(1) Kessel R. (1)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of Jerusalem, 9190401, Israel

[amit.meltzer@mail.huji.ac.il](mailto:amit.meltzer@mail.huji.ac.il)

Understanding the interaction between fluids and the depleted peridotite is essential in deciphering the geochemical and mineralogical variability of the sub-continental lithospheric mantle (SCLM). High-density fluid (HDF) inclusions trapped in diamonds during their formation in the SCLM are potential metasomatic agents. In this study, experiments were performed on a harzburgite+silicic fluid system at an 80:20 rock:fluid ratio (bulk 5 wt% H<sub>2</sub>O and 3 wt% CO<sub>2</sub>), simulating the infiltration of a slab-derived silicic fluid into the SCLM. Experiments were performed at 3-6 GPa and 900-1200°C on a rocking multi-anvil apparatus, conditions corresponding to the deep SCLM. The fluid and melt compositions were directly determined using the cryogenic LA-ICP-MS technique. The metasomatized peridotite consisted of olivine, clinopyroxene, phlogopite, orthopyroxene, amphibole, and magnesite. The H<sub>2</sub>O-CO<sub>2</sub>-saturated solidus in this system is located between 900-1000°C at 3 GPa and between 1000-1100°C at 4-6 GPa. The fluids at all pressures are alkali-rich. With increasing temperature and crossing the solidus, the melts evolve towards the initial silicic fluid composition. Together with previous studies on various peridotite+H<sub>2</sub>O±CO<sub>2</sub> systems, the results presented here suggest a positive correlation between the bulk alkali/volatile ratio and the solidus temperatures. An increase in this parameter and in the mantle fertility (i.e., Ca#) increases the near-solidus isobaric melt production rate. The experimental fluid compositions found in this study are similar to saline HDFs. We propose a scenario where the percolation of a slab-derived silicic fluid into the depleted cratonic peridotite leads to the formation of near-solidus saline fluids. Such sequence of metasomatic events was reported from fluid inclusions in diamonds from several localities in the Kaapvaal craton in South Africa (e.g., De Beers, Finsch, Voorspoed).

## **LATE MESSINIAN SUBMARINE CHANNEL SYSTEMS IN THE LEVANT BASIN: CHALLENGING A DESICCATION MODEL**

### **Messinian Salinity Crisis**

Moneron J. (1), Gvirtzman, Z. (1,2)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz st. Jerusalem 9692100

2. Institute of Earth Sciences, Hebrew University, Jerusalem 9190401, Israel

[jimmymoneron@gmail.com](mailto:jimmymoneron@gmail.com)

The question whether or not the Mediterranean Sea desiccated during the Messinian salinity crisis is strongly debated for more than 50 years. In the Levant Basin, the desiccation supporters argue that salt truncation - and its subsequent burial by a latest Messinian clastic-rich evaporitic unit - occurred subaerially on a desiccated seafloor. However, here we show that this latest Messinian unit contains a dense net of channels with meanders, levees, and overspill deposits, very similar to the turbidite channels observed today on the deep seafloor. Furthermore, the aggradation characteristics of these buried channels (levee height, channel depth, and channel-floodplain coupling), indicate a deep water origin rather than fluvial. Our conclusion adds up to a previous study which interprets that both salt truncation (dissolution) and burial occurred in deep waters. In a wider perspective, we suggest that the flush of clastics into the basin during the last stage of the MSC, indicates a combination of wet climate and sea level rise; as importantly, this also means that sea level rise probably occurred earlier than previously thought (i.e., latest Messinian and not earliest Pliocene).

## The onset of faulting around geometrically irregular faults

שבירה ראשונית בקרבת העתקים בעלי גיאומטריה אי-רגולרית

Morad D. (1, 2), Lyakhovsky V. (1), Hatzor Y. H. (2) Sagy A. (1)

1. Geological Survey of Israel, Yesha'yahu Leibowitz 32, Jerusalem 9692100, Israel

2. Dept. of Earth and Environmental Sciences, Ben-Gurion University of the Negev, Beer-Sheva 84105, Israel

[moradd@post.bgu.ac.il](mailto:moradd@post.bgu.ac.il)

Geological and geophysical observations indicate that fault geometry is nonplanar, and includes irregularities in all directions at many scales. The geometrical heterogeneity of faults is particularly critical during the interseismic stage of the earthquake cycle because it perturbs the stress field and thus affects the rupture nucleation along the fault zone and around it. We present a new analytical solution for the static stress field around a rough interlocked interface obtained under compressional stresses, and discuss its applications to faulting and seismic hazards. The model outputs are the local stress field and the Failure-Ratio, defined here as the susceptibility to failure of the bulk material around the interface. The calculation sequence is as follows: First, the interface geometry is represented by a Fourier series. Then, the stress components around the irregular interface are calculated analytically using perturbation theory for a two dimensional far-field stress tensor. Finally, the Failure-Ratio at any location near the interface is estimated by adopting a Coulomb failure criterion for the bulk material. The model results can be applied to faulting mechanics because they demonstrate how the elastic stress field around rough faults is controlled by the geometry and by the tectonic stresses. We find that under a given tectonic stress state, stress heterogeneity increases with roughness. Therefore, some zones near rough faults are expected to yield at lower tectonic shear stress comparing to zones nearby smooth ones. However, the magnitudes of these events are expected to be relatively small, as they nucleate under relatively low tectonic stresses and fail as they propagate immediately to a stress shadow. This stress distribution promotes small seismic events near rough faults and therefore we suggest that increasing heterogeneity of the surface, contributes to increasing of the b-value in Gutenberg-Richter earthquakes distribution. We compare the model predictions with results of experiments performed on rough rock surfaces and find good agreement between the locations of off-fault deformation zones and the calculated high Failure-Ratio values. We further test the model implications for stresses and failure around a natural fault system – the San Andreas Fault and find a first-order agreement between Failure-Ratio values and earthquake distribution around this fault system. We conclude that the proposed analytical approach is a useful and practical tool for evaluating the contribution of fault geometry to the seismic hazard potential around it.

## Critical roughness controls sliding instability of laboratory earthquakes

נספוס קריטי שולט על החלקה בלתי יציבה בניסויי רעידות אדמה במעבדה

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

1. Dept. of Earth and Environmental Sciences, Ben-Gurion University of the Negev, Beer-Sheva 84105, Israel

2. Geological Survey of Israel, Yesha'yahu Leibowitz 32, Jerusalem 9692100, Israel

[moradd@post.bgu.ac.il](mailto:moradd@post.bgu.ac.il)

The frictional strength of discontinuities in the upper earth crust controls the stability and dynamics of slip in diverse catastrophic phenomena such as earthquakes and landslides. Natural rock surfaces are rough at various scales with significant variability that affects their frictional behavior. Seismological and geophysical observations of large thrust faults suggest that fault geometry affects earthquake characteristics, yet the exact effects are currently being debated. In this study we show, using laboratory direct shear experiments, that a specific surface geometry enhances sliding instability and that the transition from stable to unstable sliding is non-linearly controlled by the magnitude of the initial roughness. In order to isolate the effect of roughness, we generate six levels of surface roughness in split prisms of Diabase rocks, with four orders of RMS magnitude difference between the smoothest and the roughest samples. The experiments are performed under an imposed constant normal stress of 5 MPa and load point (shear piston) velocity of 0.01 mm/s. The sliding target is typically set to 10 - 13 mm as monitored from two horizontal LVDT's that are attached to the shear box very close to the tested interface. We show that the amplitude of the stick-slip events diminishes towards the two roughness extremes. The roughest sample (RMS = 1300  $\mu\text{m}$ ) exhibits gradual increase of shear stress to a peak value of  $\sim 13$  MPa, followed by brittle fracture expressed by a large stress drop of 3 MPa and then by transition to a relatively stable sliding. For the midrange roughness (RMS = 7  $\mu\text{m}$ ), stick-slip oscillations are obtained with different levels of stress drops and sliding dynamics characteristics. The smooth sample (RMS = 0.85  $\mu\text{m}$ ) slides in a relatively stable manner while the smoothest surface (RMS = 0.7) exhibits local peak friction of 0.18, followed by stable sliding with moderate slip hardening. We further demonstrate, both experimentally and numerically that stick-slip oscillations, commonly referred to as laboratory earthquakes, are constrained to a very limited range of surfaces roughness within which a specific level, defined here as the critical roughness, triggers the highest amplitude of oscillations. We therefore suggest that the roughness amplitude strongly affects the frictional stability and slip dynamics of natural faults.

## **Coastal sand transport and sorting dynamics within the Nile littoral cell: Insights from heavy mineral assemblages**

הובלה ומיון של סדימנט חולי לאורך התא הליטורלי של הנילוס: תובנות ממאספי מינרלים כבדים

Morag N. (1), Crouvi O. (1), Katz O. (1), Mushkin A. (1)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

[navotm@gsi.gov.il](mailto:navotm@gsi.gov.il)

This study uses heavy mineral assemblages to examine wave-induced sediment sorting and transport dynamics along the Israeli Mediterranean coastline, which forms the northern-most extension of the Nile littoral cell. Heavy mineral (HM) concentrations in beach sand were measured biannually, winter and summer, at 21 beaches along the entire coastline of Israel. In Neurim beach, repeated sampling at 3-6 month intervals was carried out over the course of three years. HM concentrations were relatively low and ranged between <0.1 and 4.6 wt. %, with values >2 wt. % being very rare. HM assemblages consisted of mostly pyroxene, amphibole and epidote (>80 wt. %). Additional phases, including ilmenite, zircon, rutile, tourmaline, Fe-oxides, sphene, aluminosilicates, apatite, garnet, Cr-spinel, and staurolite, comprise the remaining ~20 wt. %. HM concentrations at the waterline correlates with the average significant wave height recorded during the day before sampling and inversely correlates with the maximal significant wave height recorded during the month before sampling. These relationships reflect 1) increased sorting and preferential accumulation of HM in the beach swash zone during the summer, when the daily average significant wave height is higher, and 2) mixing of the sand over the entire beach and dispersal of HM during the strong winter storms. The relatively low concentrations of HM found in the Israeli coastal sand differ from the relatively high concentrations reported for most of the Nile Delta beaches, reflecting the importance of transport-induced sorting along the Nile littoral cell. Nevertheless, the composition of HM in beach sands throughout the Nile littoral cell is rather constant, indicating no other significant contribution to the Israeli coastal sand, except for the reworking of older, aeolian Nilotic-origin sediments.

## Coastal reef lithostratigraphy as a geoarchaeological tool - Tel Dor, Israel as a case study

הרצף הגיאולוגי של מסלעים חופיים ככלי גיאוארכיאולוגי - תל דור, ישראל כמקרה בוחן

Nachum O.(1), Basson U. (1,2), Yasur-Landau A. (3,4), Levy T. (4,5), Lazar M. (1)

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

2. GeoSense Ltd., Netanya, Israel

3.Leon Recanati Institute for Maritime Studies University of Haifa, Mount Carmel, Haifa 3498838, Israel

4. Department of Anthropology, University of California, San Diego, California, USA

5. Levant and Cyber-Archaeology Laboratory, Scripps Center for Marine Archaeology, University of California, San Diego, California, USA

[omryna@gmail.com](mailto:omryna@gmail.com)

This study aims to analyze anthropogenic influence on the lithification of beachrock in the southeastern Mediterranean. Tel Dor, along Israel's northern coast, was chosen due to man's continuing presence in the area for over 4000 years and the protective environment of its natural bays, which have the potential to preserve geomorphological changes to the landscape. These factors result in a geological sequence on site that could hold important information regarding the areas history, as well as uncovering clues as to how people affect their (geological) environment. To examine this sequence, three abrasion platforms were chosen in the shallow waters of the Southern bay adjacent to the Tel, from which four cores were extracted. Results show the extent of the direct and in-direct anthropological influences on the landscape. The presence of building stones consisting of dolomite, which is not found along the Carmel coast but further inland, is an example of direct influence on the landscape. The evolution of the biological and non-biological reef upon the sturdy base of the port constructions is an indirect influence. The formation of a non-biological reef upon an archaeological feature is a unique process. Such a reef would not have consolidated were it not for anthropogenic activity in the area. Were it not for the usage of the natural bays in the Tel as a port, and its inventive extension to increase trade, it is highly unlikely that we would observe such intricate geological sequences. These exhibit a timeline of habituation and abandoning of the port facilities, from which one can extract conclusions regarding ancient Dor's political and financial affairs and the changing sea levels.

## **Plastic in the deep: annotated ROV video of Eastern Mediterranean sea floor Pollution**

Olawuyi G. (1), Kalman A. (1), Lazar M. (1), Makovsky Y.(1), Goodman B. (1)

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

rtmabasuniverse@yahoo.com

Materials manufactured as plastics, have been introduced into our environment since first being produced nearly seventy years ago. Plastic is a very useful material in many applications due to its low production cost, hygienic properties, durability and longevity. However, these same properties have resulted in great volumes of refuse that does not biodegrade rapidly and can release harmful toxins into their surroundings, and cannot be efficiently recycled. While efforts are made to contain plastic waste, much of it has been disposed of into the marine realm, either deliberately or as runoff from rivers and the coastline. According to the recent IUCN report, 80% of marine debris is composed of plastic, and 14 million tons of plastic enter the ocean annually. These numbers are impressive and concerning, but do not provide a sense of how these plastics are distributed and transported once they enter the sea; important information for any mitigation efforts or assessment of the efficacy of policy changes. In this study, plastics in shallow to deep sea offshore of Israel recorded during the ROV campaigns of Nautilus 2010, Nautilus 2011, SEMSEEPS 2016, and CSMS 2017 were annotated and georeferenced to available bathymetric data. Transmitted information and video annotations from remotely operated vehicle (ROV) were integrated. Identifiable objects were categorized by type (e.g. bottles, bags, fishing nets, chairs, etc.) and concentration of objects (single, scattered, concentrated 'dump') was quantified. Here, we present the preliminary findings from 73.8 km of ROV footage, with over 100 hours of ROV dive footage, its distribution and association to bathymetric features. This research indicates multiple sources of plastics (and some non-plastics) materials and how their deposition is related to sea floor morphology, prevailing sea currents, and initial introduction to the ocean (continental, mid-ocean, etc.).



## **Impact of Surface Waves over Growth Mechanism of Methane (CH<sub>4</sub>) Bubble in Muddy Aquatic Sediments: Effects of Wave Amplitude, Period and Water Depth**

השפעת גלי פני השטח על מנגנון הצמיחה של בועת מתאן (CH<sub>4</sub>) במשקעים מימיים בוציים: השפעות של משרעת גל, זמן מחזור, ועומק מים

Painuly A. (1), Katsman R. (1)

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

rkatsman@univ.haifa.ac.il

Methane (CH<sub>4</sub>) transport from organic-rich fine-grained shallow aquatic (muddy) sediments to water column is mediated dominantly by discrete bubbles, which is an important natural source of greenhouse CH<sub>4</sub>. The lifespan of CH<sub>4</sub> bubbles within sediment constitutes two successive stages: growth from nucleation up to mature size, and its buoyant ascent towards sediment - water interface. Bubbles often experience oscillating overburden load due to passage of winds/storm induced short period surface waves or long period tides, which can potentially affect both stages of bubble's lifespan. However, little is known about the wave effects over bubble growth phase. In present work this subject is investigated using a numerical single-bubble mechanical/reaction-transport model. The effects of different parameters of the wave loading (amplitude and period) and of the water depth, over the bubble growth pattern, are quantified. It is found that bubbles induce early sediment fracturing in presence of waves, attributed to low overburden load appearing at wave troughs. Bubbles in shallow depth rapidly grow at wave troughs by inducing multiple intense fracturing events, however, this ability decrease with an increasing water depth (because of a slower solute influx). In presence of waves, bubbles mature in lesser time, whose contrast from the no wave case is controlled by the ratio of wave amplitude to equilibrium water depth. Due to higher frequency of occurrence of wave troughs for shorter-period waves, they accelerate the bubble growth more compared to the long-period waves. Overall, conducted modelling suggests that fastest bubble growth can be predicted under higher amplitude short period waves travelling in shallow water. We further infer that accelerated bubble growth, along with subsequent wave-induced ascent can sufficiently shorten the bubble's total lifespan in sediment, which explains the observed episodic in-situ ebullitions correlated with wind-or storm-induced waves.

## Sahara dust fluxes over the last 20 kyrs record the limits of the African Humid Period “green Sahara”

שטפי אבק מאפריקה ב 20 אלף שנים האחרונות מגדירים את גבולות הסהרה הירוקה

Palchan D. (1,2,3), Torfstein A. (1,2)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel

2. Interuniversity Institute for Marine Sciences, Eilat 88103, Israel

3. Civil Engineering department, Ariel University, Ariel,

[Israeldanielp@ariel.ac.il](mailto:Israeldanielp@ariel.ac.il)

The Sahara Desert was exposed to significantly wetter conditions, relative to present, between the early to mid-Holocene (~11-5 ka) during a period known as the African Humid Period (AHP). An increase in Northern Hemisphere summer insolation drove the intensification and expansion of the Africa monsoon rains up the currently hyper-arid Sahara Desert. Combined with a subsequent expansion of vegetation cover, regional dust uptake was significantly suppressed, with potential global-scale impacts through a change in the albedo, cloud properties, and ocean and land dust fertilization. Yet, most of the relevant terrestrial records across the Sahara cover a limited time span, with contentious chronologic controls. Continuous, well-dated sediment records of the AHP are limited to the marine records from the sub-equatorial Atlantic Ocean and tropical Lake Bosumtwi to the west, the Gulf of Aden to the east and the Mediterranean Sea, mainly in front of the Nile Delta to the north. Here, we present new records of  $^{230}\text{Th}$ -normalized terrigenous dust accumulation rates over the last 20 kyrs in marine sediment cores across the Red Sea – Gulf of Aden meridional transect, covering the entire eastern margins of the Sahara Desert. We combine the dust accumulation rates with additional records to establish a robust framework for the geographic span of the AHP. We show that dust fluxes from the Sahara to the Red Sea declined by ~50% during the AHP only between 12°N and 19°N, over a narrower corridor than previously thought, while dust fluxes to the northern sector of the Red Sea (north of ~25°N) remained unchanged throughout the Holocene. These results coincide with evidence from the Atlantic Ocean where dust deposition dropped by ~80% across a well constrained corridor (~21-28°N). The results provide the first quantitative record of dust accumulation rates in the Red Sea and the Gulf of Aden over the past 20 kyrs, and constrain the geographic extent of the AHP hydrological impact.

## **The influence of climate on the paleolake record from southern Yemen during late Holocene: Evidence from ostracod assemblages and n-alkane abundance**

השפעת האקלים על תיעוד הפליאולה מדורם תימן במהלך ההולוקן המאוחרת: עדויות ממכלולי אוסטרקודים ושפע- אלקנים

Parth S. (1), Yadav A. (2), Mazzini I. (3), Waldmann N. (1)

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

2. Department of Earth and Environmental Sciences, Indian Institute of Science Education and Research Mohali, Mohali, India

3. Consiglio Nazionale delle Ricerche, IGAG, Area della Ricerca di Roma 1 - Montelibretti, Via Salaria km 29,300, 00015 Monterotondo (Rome), Italy

[pds.shah121@gmail.com](mailto:pds.shah121@gmail.com)

Sedimentary record from paleolake Gayal el Bazal provides a long, continuous, and high-resolution dataset inhibiting a broader understanding of environmental and climatic changes dating back to the last ca 1200 years. The previous studies of sediment lithology geochemistry and sedimentology from this site shows fluctuation in the precipitation regime during Medieval Climate Anomaly (MCA) and Little Ice Age (LIA). However, there remains an unanswered questions regarding specific details on monsoon dynamics that influence the hydroclimatic conditons in the region. This study can provide better insight to identify moisture sources and delineate possible hydrological variabilities linked with changes in the Indian summer monsoon systems. A multiproxy approach including sedimentary n-alkanes, isotopes and Ostracod assemblage is presented on a 3.3 m composite core retrieved from the paleolake. The climate reconstruction based on n-alkanes indices (Paq, TAR) suggests increased aquatic productivity (C21-C23) during MCA, due to the increased input of nutrients to the lake, indicating wet conditions. Additionally, compound-specific isotopes carried out on n-alkanes will provide information on regional humidity and moisture seasonality. Furthermore, ostracods assemblage data also revealed that the abundance of *Paracyprretta amati* (swimmer species) increases during the MCA and decreases during the LIA. Overall, this study will help us understand the role of the Intertropical Convergence Zone (ITCZ) vis-à-vis monsoonal dynamics in the region and help us develop long-term strategies for the seasonal prediction in the region area.

## **The Utility of Erosional Geomorphological Markers in Soft Substrates in Sea-Level Research: A Case Study from Israel's Mediterranean Coast**

השימוש בתוואים גאומורפיים בסלעים רכים כציינים למפלס ים: מקרה בוחן מחוף הים התיכון של ישראל

Pietraszek A.V. (1), Katz O. (2), Goodman-Tchernov B. (1)

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

2. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

avpietraszek@gmail.com

Due to the growing threat of coastal inundation with rising sea-levels, many are turning to studies of past sea-levels to predict future changes. A suite of sea level markers (biological, geological, archaeological, geochemical) are used for these reconstructions; tidal notches and marine potholes being amongst them. These erosional sea-level indicators have been identified worldwide; primarily in harder substrates such as granite, and are less frequently reported in softer substrates like aeolianite. These more friable substrates are advantageous because sea-level markers can be created more rapidly, but the disadvantage is that they can similarly be more easily erased from the landscape unless they are quickly buried or otherwise removed from direct exposure (e.g. rapid submergence). However, it is possible that the process of destruction in itself may have its own indicative morphological characteristics and signature, as was theorized in Goodman and Katz 2016 as 'cantilever boulders'. Also, the initiation of these features could be visible along shorelines undergoing coastal retreat. To this end, field observations were made (walking survey, scuba, snorkel, coastal droning) along Israel's Mediterranean coast considering both new sites and others already reporting these features. Preliminary results from these surveys suggest that it is possible to distinguish between more and less recently developed features, with a record of each step in the formation processes of notches and potholes preserved across the depth range. These results attest to the potential of erosional geomorphological markers in soft substrates in sea-level studies, especially as the need for more refined records of sea-level change increases.

## Luminescence chronology of alluvial terraces in the Negev

כרונולוגיה של טרסות נחלים בנגב -

תיארוך בשיטות הלומינסנציה

Porat N. (1), Avni A. (1), Weiler N. (2), Cohen-Sasson E. (3), Oron M. (2,4) Barzilai O. (2)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

2. Archaeological Research Department, POB 586, Jerusalem 91004, Israeli Antiquities Authority

3. Department of Bible, Archaeology and the Ancient Near East, Ben-Gurion University of the Negev, 84105 Beer-Sheva, Israel

4. Institute of Archaeology, The Hebrew University of Jerusalem, Mt. Scopus, 91905 Jerusalem, Israel

[naomi.porat@gsi.gov.il](mailto:naomi.porat@gsi.gov.il)

Abandoned alluvial terraces characterize all large ephemeral streams in the Negev. These stand 5-50 m above active stream channel and are evidence for past flow levels. They are distinguished by different elevations, amount and type of surface desert pavements and reg soil profiles, which vary according to their antiquity. Detailed mapping of the terraces assigned them to three major episodes of accumulation, separated by abandonment and events of fluvial entrenchment; these were labelled Surfaces Q1-Q3. To obtain their chronology, sediment samples for luminescence dating were collected from nine different streams, from the base of the terraces (accumulation) and their tops (abandonment). Sand-size quartz and alkali feldspars were separated from the samples and their depositional ages measured using a variety of luminescence signals and protocols. A compilation of ages from throughout the Negev show that terraces designated to Surface Q1 began depositing at least 350 ka and were abandoned before 200 ka. The age of Surface Q2 is bracketed between 160 ka and 90 ka, and might be divided into two episodes of terrace deposition. The bases of Q3 terraces were dated to 75-50 ka and their tops to 20-10 ka. The ages of the surfaces accord with the prehistoric artefacts found at their top: Q1 is associated with Lower Palaeolithic finds; Q2 with the Middle Palaeolithic and Q3 with late Middle Palaeolithic and Upper Palaeolithic sites. The ages indicate that the timing of surface accumulation and abandonment does not necessarily corresponds to particular climatic conditions. Surface Q2 was deposited mostly during the last interglacial, Marine Isotopic Stage (MIS) 5, whereas Surface Q3 accumulated during glacial times, MIS 4-2. The transition between the downcutting of Surface Q2 and the beginning of accumulation of Surface Q3 was rapid and corresponds to the transition between MIS 5 and MIS 4.

## **Feedback between divide-migration and waterfall retreat along cliffs: A conceptual model and field examples from Ovil Cliffs**

היזון חוזר (פידבק) בין נדידת קווי פרשות מים ומפלים לאורך קווי מצוק: מודל קונספטואלי ודוגמאות מצוקי אוביל

Porat O. (1), Goren L. (1), Shelef, E. (2), Qu, T. (2)

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

2. Department of Geology and Environmental Science, University of Pittsburgh, Pittsburgh, PA 15260, USA

[omripo@post.bgu.ac.il](mailto:omripo@post.bgu.ac.il)

Drainage divides and waterfalls are dynamic features of the landscape. Divide migration is widely considered as the outcome of slope and erosion imbalance across the divide, and the retreat rate of vertical waterfalls (knickpoints) is commonly modeled as a function of the upstream drainage area. In locations where channels flow across cliff lines and the divide does not coincide with the cliff, a feedback may arise that connects divide migration and waterfall retreat as part of a continued process of localized cliff retreat and embayment. When a waterfall retreats along an approximately horizontal geologic contact, it causes an increase in the average slope of the channel draining from the divide to the waterfall, leading to a greater asymmetry across the divide. This asymmetry, in turn, may lead to divide migration away from the waterfall, increasing the area draining to the waterfall and allowing it to continue to retreat and embay the cliff. The Ovil Cliffs, located in the southern Negev Desert, exhibit a wide geometric variety of divide-waterfall pairs, making the cliffs an exceptional natural laboratory for exploring the hypothesized divide-waterfall feedback. Using regional Digital Elevation Model (DEM), drone-derived high-resolution DEM, along-channel DGPS profiles and field mapping of lithologic contacts we quantify the meso-scale topography of the divide-waterfall pairs and their relations with the cliff line. Our preliminary results show that: (1) Slope asymmetry and c (Chi) difference across divides are consistent and indicate that all the divides we studied could achieve a more stable position upon further migrating away from the waterfall; (2) The asymmetry of the hillslopes bounding the divide is typically lower compared to the asymmetry of the channel sections; (3) Lower antecedent valley slope and greater waterfall drainage area likely control the extent of cliff embayment and consequently, the overall distance of divide and waterfall migration.

## Vertebrate paleontology in Israel – past, present and future

פליאונטולוגיה של חולייתנים – עבר, הווה ועתיד

Rabinovich R. (1)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel

[rivkar@mail.huji.ac.il](mailto:rivkar@mail.huji.ac.il)

Quite often fossils found during a course of a trip are considered differently to these collected during a targeted field trip. Should we treat the same biological remains differently? Moreover, what is the importance of education in preventing the disappearance of key fossils in amateur collections? On the other hand, should we encourage collection activity while cooperating with known amateur collectors? Should we open the practices applied in popular science, practices which engage the public in the social media, to monitor certain fossils of interest? In general, what should the role of the public be in particular in paleontological research? What are the constraints and what role does the scientist play in outreach and in spreading knowledge? I will further examine, how had the history of paleontology research in general, and vertebrate paleontology in particular, influenced the field in Israel? New localities are reported and when possible, they are surveyed and mapped, and fragile fossils are then collected. Several examples, from Cretaceous vertebrates to Pliocene giant tortoises, will be discussed in light of their significance to the local and regional research. What is the preferable attitude dealing with large quantities of unknown fossils awaiting study? Re-evaluation of the major rules/constraints should be done, in the interest of the entire geological community and the public.

## Saturated Granular Landslides: Insights from Grain-Scale Simulations

גלישות קרקע גרגריות רוויות: תובנות ממודל בקנה מידה של גרגר

Ratzabi Z. (1), Goren L. (1)

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

[zoharka@post.bgu.ac.il](mailto:zoharka@post.bgu.ac.il)

Landslides are a severe natural hazard that causes massive destruction and a high death toll. One of the major triggers for landslides is water level rise, due, for example to heavy rainfall. A critical parameter that was shown to control the stability and dynamics of saturated landslides is the initial porosity. When the initial porosity is low the soil tends to dilate, which causes pore-pressure reduction and shear resistance increase, leading to an arrested motion. For an initially high porosity, the effect reverses and accelerating catastrophic motion develops. When considering the downslope motion of saturated granular layers, many details regarding the coupling between sliding kinematics and the pore-pressure evolution remain poorly constrained. Specifically, if the internal deformation of the granular layer produces spatially heterogeneous porosity changes, then fluid flow from compactive to dilative zones may compensate for the pore-pressure sensitivity to pore space changes and alter sliding initiation and evolution. This effect may be more acute for high internal permeability, when the pore-pressure diffuses relatively rapidly within the sliding mass. In the current study, we explore the coupled interactions between the grain skeleton deformation, the evolution of the interstitial pore-pressure, and the stability and kinematics of fully saturated, cohesionless granular layers on a slope. Our approach consists of a fully coupled granular and fluid model that combines discrete element method for the grains and an Eulerian solver for the pore-pressure. We study dilative well-drained systems, where the pore-pressure diffusion time scale is significantly smaller than the deformation time scale. Our preliminary results show that despite the overall dilative trend, the porosity fluctuates in space and time between dilation and compaction, generating episodes of high pore-pressure and allowing for a dilative slide to accelerate and achieve relatively high sliding velocities.



## **Last Glacial Maximum to Holocene Aeolian-Fluvial palaeoarchives along the northwestern Negev dunefield margins (Israel)**

ארכיון פליאו-סביבתי המשקף תהליכים איאולים-פלוביאליים החל משיא תקופת הקרח האחרונה עד להולוקן, בשולי שדה-הדיונות

Robins L. (1,2), Roskin J. (1,3), Bookman R. (4), Yu L. (5), Greenbaum N. (2)

1. Geomorphology and Portable Luminescence Laboratory Leon Recanati Institute for Maritime Studies, U. of Haifa, Abba Hushi Ave., 199, Mt. Carmel, Haifa 3498838, Israel
2. Department of Geography and Environmental Studies, University of Haifa, Mount Carmel, Haifa, Israel
3. Department of Geography and Environment, Bar Ilan University, Ramat-Gan, Israel
4. Dr. Strauss Department of Marine Geosciences, Charney School of Marine Sciences, University of Haifa, Mount Carmel, Haifa, Israel
5. Luminescence Laboratory, School of Resources and Environmental Sciences, Linyi University, Linyi, China

[lotem.robins@oranim.ac.il](mailto:lotem.robins@oranim.ac.il)

Aeolian-Fluvial (A-F) processes serve as major factors in landscape evolution along dunefield margins. A-F research examines the bilateral impact of aeolian and fluvial systems. However, depositional mechanisms of A-F processes are not fully understood. A 120 m long and 7 m high wadi bank exposure of an A-F sequence along Nahal Atadim, at the margins of the northwestern Negev (Israel) desert dunefield was chrono-stratigraphically analyzed. This included sedimentological and geochemical analyses and a range of dating approaches using relative and absolute luminescence dating (POSL & OSL), radiocarbon and archaeology. The A-F sequence reveals four depositional cycles of aeolian sand units that partly confine low-energy fluvial deposits. The sand and dune units represent aeolian sand incursions into the fluvial system since the Last Glacial Maximum (LGM) until the mid-Holocene, whereas the low-energy fluvial deposits, resulted from full and partial dune-damming of the palaeo Atadim basin by these incursions. The sedimentary structures include: (a) event-based couplets – deposited in an ever-emptying waterbody, impounded by a dune-dam; (b) massive fine-grained beds – evidence of deposition of suspended sediments in a seasonal impounded waterbody, near the damming-dune where the waterbody is the deepest; and (c) fining-upwards deposits – deposited in low-energy fluvial environment, by partial/full damming or interdune ponding nearby the fluvial system. The chrono-stratigraphy of this study section reflects a major regional climatic shift and presents A-F sequences as exceptional palaeo-archives. In the Late-Pleistocene, dune-damming build-up and stabilization affected the fluvial systems. Three major sand incursions into the fluvial system of the Atadim during the LGM, Heinrich-1 and Younger-Dryas resulted in localized seasonal waterbodies, known to be utilized by Epipalaeolithic hunter-gatherers. During the Early-Holocene a climatic shift, which also left a signature in the Mediterranean Basin as Sapropel-1, resulted with high discharge

flows recorded in the final aggregation of event-based couplets along vast areas of the dunefield margins.

## **Solute migration through partially saturated fractured chalk under different flow modes**

הסעת מומסים בקירטון סדוק תחת תנאי תת-רוויה ומצבי זרימה שונים

Roded S. (1), Klein-BenDavid O. (2,3), Turkeltaub T. (1), Weisbrod N. (1)

1. Zuckerberg Institute for Water Research, Ben Gurion University of the Negev, Sde Boker, 84990, Israel.

2. Nuclear Research Center of the Negev, Negev, P.O. Box 9001, Beersheva, 8419001, Israel.

3. Geological and Environmental Science Department, Ben Gurion University of the Negev, Beersheva, 8410501, Israel

[sariroded@gmail.com](mailto:sariroded@gmail.com)

Spent fuel (SF) produced in the nuclear industry, requires long-term disposal solutions for at least ten thousand years, to allow its decay in an isolated setting as means to reduce the environmental threat of radioactive contamination. The feasibility of locating a SF repository within a fractured carbonate formation as the host rock in the unsaturated zone requires better understating of radionuclide transport patterns under these specific conditions. An innovative system was developed to simulate conditions of unsaturated flow and transport in fractured chalk. The system consists of an artificially fractured chalk core, situated in a flow cell, which lays on top of a ceramic membrane. The membrane separates it from a lower sealed cell where constant negative pressure is forced. Subsequently, a pressure gradient along the rock core is being developed. The system is placed on a scale to monitor the degree of saturation in the core throughout the experiment. Uranine fluorescent dye is used as a conservative tracer to investigate the impact of (1) the initial degree of saturation and (2) the fracture aperture on the transport and recovery of conservative contaminants. Transport is examined in 1-mm and 5-mm wide fractures, where the development of different aperture-dependent flow modes may cause differences in transport patterns. These results will be used for comparison with radionuclide and radionuclide-simulants transport in current studies.

## Radionuclide transport through fractured chalk under abrupt variations in ionic strength

השפעת שינויי מליחות על דפוסי ההסעה של רדיונוקליאידים בקירטון סדוק

Roded, S. (1), Klein-BenDavid O. (2,3), Turkeltaub T. (1), Tran E.L. (1), Geller Y. (1), Garara Y. (1), Deutsch N. (4), Weisbrod N. (1)

1. Zuckerberg Institute for Water Research, Ben Gurion University of the Negev, Sde Boker, 84990, Israel.
2. Nuclear Research Center of the Negev, Negev, P.O. Box 9001, Beersheva, 8419001, Israel.
3. Department of Earth and Environmental Sciences, Ben Gurion University of the Negev, Beer Sheva 8410501, Israel.
4. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel.

[sariroded@gmail.com](mailto:sariroded@gmail.com)

Radionuclide migration through saturated fractured chalk was studied to predict potential risks to groundwater in the vicinity of nuclear repositories. The present study aimed to examine the effect of swift changes in matrix water composition on the mobility of radionuclides in fractured carbonate rocks. A tracer mixture, simulating radioactive contaminants related to spent fuel (SF), including U, Sr, Ce, and Re, was injected into a naturally fractured chalk rock in the laboratory. Two sets of experiments were carried out in which tracers were added to solutions of different ionic strength (IS) represented by total dissolved solids (TDS) values (Cl<sup>-</sup> and HCO<sub>3</sub><sup>-</sup> as major anions): (1) low IS artificial rainwater (TDS of ca. 102 mg/L); and (2) high IS artificial groundwater (TDS of ca. 104 mg/L), followed by the injection of a tracer-free solution at the same IS. Next, the opposite (low/high IS) tracer-free solution was introduced to induce salinity variation. Re breakthrough curves (BTCs) were unaffected by the change in BG solution and exhibited conservative behavior. Cerium was transported as intrinsic colloidal carbonate complexes and remained unaffected by the abrupt change in BG solution. Uranium and Strontium BTCs were influenced by the abrupt change in IS. Their recovery significantly increased when high IS solution was injected into the core and reduced when low IS solution was introduced, regardless of the injection order. This indicates that U and Sr sorption to fractured surfaces is reduced at high salinity, a phenomenon attributed to the replacement of Sr and U ions by Ca and Na at the adsorption sites at elevated IS conditions. The variable mobility of radionuclides found in this study should be considered in the design of natural and engineered barriers for SF disposal, especially in regions where seasonal rains or flooding may cause abrupt changes to groundwater ionic strength.

## Re-evaluation and regional outlook of Permian and Mesozoic source rocks offshore and onshore Israel

הערכה מרחבית של סלעי מקור מהחתיכים של הפרם והמזוזואיקון ביבשה ובמדף היבשת של ישראל

Funaro E. (1,2), Bar-Dayana D.(1,2), Meilijson A. (3), Ashckenazi-Polivoda S. (4), Sagy Y. (1), Reznik I. J.(1), Korngreen D. (1), Feinstein S. (2), Rosenberg Y. O. (1)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel
2. Department of Earth and Environmental Sciences, Ben Gurion University of the Negev, Beer Sheva 8410501, Israel
3. The Dr. Moses Strauss Department of Marine Geosciences, Leon H. Charney School of marine sciences. University of Haifa, Mt. Carmel, Haifa 31905, Israel
4. Dead Sea and Arava Science Center, Central Arava Branch, Hatzeva 86825, Israel

yoavr@gsi.gov.il

Source rocks (SR) are organic-rich sedimentary rocks and a prime component in petroleum systems. Here we present two studies of SRs evaluation in the Permian and Mesozoic strata onshore and offshore Israel. Organic matter (OM) richness, hydrocarbon generation potential, kerogen type and thermal maturation were assessed on rock cuttings using a Rock-Eval analyzer in 9 offshore wells (~ 560 samples) and 7 onshore wells (~770 samples). To extend the regional outlook, literature data was also compiled. Three intervals show regional OM richness onshore Israel: the Permian Wuchiapingian, the Triassic Carnian, and the Jurassic Toarcian. In all three intervals, an enrichment in OM content is observed in the northern Negev area. This might be controlled by the paleo-position of the northern Negev area during this extended time interval on the margins of the Tethyan stable shelf. Offshore Israel, the Jurassic period is organically lean and of low generation potential, despite oil shows found in the Jurassic strata. Organic richness in the lower Cretaceous section in the offshore reached good and even excellent levels. However, it kept low generation potential and resembled its inland and regional coeval strata of terrestrial OM. The depo-center of the high productivity upwelling system of the Santonian-Maastrichtian sequence peaked in central Israel and Jordan and extended to a great distance along a N-E/S-W trajectory. However, OM preservation declined sharply in the N-W/S-E direction, accompanied by changes in kerogen type. Hence, deposition of this SR in the present-day deep basin is suggested to be limited compared to its onshore appearance. Lastly, the increase in thermal maturation with depth is assessed and compared between the onshore and offshore sequences. In both sections, a moderate rise in thermal maturation is observed down to a depth of ~ 4km, where a steeper gradient follows at deeper depths.

## The effects of Ocean Acidification on the bioavailability of phosphorus in desert dust

השפעת החמצת האוקיאנוסים על זמינות ביולוגית של זרחן מאבק מדברי

Rudnitsky N. (1), Antler G. (1,2), Gross A. (3)

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

2. The Interuniversity Institute for Marine Sciences, Eilat 88103, Israel.

3. The Department of Geography and Environmental Development, Ben Gurion University of the Negev, Beer Sheva 8410501, Israel.

[naamarud@post.bgu.ac.il](mailto:naamarud@post.bgu.ac.il)

Atmospheric CO<sub>2</sub> levels are rising since the industrial revolution as a result of fossil fuels burning. a Quarter of the CO<sub>2</sub> is absorbed in the oceans and drives the process of ocean acidification, the ongoing decrease in the pH of the Earth's oceans. Man-made atmospheric CO<sub>2</sub> sequestered to the deep ocean via the biological pump -the mechanism by which carbon exported through biological processes from the surface to the deep ocean. The rate of the biological pump is often limited by the availability of macronutrient such as phosphorus (P), which controls primary production in many oceanic regions with low surface water P concentrations. Since P does not have a gaseous phase, Most of the P that enters the oceans is transported from the continent with desert dust storms. However, most of the dust-P is unavailable to phytoplanktonic organisms due to it poor solubility in seawater. In a series of lab experiments, we examined the effects of different pCO<sub>2</sub> levels on the P solubility of various desert dust types in seawater from the Gulf of Eilat, a highly oligotrophic ecosystem. Additionally, we examined the dust-water reaction mechanisms by using the main P phases in desert dust such as apatite, iron and clay minerals. We found that elevated pCO<sub>2</sub> levels as 600,700 and 1000 ppm increased dust-P solubility by up to 24%. This P is potentially bioavailable for primary production. Next, we plan to quantify the relationship between dust composition, CO<sub>2</sub> concentration and P solubility in seawater. We suggest that increasing atmospheric pCO<sub>2</sub>, which drives ocean acidification, can increase the solubility of dust-P that enters the ocean. This can boost ocean productivity and fuel the biological pump. This process expected to act as a negative feedback mechanism for the increase in atmospheric CO<sub>2</sub>.

## 234U enrichment in waters of carbonate terrains234U enrichment in waters of carbonate terrains

Saeed S. (1,2,3), Stein M. (2,3), Bookman R. (1), Lazar B. (2)

1. Department of Marine Geosciences, Charney School of Marine Studies, University of Haifa, Mt. Carmel, Haifa.

2. The Fredy and Nadine Hermann Institute of Earth Sciences, Hebrew University, Edmond J. Safra, Jerusalem.

3. Geological Survey of Israel, Givat Ram, Jerusalem.

[dalal\\_s3eed@yahoo.com](mailto:dalal_s3eed@yahoo.com)

We present a new 1-D transport-reaction steady-state model for the behavior of Sr and U isotopes (expressed by the  $^{87}\text{Sr}/^{86}\text{Sr}$  ratio and  $(^{234}\text{U}/^{238}\text{U})$  activity ratio) in groundwaters of saturated carbonate aquifers. The model equations are applied to the Sr and U in the waters of the Sataf and Dan springs that discharge the Upper Cretaceous Judea Mountains aquifer and the Jurassic limestones of Mount Hermon, respectively. The model considers weathering of calcite and a-recoil effects as well as the effect of calcite precipitation, enabling us to consider the net effect of water-rock interaction on the isotope systems. Since Sr isotopes are not affected by recoil the  $^{87}\text{Sr}/^{86}\text{Sr}$  ratios are used to evaluate the extent of water-rock interaction on the U isotopic system. Model runs using distribution coefficients of Sr and U, within their accepted ranges, show a rather small effect on the isotope systems when the distance of groundwater flow within the aquifer is  $<10$  km. Applying the model equations to the Sataf data suggests that the enrichment of the Sataf groundwater with  $^{234}\text{U}$  ( $^{234}\text{U}/^{238}\text{U}=1.3$ ) results mainly from a-recoil during the relatively short travel distance of the waters in the aquifer ( $\sim 2$  km). On the other hand, the high  $^{234}\text{U}/^{238}\text{U}$  ratio of 1.8 in the Dan spring water is consistent with the effects of water-rock interaction and weathering as the main process responsible for the observed  $^{234}\text{U}$  enrichment. The characteristic time for weathering as calculated by the model for Sr and U using the  $^{87}\text{Sr}/^{86}\text{Sr}$  and  $^{234}\text{U}/^{238}\text{U}$  data in the Dan spring is on the order of 1 My, suggesting that this is the time frame for reaching a steady state in the karstic system of Mt. Hermon.

## The Levant basin syn-rift evolution

השלבים המוקדמים של התפתחות אגן הלבנט

Sagy Y. (1), Gvirtzman Z. (1)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

2. Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of Jerusalem, Jerusalem, 9190401, Israel

[yaels@gsi.gov.il](mailto:yaels@gsi.gov.il)

The Levant basin is a remnant of the Tethys marginal basin and has preserved an exceptionally thick (>15 km) sedimentary section that records more than 250 Myr of tectonic and sedimentary history. Seismic reflection image the complete sedimentary column, but wells penetrates solely the uppermost < 6km section, hence constraining sediments age only for the last 35 Myr. The interpretation of the deeper section is controversial. One possibility to advance our knowledge about the early history of the basin is to differentiate the syn-rift section from the post-rift section. The conventional method of mapping faults and identifying displaced units is difficult, because these sedimentary sections are deeply buried at more than 10-12 km (>7 sec. TWT) where seismic resolution decreases and hamper the interpretation of syn-rift faults. In addition, the post-rift contractional deformation of the Alpine orogeny that affected the Eastern Mediterranean further challenge the identification of these faults. Here we adopt a different approach; we distinguish the transition from syn-rift to post-rift section by focusing on abrupt versus gradual thickness variation. By applying a low pass post-stack filtering on 2D seismic reflection surveys covering the Israeli economic water, we improved the imaging of the deeper reflectors and enabled the distinction of the deep units, which otherwise appeared blurred at conventional industry processed data. This improved data set enabled us to 1) map the syn-rift / post-rift transition in the deep basin and tie it to an horizon penetrated in the shelf area and dated as nearly Callovian (163.5 Ma), 2) perform a basin wide interpretation of reflectors within the syn-rift section. We further present isopach maps documenting the Levant basin's depocenter evolution during its syn-rift and post rift phases. Our results are consistent with data derived from onshore wells dating the end of the rifting within the Middle Jurassic.



## High-quality revision of the Israeli seismic bulletin

ניתוח איכותי מחודש של הבולטין הסיסמי של ישראל

Schardong L. (1,2), Ben Horin Y. (3), Ziv A. (1), Myers S. (4), Wust-Bloch H. (1), Radzyner Y. (3)

1. The Department of Geosciences, Tel-Aviv University, Tel-Aviv 69978, Israel
2. Now at Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 96921, Israel
3. National Data Center, Soreq Nuclear Research Center, Yavne 81800, Israel
4. Geophysical Monitoring Programs, Lawrence Livermore National Laboratory, Livermore, California, U.S.A.

[lewiss@gsi.gov.il](mailto:lewiss@gsi.gov.il)

Seismic bulletins, with trustworthy phase picks, origin times, and source locations are key for regional seismic studies, such as travel-time (TT) tomography, attenuation tomography, and anisotropy studies. To lay the groundwork for such studies in Israel and surrounding areas, we revised the local seismic bulletin and obtained a trustworthy TT data set. From the earthquake and explosion bulletins of the Geophysical Institute of Israel, we compiled a starting dataset of about 123,000 earthquakes and explosions that occurred during the past 40 yr. After screening out poorly recorded events, we were left with a data set of ~38,000 well-recorded events. We then revised the remaining data set in two consecutive steps. First, we reviewed and updated station metadata, including changes in station metadata parameters over time. In the second step, we jointly relocated a list of selected seismic events, using the Bayesian hierarchical location software package (BayesLoc) of Myers et al. (2007) that performs joint relocation of multiple events. We observed striking dissimilarities between the spatial distributions of the newly relocated catalogue and the initial locations. Although the depth distribution of the starting catalogue is trimodal with peaks at 0, 5, and 10 km, the distribution in this study is unimodal, with a broad peak between 7.5 and 12.5 km. By differencing the observed arrival times and the origin times obtained through relocation with BayesLoc, we obtained a revised TT database that consists of 261,336 Pg, 132,876 Pn, 114,816 Sg, and 60,394 Sn arrivals, from a set of 30,458 jointly relocated seismic sources. We compared pre- and post-revision TTs as a function of epicentral distance and concluded that the revised data set contains far fewer outliers and inconsistencies than the original data set. The revised TT data set may be used for seismic studies, such as TT tomography, attenuation tomography, and anisotropy studies.

## Science on bicycle - detailed magnetic mapping of northern Israel

מדע על אופניים - מיפוי מגנטי מפורט של צפון ישראל

Schattner U. (1), Segev A. (2), Mikhailov V. (3,4), Rybakov M. (2), Lyakhovsky V. (2)

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

2. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

3. Schmidt Institute of Physics of the Earth, Russian Academy of Sciences, 10 Bol'shaya Gruzinskaya, Moscow, 123995 Russian Federation

4. Lomonosov Moscow state University, Department of physics, Leninskie Gory, Moscow, 119991, Russian Federation

[schattner@univ.haifa.ac.il](mailto:schattner@univ.haifa.ac.il)

This study presents new regional Total Magnetic Intensity and Reduced to Pole (TMI and RTP, respectively) magnetic anomaly maps of northern Israel and NW Jordan (10,620 km<sup>2</sup>), in an unprecedented 1-km grid spacing. The maps quantitatively integrate new ground data, collected along 5,000 km using the bike-mag design, with all available marine and aerial magnetic surveys previously conducted. The removal of anthropogenic influences during processing is evident from a comparison of the resulting maps with the distribution of infrastructure. The study discusses the correlation between previously mapped magmatic outcrops and the new RTP anomalies. This correlation suggests that the subsurface magmatic bodies are broader than their surficial outcrops. RTP anomalies found over areas free of surface basaltic outcrops indicate subsurface causative bodies. Some of these bodies were previously identified in wells. The complete spatial coverage of the RTP map allows linking these sporadic occurrences and placing them into the regional geological context. The detailed map breaks down the previous coarse anomalies and allows a better understanding of magmatic events spanning from the Jurassic to the present. This study demonstrates the robustness and efficiency of the bike-mag for ground data acquisition, and the integration procedures for producing maps from a variety of sources and parameters.

## **Sedimentary response of the deep eastern Mediterranean basin to the North African desertification, sea level variation and regional tectonics**

כיצד השפיעו מדבור צפ' אפריקה, שינויי מפלס וטקטוניקה אזורית על הסדימנטציה בעומק הים התיכון?

Schattner U. (1), Kanari M. (1,2), Goodman-Tchernov B.N. (1), de Mahiques M.M. (4,5), Bernhardt A. (3)

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

2. Israel Oceanographic & Limnological Research Ltd., Tel-Shikmona, P.O.Box 8030, Haifa 31080, Israel

3. Freie Universität Berlin, Institute of Geological Sciences, Berlin, Germany

4. Institute of Energy and Environment, University of Sao Paulo, Brazil

5. Oceanographic Institute, University of Sao Paulo, Brazil

[schattner@univ.haifa.ac.il](mailto:schattner@univ.haifa.ac.il)

The buildup of a continental rise and its morphological patterns depend on sediment transport and deposition via downslope slumps, turbidity currents, along-slope contourites, and other deepwater currents. These delivery mechanisms are central to source-to-sink reconstructions, yet untangling their individual roles is not straightforward. The current study focuses on the sink section of the Nile system at the northern Levant continental rise (eastern Mediterranean). During the Pliocene, fluvial systems from northern Africa and the Levant margin supplied sediments to the study area. This supply decreased significantly during the Quaternary because of two processes: (1) the aridification of North Africa made the Nile River the predominant contributor to the basin; (2) the topographic rise of the Levant landmass severely limited fluvial supply. Meanwhile, on-going counter-clockwise marine currents became the prevalent supply system to the Levant margin, and downslope sediment-transport became the only source to the northern Levant continental rise, which became a significant sink of the larger Nile system. These conditions provide an excellent natural laboratory for understanding the individual role of downslope sediment-transport processes in building a continental rise. This research is based on single-channel sparker seismic data, multibeam bathymetry, and four 7-8 m long piston-cores collected over the northern Levant continental rise at water depths of 1,200-1,800 m, together with available multibeam bathymetry and industrial multi-channel seismic reflection data. Results show a major depositional changeover during the Pliocene-Quaternary transition from concordant aggradation to repeated deposition of >12 sediment wave subunits, interpreted as upslope migrating cyclic steps. Sediment wave morphology at the seafloor and subsurface, along with core data, indicates that the immediate sediment source was the nearby shelf. Supply was regulated by basinward-landward shifts of the shore-parallel marine currents during lowstand-highstand conditions (respectively). Hence, this case

study highlights the connection between sea-level change and sedimentation patterns on a continental rise.

## Global warming in semi-enclosed marine basins: insights from the Paleocene-Eocene Thermal Maximum (PETM) event in the southern Neo-Tethys of Israel

השפעת התחממות גלובלית על אגנים ימיים סגורים למחצה: תובנות מאירוע חימום הפליאוקן-איאוקן (PETM) בדרום הניאו-תטיס של ישראל

Schneider-Mor A. (1), Morag N. (1), Ovechkin M. (1), Amoyel Z. (1), Yasur G. (1), Zilberman T (1)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

[ayas@gsi.gov.il](mailto:ayas@gsi.gov.il)

Following the industrial revolution, CO<sub>2</sub> concentration in the atmosphere has increased by ~120 ppm over 170 years. The last time Earth experienced such a rapid rise in atmospheric CO<sub>2</sub> content was during the Paleocene-Eocene Thermal Maximum (PETM) event (56 Ma), when atmospheric CO<sub>2</sub> increased to >1000 ppm in a short period of <20 kyr. During the Paleocene-Eocene transition, Israel was located at latitudes 20-25° N, forming part of the southern Neo-Tethys margins. This study measured calcium carbonate stable isotope records combined with chemical composition and clay mineralogy in two Paleocene–Eocene sections from the Northern and Southern Negev, representing semi-enclosed marginal basins in order to study their paleoenvironmental conditions. Three hyperthermal events were identified in the studied sections by the carbon isotope record: the PETM at the upper part of the Taqiye Formation, the Eocene Thermal Maximum 2 (ETM2) at the lithological transition from the Taqiye Formation shales to the Mor Formation chinks, and the Eocene Thermal Maximum 3 (ETM3), about 3m above the lithological transition. The chemical composition and Ce anomaly record suggest that the PETM event pushed these closed basins to increased stratification and more reduced conditions. In the ETM2 and ETM3 events, significant transgressions were the tipping points that led to lithological changes from shales to chinks. These events, based on Ce anomaly and P/Al records, the northern site (Zomet Telalim) showed considerable oxidation of the water column and increased productivity. The southern site (Givat Rehavam) showed limited aeration with a slight increase in productivity. The clay assemblages suggest aridization of the terrestrial environment with palygorskite dominance during the Eocene Thermal Maximum events. Thus, during the hyperthermal events, the restricted basins of Israel were mainly affected by the transgression caused by global warming

## **Inorganic stable isotope records of coexisting minerals in Israel's phosphate rocks from the Late Cretaceous as a possible paleoenvironmental marker**

איזוטופים יציבים של חמצן ופחמן במינרלי הקלציום קרבונט ופאזט הקרבונט בפרנקוליט, כסמנים פאלאו-סביבתיים אפשריים בשדות הפוספאט בישראל של הקרטיקון המאוחר

Schneider-Mor A. (1), Bar O. (1), Levy A. (1,2), Yasur G. (1), Zilberman T. (1)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

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

[ayas@gsi.gov.il](mailto:ayas@gsi.gov.il)

The Late Cretaceous succession in Israel is enriched in Si-C-P and is part of an extensive high productivity upwelling regime that deposited successions of phosphates, cherts, porcellanites, and organic-rich carbonates. The Israeli phosphates are part of a large phosphorites belt deposited from the mid-Cretaceous to Eocene and stretched between Turkey and Morocco. The phosphorites records in the synclines show repeated alternation between two main facies: pristine and reworked (economic) phosphorites. The pristine phosphorite deposition occurred under high productivity and sedimentation rates and more reduced conditions, whereas the reworked phosphorite deposits occur under a high-energy and relatively more oxidizing environment. This study focused on three sites A3 from Zin syncline, Z1 from Rotem syncline, and B5 from Oron syncline. We present a high-resolution record of stable carbon ( $\delta^{13}\text{C}$ ) and oxygen ( $\delta^{18}\text{O}$ ) isotopes of calcite and carbonate phase of francolite mineral combined with rare earth elements to study the paleo-deposition environment. The calcite and the carbonate phase of francolite isotopic records measured low values than the "normal" marine signal in carbonate skeletal. We suggest that the calcite records represent a mixture of carbonatic shells and autogenic carbonate. At the same time, the carbonate phase of the francolite represents the conditions at the phosphogenesis window. Hence, it appears that combining the coexisting minerals records has the potential to enhance our understanding of the paleoenvironmental conditions during phosphorite deposition. In addition, we show that the calcite  $\delta^{13}\text{C}$  records could be used as a tool to correlate between phosphate fields, with different stratigraphy, in southern Israel.

## High-temperature metamorphism of phosphorite is the Hatrurim Basin: the occurrence of Si-bearing fluorapatite

התמרה בטמפרטורה גבוהה של פוספוריט בבקעת חתרורים: הופעה של אפטיט עשיר בסיליקה

Segall Z. (1), Vapnik Y. (1), Katzir Y. (1)

1. Department of Earth and Environmental Sciences, Ben-Gurion University of the Negev, Be'er

Shevzoharseg@post.bgu.ac.il

The Mottled Zone complex in the Hatrurim Basin is composed of high-temperature and low-temperature metamorphic equivalents of the Ghareb and Taqiya formations. The High-temperature assemblage commonly include calc-silicate minerals such as spurrite, larnite and gehlenite, whereas the overprinting low-temperature assemblages are composed of secondary calcium-carbonate and hydrous calc-silicates and aluminum-calc-silicates. The heat source of the metamorphism has been shown to be near-surface combustion of organic matter, ignited by introduction of atmospheric oxygen. High-temperature metamorphism and low-temperature alteration also affected the uppermost phosphoritic horizons of the Mishash formation at the base of the Mottled Zone. This is indicated by recrystallization and decarbonization of biogenic calcite and francolite (carbonate-bearing fluorapatite) to neo-formed fluorapatite-marble. Semi-quantitative XRD analysis shows that the apatite-calcite marbles are composed of 55-79.5 wt.% fluorapatite, and sometimes also include hydroxyapatite and carbonate-fluorapatite. Here we report the occurrence of the minerals perovskite [CaTiO<sub>3</sub>], lakargiite [Ca(Ti,Sn,Zr)O<sub>3</sub>], oldhamite [(Ca,Mg)S], covellite [CuS], magnesioferrite [MgFe<sub>2</sub>O<sub>4</sub>], srebrodolskite-brownmillerite [Ca<sub>2</sub>(Fe,Al)<sub>2</sub>O<sub>5</sub>] and fayalite [Fe<sub>2</sub>SiO<sub>4</sub>] in the recrystallized rocks, also indicating high temperature metamorphism of the phosphorites. The low-temperature assemblage include Ca-zeolites (gismondine-Ca, chabazite-Ca and gmelinite-Ca), beyerite [Al(OH)<sub>3</sub>], brucite [Mg(OH)<sub>2</sub>], chlorite and native Cu. Nonetheless, calc-silicate minerals characteristic for the high-temperature metamorphic facies of the Mottled Zone may be exclusively rare in the apatite rich meta-phosphorite. Electron microprobe analysis (WDS) reveals up to 6 wt.% SiO<sub>2</sub> in metamorphic fluorapatite, indicating a considerable substitution of P by Si. These findings are consistent with previously reported microprobe data on fluorapatites in metamorphosed rocks of the Mottled Zone from Israel and Jordan.

## Classification of Quaternary capable faults in Israel for a regional assessment of surface rupture hazard

חלוקה של העתקים רביעוניים בישראל עבור הערכה רגיונאלית של סיכוני קריעת פני שטח

Sharon M. (1,2,3), Sagy A. (1), Biran G. (1), Kurzon I. (1), Hamiel Y. (1), Marco S. (2)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

2. Department of Geophysics, Tel-Aviv University, Tel-Aviv 69978, Israel

3. Fredy and Nadine Herrmann Institute of Earth Sciences, Hebrew University of , Jerusalem, 9190401, Israel

[matty.sharon@mail.huji.ac.il](mailto:matty.sharon@mail.huji.ac.il)

Surface rupture hazard is defined as the hazard of a permanent fault displacement that reaches the Earth's surface. Such events typically occur during strong earthquakes ( $M > 6.0$ ). This hazard is at its maximum along fault traces and decreases as a function of distance from them. Here, we aim to estimate the on-fault and the off-fault hazard, which are particularly relevant for the siting of sensitive facilities (e.g., dams; nuclear power plants). We assess the fault displacement hazard of these faults based on the methodology of a Probabilistic Fault Displacement Hazard Analysis (PFDHA), applying existing empirical-based regressions for strike-slip faults, which tectonically are the most suitable for Israel. The seismic sources that are most likely to produce future surface rupture are taken from the Quaternary Fault Map of Israel, considering an internal classification of faults to the definitions of 'capable' and 'main seismic sources'. For our purpose, the Quaternary faults are classified into five groups according to fault lengths and estimated slip rates. We then assess the fault displacement hazard through moment balance considerations, assuming 'characteristic' earthquake model. As expected, the hazard is higher for faults characterised by high slip rates and large magnitudes, and decreases with distance from the faults. These results can be regarded as first-order estimation, which can be improved with further methodological development and based on larger databases.



## **Strontium immobilization in Portland cement matrices – influence of low-pH systems, minor phases and carbonation**

קיבוע סטרונציום במטריצות צמנטיות - השפעה של מערכות נמוכות pH, פאזות משניות וקרבונציה

Shiner M.E. (1), Klein-BenDavid O. (1,2), Harnik Y. (3), Teutsch N. (4), Peled A. (5), Bar-Nes G. (2,5)

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

2. Department of Chemistry, Nuclear Research Center Negev, P. O. Box 9001 Beer-Sheva, 8419001 Israel

3. Israel Atomic Energy Commission

4. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

5. Department of Structural Engineering, Ben Gurion University of the Negev, Beer-Sheva 84105, Israel

[shinerm@post.bgu.ac.il](mailto:shinerm@post.bgu.ac.il)

Strontium-90 ( $^{90}\text{Sr}^{2+}$ ) is common in low- and intermediate-level radioactive waste streams, often solidified and stabilized by Ordinary Portland Cement (OPC) matrices. Low-pH cementitious systems, where part of the OPC is replaced by amorphous silica-rich additives, are often used for radioactive waste disposal applications. Such formulations can improve the performance of radioactive waste-forms, due to lower heat of hydration, refined porosity and lower pH, decreasing radionuclide migration to the host rock. Although Sr behavior in cementitious systems has been widely studied, full understanding of the phases and mechanisms controlling Sr immobilization in these systems has not been achieved yet. Furthermore, waste-forms are expected to experience carbonation, which may further affect the immobilization process. This study integrates experimental work with geochemical modelling to address these open questions and can provide tools for cementitious waste-forms formulation design, optimizing Sr retention. In this study, cementitious specimens were spiked with non-radioactive Sr during casting to simulate the immobilized Sr ions. Leaching experiments were held to study Sr retention, in equilibrium and in diffusion-controlled conditions. The experimental approach is based on the use of synthetic alite- (tri-calcium silicate) based pastes, as a model material, compared to traditional OPC pastes, to study the effect of minor OPC hydrates on Sr immobilization separately from the major hydrates – C-S-H and portlandite. Low-pH systems were prepared by amorphous silica addition to alite/OPC-based mixtures and compared to their high-pH corresponding systems. To study the carbonation effect, specimens were subjected to accelerated carbonation followed by leaching tests. For non-carbonated samples, Sr retention was significantly improved in low-pH compared to high-pH systems, and in OPC over their alite model systems. To conclude, Sr retention was improved in the low-pH systems due to sorption to low Ca/Si C-S-H. Carbonation influence on Sr retention will be discussed as well (experiments underway).

## Variations in extreme rainstorms govern arid cliff-talus morphology

שינויים במאפיינים של אירועי גשם קיצוניים והתפתחות הנוף של מצוקים באקלים מדברי

Shmilovitz Y. (1), Marra F. (2), Enzel Y. (1), Morin E. (1), Armon M. (1,3), Matmon A. (1), Mushkin A. (4), Levi Y. (5), Khain P. (5), Haviv I. (6)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel
2. National Research Council of Italy, Institute of Atmospheric Sciences and Climate (CNR-ISAC), Bologna, Italy
3. Institute for Atmospheric and Climate Science, ETH Zurich, Zurich, Switzerland
4. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel
5. Israel Meteorological Service, Beit Dagan, 5025001, Israel
6. Department of Earth and Environmental Sciences, Ben Gurion University of the Negev, Beer Sheva 8410501, Israel

[yuval.shmilovich@mail.huji.ac.il](mailto:yuval.shmilovich@mail.huji.ac.il)

The impact of climate on the landscape have previously been demonstrated in settings with pronounced gradients in average climatic properties (e.g., mean annual precipitation or temperature). However, in arid regions, where meteorological observations are scarce, and discrete, short-duration and intense rainstorm events often trigger substantial hydrogeomorphic changes, the relevance of "average conditions" is doubtful. Even so, the sensitivity of topography to storm scale properties is rarely explored. Here we attempted to bridge this gap by documenting systematic precipitation and storm properties variations along the 40 km arid escarpment of Ramon crater and their associated topographic signature. We used 0.5 m pixel-1 LiDAR-derived topographic data coupled with field measurements to characterize cliffs and slopes topography. Sub-hourly rainfall intensities were characterized using an 8-year record of high-resolution, convection-permitting, numerical weather model prediction (NWP). Spatial frequency analyses of rainfall intensity were conducted using a novel statistical method and used to determine sediment transport along sub-cliff slopes, through grid-based hydrological simulations of synthetic rainstorms with different frequencies. Our results indicate that due to a pronounced decreasing gradient in the number of rainstorms per year, the mean annual rainfall decreases from ~100 mm in the southwest (SW) cliff segment to ~40 mm in the northeast (NE) segment. However, in the drier NE segment, extreme rainfall intensities are higher. Topographic cliff gradients and the percentage of exposed bedrock over the cliffs increase toward the drier NE segment, where the sub-cliff slopes are also straighter, shorter, and associated with smaller clast sizes. Hydrological simulations reveal that under extreme storms, sediment is mobilized by sheetwash on the NE slopes but is less mobile on the wetter SW slopes. Our results indicate that significant morphologic differences can be imprinted in arid landforms due to spatial gradients in the properties of extreme rainstorms.

## The Effect of Seagrass *Halophila stipulacea*'s Rhizosphere on Marine Sediments Biogeochemistry

השפעת הריזוספירה של עשב-הים על ביוגיאוכימיה של סדימנטים

Soto N. (1), Winters G. (2), Antler G. (1)

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

2. Dead Sea and Arava Science Center, Central Arava Branch, Hatzeva 86825, Israel

[sotonet@post.bgu.ac.il](mailto:sotonet@post.bgu.ac.il)

As carbon dioxide is the dominant greenhouse gas in the atmosphere, carbon has a marked impact on climate via the carbon budget of the Earth's surface reservoirs. Marine ecosystems including seagrasses mitigate these changes by carbon sequestration. Seagrasses are highly efficient in trapping suspended matter and store most of the sequestered carbon in the sediments. In carbon-rich sediments, the oxidation of organic matter is the driving force behind most diagenetic reactions, which affect the water column as well. The seagrass's rhizosphere (the zone of influence generated by root growth and activity) creates an oxidizing microenvironment in the sediments, greatly affecting the rates of microbial carbon mineralization. Therefore, the rhizosphere has very complex and strong redox gradients. Since seagrass profoundly affect their sediments, understating their role in the marine carbon system and examining the changes they cause holds ecological and global importance. The aim of this study is to explore how the subsurface geochemistry is affected by the seagrass (*Halophila stipulacea*). First, we compared the porewater geochemistry from vegetated (with seagrasses) and unvegetated sediments. We then incubate sediment from the vegetated (after seagrass removal) and unvegetated sediments over time, and follow the changes in several geochemical parameters. Results indicate that while vegetated sediments are more oxidized in the field, after seagrass removal the sediment are more reduced than unvegetated sediments. This implies that while seagrasses are present, they enriched the sediment with organic carbon, which keeps the pore water oxidized; however, once the seagrass is removed the sediment is quickly gets reduced. This work has important implications to the conservation of seagrasses worldwide, since degradation in these ecosystems, would have global implications to the shallow sediments worldwide.

## Carbon capture and geological storage (CCS): An overview

לכידה והטמנת פחמן: סקירה

Steinberg, J (1)

1. Ratio Energies, Tel Aviv, Israel

[josh@ratioenergies.com](mailto:josh@ratioenergies.com)

Carbon capture and geological storage (CCS) is a technique for trapping CO<sub>2</sub> emitted from industrial and energy-related sources, compressing it, and transporting it to a suitable storage site where it is injected (back) into the subsurface. Storage of CO<sub>2</sub> in deep, onshore or offshore geological formations uses many of the same technologies that have been developed by the oil and gas industry and has been proven to be economically feasible under specific conditions for saline aquifers, either depleted oil and gas fields or those that require enhanced injection methods for additional production (EOR). This technology has significant potential, particularly in countries with large reserves of fossil fuels and a fast-increasing population and energy demand. The importance of future capture and storage of CO<sub>2</sub> for mitigating climate change will depend on a number of factors, including financial incentives provided for deployment, and whether the risks of storage can be successfully managed. Despite unprecedented growth in the CCS awareness and multi-government commitments over the last 24 months, there remains a massive gap between today's CCS portfolio, both currently operating and future projects and what is required to reduce global anthropogenic emissions to net zero. Limiting global warming to 2°C requires installed CCS capacity to increase from around 40 Mtpa today to over 5,600 Mtpa by 2050 (International Energy Agency assessment). This talk will provide a brief overview and history of CCS systems, its current global status, and key opportunities and challenges that it faces.

## Geochemical and hydrological processes in the coastal area of the Dead Sea, Einot Tzukim area

תהליכים גיאוכימיים והידרולוגיים בחופים החדשים של ים המלח, אזור עינות צוקים

Swaed I.(1,2) , Yechieli Y.(1) , Ganor J.(2) , Weisbrod N.(3)

1. Geological Survey of Israel, Yesha'ayahu Leibowitz 32, Jerusalem 9692100, Israel

2. Department of earth and environmental science, Ben Gurion University of the Negev, Beer Sheva 84105, Israel

3. The Zuckerman institute for water research, The Jacob Blaustein institutes for desert studies, Ben Gurion University of the Negev, Israel

[swaedi@gmail.com](mailto:swaedi@gmail.com)

The coastal area of the Dead Sea (DS), which was previously covered by DS brine, is now rapidly exposed to geochemical and hydrological processes due to its decreasing water level such as: flushing of the original DS brine by relatively fresh groundwater; capillary rise; evaporation; salts accumulation; and ambient atmospheric humidity absorption. In order to understand and estimate the effect of exposure time and cyclic winter–summer impact on these processes, boreholes were drilled to depths of up to 3 m into the unsaturated zone of different shorelines (1991, 1999 and 2008 shorelines). At the 1999 shoreline, we drilled 4 boreholes in both winter and summer to observe the seasonal effects on the sediment profile. In-situ sediment temperature was recorded and samples were taken for high-resolution chemical and isotopic analyses of the interstitial solutions. The concentration of most ions increased toward the surface, leading to salt precipitation (gypsum, halite, carnallites, and bischofite). In areas which were exposed in 1999, the effects were observed to a depth of about 1.5 m. below this depth, the sediment still contained pore water with a composition similar to the original upper layer DS water in 1959. In the area at the 1991 shoreline, the interstitial solution composition at 3 m depth had a low ion concentration, similar to that in the nearby Einot Tzuqim springs indicating flushing of the original DS brine by relatively fresh groundwater. Seasonality impacts the composition of the interstitial solutions in the sediment profile which changed dramatically at the same location in different seasons due to high temperatures in the summer accelerating evaporation and salt precipitation. For example, the summer concentration of the relatively conservative ion  $\text{Sr}^{2+}$  rise from 0.003 mol/kgH<sub>2</sub>O at 1.5 m depth to 0.02 mol/kgH<sub>2</sub>O at the surface (reaching values of ~4 times that of the DS), more than in the winter profile (0.003 to 0.008 mol/kgH<sub>2</sub>O) due to the higher degree of evaporation.

## First quantification of the biological carbon pump efficiency in the deep, oligotrophic, subtropical Gulf of Aqaba

הכימות הראשון של יעילות המשאבה הביולוגית בעמודת המים העמוקה האוליגוטרופית והסבטרופית של מפרץ אילת

Torfstein A. (1,2), Kienast S.S. (3)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel

2. Interuniversity Institute for Marine Sciences, Eilat 88103, Israel

3. Department of Oceanography, Dalhousie University, Canada

[adi.torf@mail.huji.ac.il](mailto:adi.torf@mail.huji.ac.il)

The oceanic biological carbon pump modulates atmospheric CO<sub>2</sub> concentrations by transporting carbon from the surface to greater depths. The efficiency of the biological pump and its response to warming are of great importance to future projections of global change. This study presents a sediment trap record of particulate organic carbon (POC) fluxes between 2014 to 2016 in the Gulf of Aqaba (GOA), northern Red Sea, which serves as a quasi-analogue for oligotrophic open oceans. Monthly POC flux observations (120-600 m) are combined with temperature, in-situ chlorophyll-a (chl-a) concentrations, and net primary productivity records to produce the first assessment of carbon attenuation and biological pump efficiency in this area. The integrated vertical POC fluxes are generally elevated during the winter mixing season, consistent with the seasonal cycle of elevated surface chl-a concentrations and net primary productivity. The base of the primary production zone, defined using the in-situ chl-a measurements, co-varies as expected with the depth of mixed layer from 150 ± 20 m in the stratified summer to >300-400 m in the winter. By contrast, the 1% light level (1% PAR), previously used to indicate the base of the euphotic zone, is shallower (80-120 m) and does not show a seasonal cycle. Carbon attenuation, assessed using Martin's b coefficient, is  $0.80 \pm 0.36$  on average across the study period, less intense than expected from the consistently warm temperatures that remain above 20°C year-round, even in deep waters. Export ratios (T100) decrease from 0.4 in summer to 0.2 in winter, opposite to transfer efficiencies (E<sub>z</sub>), which increase from 0.5 in summer to > 0.9 in winter. Overall, the carbon pump efficiency in the GOA is 20% during both summer and winter. These observations challenge the notion of a globally uniform role of temperature on carbon attenuation in the ocean but support the view that warm subtropical ecosystems support moderately enhanced carbon pump efficiencies.

## **Eolian chronology reveals causal links between tectonics, climate, and erg generation**

קשרים סיבתיים בין טקטוניקה, אקלים, ויצירת שדה חולות מתגלים באמצעות כרונולוגיה איאולית

Vainer S. (1,2,3,4), Matmon A. (2), Ben Dor Y. (5), Verrecchia E. (3), Eckardt F. (6), ASTER Team(4,a)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of, Jerusalem, 9190401, Israel
2. Institute of Earth Surface Dynamics, University of Lausanne, 1015 Lausanne, Switzerland
3. Aix-Marseille Université, CNRS, Collège de France, IRD, INRA, CEREGE, 13545 Aix-en-Provence, France
4. Dead Sea and Arava Science Center, Mitzpe Ramon branch, Mitzpe Ramon 80600, Israel
5. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel
6. Dept. Environ. & Geog. Sci., University of Cape Town, Cape Town 7701, South Africa
- a. Georges Aumaître, Didier L. Bourlès, Karim Keddadouche

[shlomy@adssc.org](mailto:shlomy@adssc.org)

Evaluating the impact and implications of eolian repositories that mark large-scale climatic transitions requires knowledge about the timing of their emplacement and the mechanisms responsible for their production, which remain highly uncertain. We apply numerical modeling of cosmogenic nuclide data, measured in the largest continuous terrestrial body of sand on Earth, to determine settings under which the sand was generated, by constraining the timing of sand introduction into the interior of southern Africa. Our findings reveal that major events of sand formation and accumulation in the Kalahari Basin occurred between ~2.2 and 1 Myr ago. The establishment of the Kalahari sand field corresponds to regional, continental, and global scale morphotectonic and climatic changes that contributed to the mass production and widespread dispersion of sand. These changes substantially altered existing habitats, thus constituting a crucial milestone for floral, faunal, and hominin evolution throughout the African continent during the Pleistocene.

## **Geo-archaeological mapping of alluvial terraces and Paleolithic sites in the Negev Desert, Israel**

מיפוי גיאוארכיאולוגי של אתרים פליאוליתיים בנגב

Wieler N. (1), Avni Y. (2), Porat N. (2), Cohen-Sasson E. (3), Oron M. (1,4) Barzilai O. (1)

1) Archaeological Research Department, POB 586, Jerusalem 91004, Israeli Antiquities Authority 2) Geological Survey of Israel, 32 Yesha'ayahu Leibowitz St. Jerusalem 9692100, Israel

3) Department of Bible, Archaeology and the Ancient Near East, Ben-Gurion University of the Negev, 84105 Beer-Sheva, Israel

4) Institute of Archaeology, The Hebrew University of Jerusalem, Mt. Scopus, 91905 Jerusalem, Israel

[wielern@gmail.com](mailto:wielern@gmail.com)

The location of the Negev Desert, Israel, at the crossroads between Africa and Eurasia, makes it a perfect region to trace the presence of early hominins in major dispersal events. Nevertheless, finding preserved Paleolithic sites which can indicate on such events is quite difficult. In this study, we aimed to unravel the spatial distribution of Paleolithic sites in the Negev desert and suggest a possible large scale activity pattern that can be used as a predicting model in arid regions. Geomorphological mapping of Pleistocene abandoned alluvial terraces and wetland deposits (e.g., travertine) coupled with archaeological excavation demonstrate an association between the sequence of alluvial terraces and prehistoric artifacts. Characterizing the morphostratigraphic alluvial terraces (Q1-Q3) at different drainage systems (e.g., Besor, Zin, Paran, Kuntilla, Neqarot, Haroa, Resisim) by using their relative height above the present-day active channel, sedimentological characteristics including clast assemblage, soil profile and surface roughness, we managed to better define the processes involved in terraces formation in arid regions. By applying luminescence dating to the alluvial terraces we were able to estimate the time of their deposition and abandonment. This new integrated approach correlates the Lower Paleolithic Acheulian handaxes to the oldest Q1 terraces, and the Middle Paleolithic Levallois cores and blanks to the Q2 terraces. Our approach increased the number of Paleolithic sites in regions that were not surveyed in the past. It further showed that a correlation between the alluvial terraces and the prehistoric findings is valid regardless of the drainage basin (Mediterranean or Dead-Sea). Future studies of the newly discovered Lower and Middle Paleolithic sites, found in the framework of our study, are expected to assist in comprehending the nature of hominin dispersal events during the Middle Pleistocene and their relationship with the Negev Desert.



## Heavy metals at the outer Haifa Bay sediments – insights into potential sources and transport processes

מתכות כבדות בסדימנטים בחלק החיצוני של מפרץ חיפה - תובנות לגבי מקורות אפשריים ותהליכי הסעה

Weiss-Sarusi K. (1,2), Bookman R. (2), Silverman J. (3), Teutsch N (1)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

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

3. Israel Oceanographic & Limnological Research Ltd., Tel-Shikmona, P.O.Box 8030, Haifa 31080, Israel

[kerenw@gsi.gov.il](mailto:kerenw@gsi.gov.il)

The abundance of anthropogenic heavy metals (HMs) in the marine environment has risen significantly since the beginning of the Industrial Revolution, especially in industrially developed urbanized bays and estuaries. Flooding events, turbidites, wave action, currents, adsorption/desorption and biological vectors influence the transport, resuspension and settling of HMs from their terrestrial sources throughout the bay and eventually out into the open sea. Many previous studies have demonstrated the accumulation of HMs in sediments and biota of Haifa Bay (HB), highlighting the fact that HB has been a hotspot of HM pollution since the early 20th century. In this study, we focus on the transport of HMs from HB and try to reconstruct its pollution history. To this end, we sampled a total of nine short sediment cores, of which seven were along a 60 m depth contour west of HB and two were collected at open sea ca. 50 and 100 km NW of HB at 1400 and 1800 m bottom depth, respectively. The cores were sliced at 0.5/1 cm intervals and analyzed for  $^{210}\text{Pb}$ , grain size distribution, major and trace elements, and organic matter content. Elemental concentrations were determined for the sediment leached fraction. Shallow southern cores display very low HMs top core concentrations while others contain semi constant values with several enrichment and depletion peaks. Correlations observed between major elements and between anthropogenic HMs are linked to joint terrestrial origins and contamination sources, respectively. Fluxes of HMs are calculated using  $^{210}\text{Pb}$  dating, where fluxes of Zn and Pb show similar trends for each core, but rates vary between the cores at common depths. Significant variations in HMs dated profiles can be associated with anthropogenic activities that occurred in HB in recent history.

## Asymmetry of faults and stress patterns within the Dead Sea basin as displayed by seismological analysis

המבנה האסימטרי של אגן ים המלח ע"פ מידע סיסמולוגי

Wetzler N. (1), Sagy A. (1), Marco S. (2), Reches Z. (3)

1. The Geological Survey of Israel, Jerusalem
2. The Department of Geophysics, Tel Aviv University, Israel
3. School of Geosciences, University of Oklahoma

[nadav.wetzler@gmail.com](mailto:nadav.wetzler@gmail.com)

The Dead Sea pull-apart basin (DSB), which is located within the Dead Sea Transform fault system, displays tectonic asymmetry between its eastern and western longitudinal zones. We investigate the seismological and mechanical signature of this asymmetry by the analyzing the hypocenter distribution and focal-mechanisms of 114  $M_w=1.5-5.2$  earthquakes recorded from 1985 till 2012. The analysis indicates that the seismicity along the western longitudinal zone is deeper than the eastern one. Focal mechanism analysis indicates that about 50% of solutions are strike-slip, compatible with the plate motions along the Dead Sea transform. Comparison between the two longitudinal zones of the basin shows that the focal mechanisms in the eastern DSB are dominated by strike-slip faulting shallower than 12 km depth, whereas those in the western DSB are dominated by oblique faulting below 12 km depth. The b value of the Gutenberg-Richter magnitude distributions also show difference between the two zones with  $\sim 0.9$  in the west and  $\sim 0.7$  in the east zone. We develop stress-inversion analysis to identify the fault planes of the focal mechanisms by using friction-dependent selection process. The horizontal maximum compression ( $sH_{max}$ ) trends NNW-SSE, with increasing value of the vertical stress component along the western part of the basin, corresponds to the oblique faulting in this zone. The optimal friction coefficient determined by the stress-inversion for the fault planes is  $m \sim 0.5$ . Our analysis emphasizes the significant contribution of frictional dependent stress-inversion as an effective tool in seismotectonic analysis.

## **Fresh-saline water interface dynamics due to saline groundwater pumping in a confined coastal aquifer**

דינמיקת הפן הביני באקוויפר חופי כלוא עקב שאיבת מי תהום מלוחים

Wolansky Y. (1), Reznik I. (2), Levy E. (3), Shalev E. (2), Yechieli Y. (3), Sivan O. (1)

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

2. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

3. Geophysical Institute of Israel, P.O.Box 182, Lod 71100, Israel

[yairwo@post.bgu.ac.il](mailto:yairwo@post.bgu.ac.il)

Coastal aquifers are an important source of water worldwide. Recently, it has been suggested to examine the desalination potential of beach wells in coastal aquifers, which penetrate beneath the fresh-saline interface (FSI). The water that usually exhibits a salinity that is slightly lower than the salinity of seawater is considered a better source for desalination by RO due to a lower fouling potential, and reduced pretreatment costs (filtration). However, the effect of pumping water below the FSI on the aquifer is yet to be understood, especially in confined sub-aquifers. This research focuses on two observations wells within the confined aquifer in the Michmoret area, which are affected by two nearby pumping wells of saline groundwater. This study aims to quantify and model the changes in water levels, salinity, chemical composition, and FSI location as a result of the nearby pumping. A complex array of sensors was installed for this purpose both within the wells and outside of them. Continuous monitoring of temperature, salinity, redox potential, dissolved oxygen, and pH within the wells is performed. This is combined with seasonal traditional sampling. Outside of the well multiple (around 30) electrical resistivity sensors were deployed along the wellbore casing at a 1 m spacing, providing high-resolution monitoring of the salinity changes along the columnar sections. Initial results show both seasonal variations as well as recurring cycles which are correlated to the operation of the nearby pumping wells. Thus far, it is shown that the effect of the local pumping is significant in a short timescale. An important question remains whether the pumping also has an important effect on a larger timescale or is it the regional water table elevation that has a more profound effect on the aquifer.

## Reconstructing environmental changes in Northern Israel during the Upper Pleistocene by utilizing sediments from Lake Hula

שחזור שינויים סביבתיים בצפון ישראל בתקופת הפלייסטוקן העליון על ידי ניצול משקעים מאגם החולה

Abdrahamane Yassine A.A. (1), Parth S.(1), Weinstein-Evron M. (2), Taha N. (1), Waldmann N. (1)

1. Dr. Moses Strauss Department of Marine Geosciences, Charney School of Marine Sciences, University of Haifa, 3498838 Haifa, Israel

2. Zinman Institute of Archaeology, University of Haifa, Haifa, Mount Carmel 3498838, Israel.

[abdaziz.fils@gmail.com](mailto:abdaziz.fils@gmail.com)

Lake sediments have been shown to serve as reliable archives of geological processes, environmental variability, and climate change. Lake Hula (freshwater) occupies a structural pull-apart basin of ca. 150 km<sup>2</sup> that evolved in the northern part of the Dead Sea transform fault system already in the Miocene. A previous study carried out on a 160 m long core retrieved in the 1970's and anchored by radiocarbon dating, show that the terrestrial vegetation (pollen analyses) validly responds to climate variability on a millennial-scale pattern. This current research is targeted at unravelling the prevailing environmental conditions of the region utilizing the physical and chemical properties of the same core for the upper Pleistocene. The approach includes sedimentological (e.g. grain size), physical (magnetic susceptibility), geochemical (e.g. elemental measurements with X-Ray Fluorescence (XRF)) and mineralogical (X-Ray Diffractometer (XRD)) analyses. Initial investigation of the lithology and elemental ratio concentrations show intervals that appear to be associated with lower runoff from the lake catchment area, which is shown by decrease in the allogenic particles and increase in authigenic minerals deposition. These intervals might point to establishment of long dry climate conditions. Moreover, variations in the sediment lithology and geochemical proxies suggest fluctuations in the precipitation regime, which is estimated to be dominated by orbital forcing. However, an improvement in the chronological constrain is currently under way, which might solve this hypothesis. Overall, it is envisaged that the current study will enhance our understanding on the impact of climate variability in the Levant and fill the gap of knowledge on large scale latitudinal teleconnections.

## **Climate effects on weathering progression of young Mauna Loa basalts, and its implication to soil development**

השפעת האקלים על תהליך הבליה של בזלות צעירות וההשלכות על שלו על התפתחות קרקעות

Zaarur S. (1)

1. Department of Soil and Water Sciences, The Robert H Smith Faculty of Agriculture, Food and Environment, The Hebrew University of Jerusalem, Rehovot, 76100, Israel.

[shikma.zaarur@mail.huji.ac.il](mailto:shikma.zaarur@mail.huji.ac.il)

The weathering of silicate minerals is among the most important processes in soil formation and the development of the critical zone; it has long been recognized that parent material, climate, and time are amongst the key factors that govern and control this process. In a developed critical zone, within an established soil profile, the silicate weathering and release of nutrients occurs at the soil-rock interface, where primary minerals are exposed to reactive fluids. In this study we use microscopic and geochemical tools to examine the progression of basalt weathering along two chronosequences in two climate zones, to study the effect of climate on the very early stages of critical zone development and soil formation. Basalt samples (pāhoehoe), ranging in age from the historical 1880 Mauna Loa lava flow to ~16,000 years BP were collected from the windward (~4m MAP) and leeward (~1m MAP) flanks of Mauna Loa volcano, Hawai'i. On the windward side, weathering progression with time is observed in deepening of the weathering front from the surface inward. As the degree of weathering advances, secondary minerals precipitate to replace the primary minerals and fill the vesicles. In contrast, on the leeward side, even after ~16,000 years, weathering and the leaching process appear to be more homogeneous throughout the rock. Moreover, devitrification of the basalt matrix, appears to outpace the chemical weathering, and further slow the progression of weathering and soil development. Our results demonstrate and quantify the large range of weathering rates that can occur within a small but heterogeneous area due to the differences in environmental conditions (e.g., precipitation). Furthermore, they demonstrate how differences in weathering patterns at the initial stages of critical zone development, may determine the distinctive properties of soils developed under different climatological conditions.

## **A combined chemical-magnetic mapping of natural and anthropogenic sediment compositions in the northern Gulf of Eilat**

מיפוי כימי-מגנטי של הרכבים טבעיים ואנתרופוגנים של משקעים בצפון מפרץ אילת

Zahavi E. (1), Shaar R. (1), Torfstein A. (1,2)

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

2. The Interuniversity Institute for Marine Sciences, Eilat, Israel.

eilamzahavi@mail.huji.ac.il

Marine pollution is a growing problem in today's world. Detection, characterization and quantification of pollutants allows identification of their source and delivery process. Typically, the chemical analysis of bottom sediments provides information on the excess presence of heavy metals associated with pollution processes, but these analyses are time and effort consuming. By contrast, an analysis of the magnetic properties of the sediments is relatively easy. The purposes of our analysis are two: (1) to characterize the natural and anthropogenic end-members components responsible for the chemical variability of the sediments and detect their geographic origin in the Gulf of Eilat (GOE). (2) examine if and how the chemical composition and the magnetic properties are related, in order to develop an efficient tool for monitoring pollution. We present high-resolution spatial maps of the magnetic properties and elemental abundances of 52 core-top samples collected between water depths of 20-720 meters in the northern GOE. The samples were sieved to <63um and split such that the major and minor element composition of both the bulk and the acid-leached fraction were determined. Of these, we measured the magnetic properties in 23 samples. The end-members components in this system were determined using a principal component analysis (PCA) yielding two dominant end-members. The first is controlled by terrigenous fluvial material originating on the western flanks of the study area. The second end-members represents the supply of heavy metals from the Kinet Canal in the northern shores of the GOE. These results provide a distinct quantitative characterization of the sources of natural sediments and anthropogenic pollution in the GEO and provide policymakers with important tools for the environmental management of this area. We further show that the coupling between the chemical and magnetic properties of the sediments has potential to be applied in future studies of environmental pollution.

## **The effect of early diagenesis on paleomagnetic signal in sediments: a case study from the Southeastern Mediterranean continental shelf**

ההשפעה של דיאגנזה מוקדמת על הסיגנל פלאומגנטי בסדימנטים: מקרה בוחן ממדף היבשת של דרום-מזרח הים התיכון

Zemach Y. (1) , Shaar R. (1), Sivan O. (2), Herut B. (3), Katz O. (4), Hyams-Kaphzan O. (4)

1. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel. 2. Department of Earth and Environmental Sciences, Ben Gurion University of the Negev, Beer Sheva 8410501, Israel.
3. Israel Oceanographic & Limnological Research Ltd., Tel-Shikmona, P.O.Box 8030, Haifa 31080, Israel.
4. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel.

[yakar.zemach@mail.huji.ac.il](mailto:yakar.zemach@mail.huji.ac.il)

Marine sediments provide one of the most important records for global paleomagnetic data. However, some of the processes responsible for the magnetic properties of these sediments are not fully understood. Specifically, the effects of 'early diagenesis' have been under-studied. Diagenetic processes may trigger dissolution or/and precipitation of ferromagnetic minerals, attributed to changes in the oxidation/reduction state along with depth profiles. These changes in the magnetic mineralogy can significantly affect the recorded magnetic signal. In this study, we examined the relationships between diagenetic processes and the magnetic parameters in sediment cores collected from the oligotrophic Southeastern Mediterranean shelf. Duplicate 6m-long piston cores were sampled from four locations, at water depths between 45 to 80m. In each core, we measured the paleomagnetic directions and a range of rock-magnetic parameters as proxies for the concentration and composition of the magnetic minerals. The rock-magnetic data were compared to depth profiles of methane, sulfate, and iron concentrations in pore water. Each core was dated using a profile of radiocarbon age (on foraminifera shells). The combined geochemical – magnetic - and electron microscopy observations reveal precipitation of magnetic minerals, probably iron oxides in the uppermost, Fe-reduction zone, followed by dissolution of magnetic minerals in the sulfate reduction zone and precipitation of diagenetic iron sulfides. The insights gained from our analyses are applicable to marine environments elsewhere and enable a better understanding of the interplay between sedimentary magnetism, microbial respiration, and diagenesis processes.

## Uranium isotopes of authigenic minerals track the shifts in Dead Sea water sources during the arid early Holocene

איזוטופים של אורניום של מינרלים אותגניים עוקבים אחר השינויים במקורות מי ים המלח במהלך ההולוקן המוקדם

Jie Z. (1), Yael K. (1)

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

[jie.zhao@weizmann.ac.il](mailto:jie.zhao@weizmann.ac.il)

The populated south Levant region at the desert fringe is drought-sensitive to the warming climate. Hydroclimate studies of past warm periods may help to picture future hydroclimate scenarios. Thick halite deposition recorded in the DSDDP core from the deepest basin of the Dead Sea indicates severe regional aridity during the early Holocene (~11.3–7.6 ka). Here we aim to determine Dead Sea water sources during that arid period by analyzing  $^{234}\text{U}/^{238}\text{U}$  activity ratios of authigenic minerals (halite, gypsum, and aragonite) in the core sediments. The  $^{234}\text{U}/^{238}\text{U}$  activity ratios plummet from typical values of ~1.4–1.5 that characterize the lake solution over long periods of the Quaternary to values of ~1.0 during the time interval of ~11–10 ka when the Dead Sea lake level sharply dropped. This change reflects a major shift of water sources from the north and west (Jordan River and Mediterranean-sourced rainfall,  $^{234}\text{U}/^{238}\text{U}$ : ~1.5–1.7) to the eastern and southern catchments and flash floods ( $^{234}\text{U}/^{238}\text{U}$ : ~1.0–1.2). Our preliminary data provide insights into the regional hydrological behaviors over the arid period.



## **Mechanical controls of solute exchange of growing methane bubble within muddy aquatic sediments**

בקורות מכניות של חילופי מומס בבועת מתאן בתוך משקעים מימיים בוציים

Zhou X. (1), Katsman R. (1)

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

[rkatsman@univ.haifa.ac.il](mailto:rkatsman@univ.haifa.ac.il)

Methane (CH<sub>4</sub>) bubbles residing in muddy aquatic sediments and their release threaten climate sustainability and sediment mechanical stability. Mechanical response of muddy sediment to bubble growth is described by Linear Elastic Fracture Mechanics (LEFM). Minor roles of mechanical sediment characteristics in CH<sub>4</sub> bubble solute supply and growth rates were quantified compared to biogeochemical controls. We investigate them using coupled single-bubble mechanical/reaction-transport numerical and analytical models. We demonstrate that the inner pressure of the growing bubble at fracturing, the concentration at its surface, bubble size and spatial location, are uniquely defined by Fracture Toughness. However, the temporal evolution of the inner bubble pressure at expansion between the fracturing events depends on Young's modulus. Fracture Toughness and Young's modulus thus play complementary, spatial, and temporal, roles in the bubble growth. The proportionality of Fracture Toughness and Young's modulus suggested by LEFM manages the bubble growth rates. Higher Fracture Toughness results in development of longer flatter bubbles in the deeper sediments. A substantial role of the mechanical muddy sediment characteristics in the CH<sub>4</sub> bubble growth dynamics and solute exchange is demonstrated, being comparable to the role of the biogeochemical controls. Their contribution to the emergence of "no-growth" and competitive bubble growth conditions, affecting macro-scale gas dynamics are discussed that encourage a proper experimental evaluation of muddy sediment mechanical characteristics.

## Understanding the past to prepare for the future - Magnitude and frequency of floods in the Judean Desert streams using palaeoflood hydrology

הבנת העבר למען העתיד – העוצמה והתדירות של שטפונות העבר במדבר יהודה על ידי שימוש בפליאווידרולוגיה

Zituni R. (1), Greenbaum N. (1), Benito G. (2), Porat N. (3)

1. Department of Geography and Environmental Studies, University of Haifa, Mt. Carmel, Haifa 3498838, Israel.
2. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel
3. Department of Geology, National Museum of Natural Sciences (MNCN), CSIC, Serrano 115 bis, 28006, Madrid, Spain

[zitunirami@gmail.com](mailto:zitunirami@gmail.com)

The Judea Desert constitutes a distinctive hydrological region characterized by short and steep ephemeral streams draining eastward to the Dead Sea Valley. The hydrological data for these streams is scarce, leading to poor estimation of magnitude and frequency of floods. The lack of data is particularly significant when it comes to risk assessment for infrastructure. The current study is based on Palaeoflood Hydrology which uses geomorphological evidence for real floods that accumulate in typical natural traps, along the course of the streams for hundreds and thousands of years. Those evidences indicate on the minimum water elevation enabling discharge calculations using HECRAS hydraulic engineering software. The ages of the floods are determined by radiocarbon and OSL dating of the flood deposits. The collection of these data enables to reconstruct the history of the floods in the streams including/at least the largest event that occurred in the stream during the last hundreds to thousands years. By combining these data with measured and historical data (if any), a long, solid database can be reconstructed. The largest flood that occurred in the stream serves as a control on regional envelope curves. The streams in this study are: Darga (71 km<sup>2</sup>), Arugot (217 km<sup>2</sup>), Ze'elim (250 km<sup>2</sup>) and Rahaf (55 km<sup>2</sup>), along with Heimar (450 km<sup>2</sup>) and Ashalim (35 km<sup>2</sup>) from previous study. The maximum reconstructed palaeodischarges were 300, 830, 900, 1250, 1100 and 400 m<sup>3</sup>/sec, respectively in relation to the maximum measured peak discharges of about 140, 530, 680, 525, 540 and 100 m<sup>3</sup>/sec, respectively. Frequency analyses using Max and FLDFRQ3 programs with the integrated data (systematic and palaeo) shows in some cases a significant decrease in the discharge values for low probabilities, while in others, the opposite trend was obtained. In all streams, the values for the integrated data are significantly more reliable.

## Dynamics of biogenic silica fluxes in the southeastern Levantine basin

דינמיקה של שטפי סיליקה ביוגנית בדרום-מזרח אגן הלבנט

Kuzyk T. (1), Katz T. (2), Sisma-Ventura G. (2), Weinstein Y. (1)

1. Department of Geography and Environment, Bar-Ilan University, Ramat-Gan, 52900, Israel.

2. Israel Oceanographic & Limnological Research Ltd., Tel-Shikmona, P.O.Box 8030, Haifa 31080, Israel.

[tkuzk6@gmail.com](mailto:tkuzk6@gmail.com)

The southeastern Levantine basin is one of the most oligotrophic seas in the world. This was aggravated by the damming of the Nile River in the 1960s, which caused a severe decline in nutrients and silica discharge to the eastern Mediterranean. Such oligotrophic, low silica conditions are unfavorable for the growth of diatoms and other siliceous phytoplankton which are the main primary producers in nutrient-depleted marine environments. Up to date, the Si cycle and the importance of diatoms in the southeastern Levantine Basin were scarcely studied. Therefore, little is known about the dynamics of the silica cycle in this basin and its importance in carbon export processes. Here we present first BSi measurements from time series sediment traps, deployed between Dec 2017 and Dec 2019 at the DeepLev marine station (1500 m depth, ~50km offshore) at depths of 180, 280 and 1300 m. The BSi fluxes at 180 m depth demonstrated strong seasonality with lower values in summer and autumn (mean = 0.04 mg m<sup>-2</sup> d<sup>-1</sup>) than in the productive winter-spring season (mean = 1.00 mg m<sup>-2</sup> d<sup>-1</sup>). Moreover, the lowest sediment trap, at 1300 m recorded higher BSi fluxes than at 180 m, with means of 0.58 and 4.92 mg m<sup>-2</sup> d<sup>-1</sup> during the summer-autumn and winter-spring seasons respectively. This finding implies lateral input of Biogenic silica, from the nearby margins between 180 and 1300 m. Despite the depletion of silicic acid in the basin, many diatom species were detected in all three traps. Their abundance and taxonomic identification are currently being analyzed. These preliminary results are invaluable for the understanding of the silica dynamics with relation to the carbon flux, which will be further studied.

## Evidence for trapped Pliocene seawater within a tectonically uplifted Eocene chalk formation

עדות למי ים פליוקנים כלואים בקירטונים איאוקנים שעברו הרמה טקטונית

Reznik I.J (1), Rabinovitch N. (1,2), Netzer L. (3), Livshitz Y. (3), Lazar B. (2), Bar O. (1)

1. Geological Survey of Israel, 32 Yesha'ayahu Leibowitz, Jerusalem 9692100, Israel

2. The Fredy and Nadine Herrmann Institute of Earth Sciences, The Hebrew University of , Jerusalem, 9190401, Israel

3. Israeli Hydrological Service, Israeli Water Authority, 7 Bank Israel, Jerusalem.

[reznik@gsi.gov.il](mailto:reznik@gsi.gov.il)

Tectonically uplifted ancient seawater, enriched in  $\text{Ca}^{2+}$  and  $\text{SO}_4^{2-}$ , was found within an exposed chalk formation (Avdat) of Eocene age at the Judea Mt. foothills (Shfela). This enriched seawater (along with its diluted derivatives) was found at elevations of 200-300 m above mean sea level (aMSL), which are substantially higher than maximum flooding surface recorded since the Eocene. Four tectonic phases led to the uplift of the Eocene marine chalks to their modern-day exposures. By the third uplift phase (early-middle Miocene), the cumulative uplift of the Judea Mountains and its foothills was ~1 km. This uplift was followed by a 10 My tectonic quiescence during which the region was subjected to several transgression-regression cycles (including the Messinian salinity crisis). Each transgression abraded a wave-cut platform on which shallow marine sediments and evaporites (including gypsum) were deposited. The fourth and final uplift phase (Pliocene) raised the Shfela region by an additional 350 m to its current elevation, completely exposing the Judea Mountains and its foothills. Therefore, this tectonic reconstruction suggests that the seawater has been preserved at least since the Pliocene in the lower Shfela, despite being exposed to direct meteoric precipitation and despite undergoing a tectonic uplift to the current elevation of ~250 m aMSL. This preservation is attributed to the dual-permeability behavior of the chalks (low matrix permeability and high fracture permeability), which channeled rainfall to the underlying formations while allowing only partial dilution of the porewater since the Pliocene. The trapped seawater retained most of its major ionic ratios (e.g.,  $\text{Na}^+/\text{Cl}^-$  and  $\text{Mg}^{2+}/\text{Cl}^-$ ). However, thermodynamic calculations suggest that the intruding seawater dissolved gypsum, which was deposited during the Miocene transgression-regression cycles, until reaching saturation. Subsequently, the  $\text{Ca}^{2+}$  and  $\text{SO}_4^{2-}$  enriched seawater was gradually diluted by meteoric water, thereby explaining constant  $\text{SO}_4^{2-}$  enrichment factor in the studied water.

## Lead-210 measurements on short cores from the Haifa Bay surroundings

Wan G (1), Teutsch N. (2), Jacob Silverman (3), Nimer Taha (1), Revital Bookman (1)

1. Dr. Moses Strauss Department of Marine Geosciences, Charney School of Marine Sciences, University of Haifa, Mount Carmel, Haifa 31905, Israel
2. Geological Survey of Israel, Jerusalem 9550161, Israel
3. Israel Oceanographic and Limnological Research, Haifa 31080, Israel

Industrialized bays are hotspots of pollution, specifically heavy metals (HM). The low water energy of the bay, adsorption of HMs to settling inorganic particles and their incorporation in the marine food web causes the retention and accumulation of HMs in bay bottom sediments and biota. Where, only resuspension of bottom sediments and transport during storm events or incorporation of dissolved HMs in planktonic biota can transport HMs out of the bay. Thus, reduction of HM discharge from industrial sources could slow down heavy metal accumulation in bay bottom sediments and even reverse it to background levels, as recently observed in Haifa Bay. Thus, it is hypothesized that the pollution history of bays is better preserved in deeper sediments near their mouths, which are less susceptible to wave action and resuspension. In this study, a series of short cores (20-30 cm) were sampled in 2020 along the 65-meter isobath west of Haifa Bay. The cores were sliced every 0.5-1 cm and the activity of  $^{210}\text{Pb}$  in each slice was measured by OCTETE-PLUS Alpha Spectrometry System. Lead-210 profiles were fitted to the measurements with Constant Rate of Supply (CRS) and Constant Initial Concentration (CIC) models, also taking into consideration variations in grain size distribution for adjusting modeled accumulation rates. According to the modeled profiles, the highest sedimentation rate at the shallow site calculated using the CRS model reached  $0.394 \text{ g}\cdot\text{cm}^{-2}\cdot\text{yr}^{-1}$  at depth of 0.5 cm, while the average sedimentation rate was around  $0.144\pm 0.15 \text{ g}\cdot\text{cm}^{-2}\cdot\text{yr}^{-1}$  within all cores. Finally, the three cores that were sampled across from the center of the bay had double and even triple the sedimentation rate of other sampling sites to the north and south which are more than  $0.1 \text{ g}\cdot\text{cm}^{-2}\cdot\text{yr}^{-1}$ . The results show sediment (and HM) transportation and accumulation is highly dynamic and is probably also affected by recent dredging and dumping activities within the bay.