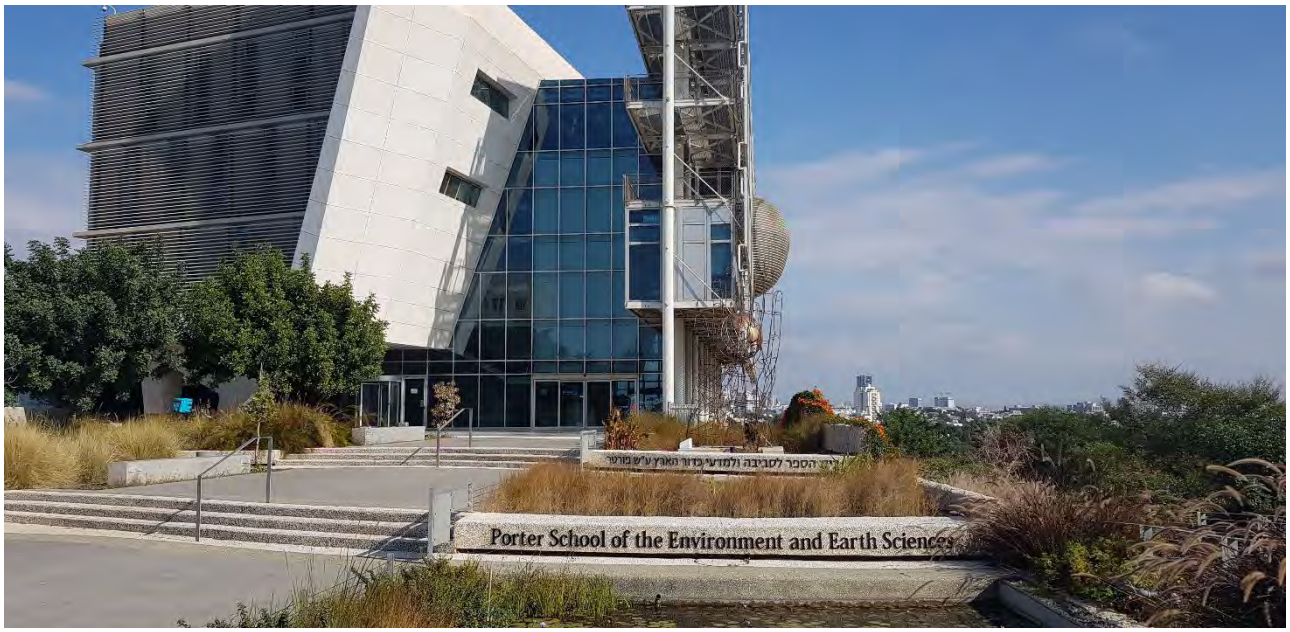

Symposium

Geodynamics, Sedimentary Basins and Georesources

Department of Geophysics
Porter School of the Environment and Earth Sciences
Tel Aviv University

Prof. Klauzner Str., Ramat Aviv 6997801, Tel Aviv, Israel

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Geodynamics, Sedimentary Basins and Georesources

Geodynamics deals with dynamic processes in the Earth's interior and on its surface. Thermal convection in the mantle, hotspots and mantle plumes, lithosphere dynamics and plate subduction as well as their surface manifestation, such as sedimentary basins, are among principal geodynamic problems. Sedimentary basins attract considerable attention of geoscientists as the basin study, apart from scientific importance, is of practical significance due to energy resources located within the basins. Sedimentary basins evolve in depressions of the Earth's crust caused by tectonic subsidence and accumulation of sediments. As the sediments are buried, they undergo the compaction and lithification processes due to the pressure increase and transform into sedimentary rocks. Under the weight of the rocks, sedimentary basins become deeper and their cover thicker. Considerable accumulation of salt deposits in a sedimentary basin leads to deformations of overlain sediments and results in salt tectonics. Salt diapirs possess physical properties that lead to natural traps of hydrocarbons and allow engineering of cavities for storage of fuels or CO_2 waste. As heat comes from the mantle and the crust, it warms sedimentary basins above, and hence influences the maturation of hydrocarbons. Meanwhile the heat can be used as a geothermal energy providing a transition from fossil fuel to renewable energy sources. This symposium addresses the problems of regional geodynamics, sedimentary basin evolution, heat and mass transfer in the Earth, salt tectonics, and energy resources for future generations. This symposium is dedicated to the 85^{th} birthday of Professor Yuri Volozh.

Scientific Organizers

Lev Eppelbaum, Tel Aviv University, Israel

Alik Ismail-Zadeh, Karlsruhe Institute of Technology, Germany

Local Organizers

Lev Eppelbaum, Tel Aviv University, Israel

Nathan Scharff, MOSESTRO Exploration, Israel

Professor Yuri Volozh

Yuri Abramovich Volozh is a Kazakh, Russian, and Israeli geologist, an expert in the Pricaspian Basin evolution, salt tectonics, and one of the discoverers of the Kashagan oil-and-gas field in Kazakhstan. He was born on 30 March 1938. In 1959, he graduated from the Department of Geology of the Kazakh State University, and then worked in geophysical organizations of the USSR Ministry of Geology in Belarus and Kazakhstan. Yuri received his PhD in 1971; his thesis addressed the formation and evolution of the Pricaspian Basin. In 1973, he was appointed a senior geologist at the Laboratory of Regional Studies of the Kazakh branch of the USSR Institute of Applied Geophysics, where he was engaged in interpretation of deep seismic profiles and continued studies of sedimentary basins. From 1977 to 1991, he founded and led the Laboratory of Seismic Stratigraphy in the Institute of Geological Sciences of the Kazakh Academy of Sciences. In 1990, he wrote a monography *Sedimentary Basins of Western Kazakhstan*, which became a basis for his Habilitation thesis (Doctor of Science). In 1991, Yuri moved to Moscow to take a position of Chief Scientist at the Geological Institute of the Russian Academy of Sciences. For several last years, Professor Volozh lives and works as a Regional Geologist at Mosestro Exploration Company in Tel Aviv.

Yuri Volozh is an author of more than 100 scientific papers on the geological structures and oil-and-gas prospecting of sedimentary basins, and on methods of geological interpretation of geophysical and seismological data. He co-authored four monographs, a number of tectonic maps, and maps of oil-and-gas prospects in Kazakhstan and in the former Soviet Union. He is an author of an international Atlas of Palaeogeographic and Palinspastic Maps of Central Asia. Under his leadership, a new model of the structure of the Astrakhan carbonate massif was developed. Yuri Volozh contributed to the discoveries of the gas fields “West Astrakhan” in the Astrakhan region and “Khongr” in Kalmykia. He is an author of monographs “Astrakhan Carbonate Massif: Structure and Oil-and-gas Content" and “Orenburg Tectonic Junction: Geological Structure and Oil-and-gas Content". Yuri Volozh was bestowed several professional awards: the “Discoverer" Badge for the discovery of the Kumkol gas-and-oil field and the “Honored Geologist” Badge of the USSR Ministry of Geology; the 2015 Shatsky Prize of the Russian Academy of Sciences; and the 2022 Embamunaigas Medal of the Kazakh Oil Company.

PROGRAM

08:15-8:45 Morning Coffee/Tea

8:45-11:00 Session 1 (chairs: *Lev Eppelbaum and Alik Ismail-Zadeh*)

08:45 Welcome and Introduction

09:00 Mechanisms of Geodynamics and Earthquakes
Carlo Doglioni

09:30 Geophysical Studies of the Crustal Structure Along the Southern Dead Sea Fault
Zvi Ben-Avraham

10:00 Formation of the Levant Basin and its Place in the Large-Scale Regional Tectonic Framework
Zvi Garfunkel

10:30 East European Sedimentary Basins Stewed Over an Ancient Mantle Upwelling
Alik Ismail-Zadeh, *Anne Davaille, Jean Besse, Yuri Volozh*

11:00-11:30 Coffee/Tea Break

11:30-13:00 Session 2 (chair: *Lev Eppelbaum*)

11:30 Limited Mediterranean Sea-Level Drop During the Messinian Salinity Crisis Inferred from the Buried Nile Canyon
Zohar Gvirtzman, *Hanneke Heida, Daniel Garcia-Castellanos, Oded Bar, Elchanan Zucker, Yehouda Enzel*

12:00 Initiating Salt Tectonics by Tilting: Viscous Coupling Between a Tilted Salt Layer and Overlying Brittle Sediment
Itzhak Hamdani, ***Einat Aharonov****, Jean-Arthur Olive, Stanislav Parez, Zohar Gvirtzman*

12:30 From Evaporation to Evaporites: Lessons From the Dead Sea, the Closest Modern Analog for Deep Evaporitic Basins
Nadav G. Lensky, *Ido Sirota, Ziv Mor, Ali Arnon, Yehouda Enzel, Tim K. Lowenstein, Eckart Meiburg*

13:00-14:00 Lunch

14:00-16:00 Session 3 (chair: *Yuval Bartov*)

14:00 Use of Sedimentary Basins for Sustainable Energy Supply
Frank R. Schilling

14:30 Multi-scale depositional successions in tectonic settings and their bearing for quantifying georesources
Liviu Matenco*, Bilal U. Haq*

15:00 Azraq–Sirhan-Irbid rift and tectonics of the Northern Israel and Lebanon
Vladimir Lyakhovsky

15:30 Influence of Deep Geodynamics on the Subsurface Features in the North African-Arabian region
Lev Eppelbaum*, Zvi Ben-Avraham, Youri Katz*

16:00-16:30 Coffee/Tea Break

16:30-18:00 Session 4 (chair: *Alik Ismail-Zadeh*)

16:30 Assessment of Hydrocarbon Resources Using Basin Modeling: Phase 1 of the Eurasia Project
Sergei Khafizov*, Baltabek Kuandykov*

17:00 Deep Exploration On-shore Israel – New Observations and Targets
Yuval Bartov*, Stepan Vygovskiy, Yuri Volozh*

17:30 ***Yuri Volozh*** Concluding remarks

ABSTRACTS

Deep Exploration On-shore Israel – New Observations and Targets

Yuval Bartov, Stepan Vygovskiy, Yuri Volozh

MOSESTRO Exploration LLP

Israel's onshore oil exploration suffered some bad timing while major drilling efforts, along the years, missed important technology and research developments. Recently, major efforts have been conducted to improve the deep subsurface imaging to obtain a more accurate regional picture of the deeper geological horizons. New processing technologies were developed and applied to most of the existing seismic data and reassembled into a unified subsurface geological model of time and depth migrated data. This huge data base has been the pivot of a new approach to observe some of the exploration concepts that were used in the past. It has long been suggested that Central Israel is an extension of the well-known oil and gas province of the Central Syria - the Palmyrides. Such recognition spotlights the significance of the evaporitic deposits from the late Triassic Carnian age. In Palmyra these deposits serve as a seal on the deformed structures that prevent any leakage of hydrocarbons from deeper horizons to the above Jurassic beds. If so, this may partly explain the lack of success in Jurassic discoveries in Israel. Two key components need to be considered, deep source rock existence within the Triassic or Paleozoic age and adequate seal created at the top of the Triassic. A major difficulty of the seal integrity was associated with the fault reactivation that jeopardized the integrity of the Triassic evaporite seal. The newly interpreted data sets the stage for the new look at deep structures and the analogous comparison of significant parts of the onshore of Israel with the Syrian Palmyrides. Recognizing these structures marks a new potential of petroleum systems in the region.

Geophysical Studies of the Crustal Structure Along the Southern Dead Sea Fault

Zvi Ben-Avraham

Department of Geophysics, Tel-Aviv University, Israel

The Dead Sea Fault (DSF) is an active transform fault linking opening in the Red Sea with collision in the Taurus/Zagros Mountains. Motion is left-lateral and estimated at approximately 5–7 mm/year. The fault is seismically active. The extensional regime combined with the dominant lateral motion along the DSF resulted in the formation of a series of deep pull-apart basins. These basins are among the largest and deepest in the world. The crustal structure of the DSF and its surroundings played a significant role in the development of the physiography and the architecture of the basins. The subsurface structure of the southern DSF has been studied quite intensively by various geophysical methods over the past few decades. This review summarizes the main geophysical findings of the crustal structure under the deep basins along the southern DSF, comparing the three deep basins against each other in contexts of various geophysical properties, and discussing their tectonic implications. A simulation of faulting processes along the northern DSF and the Levant margin suggested that the formation of the DSF could be explained as a result of simultaneous propagation from the north and south. Normally most basins are bordered only on one side by a strand of the DSF, leading to their asymmetry. Where asymmetry occurs, basins do not extend to great depth. In areas where the deep basins occur, two strands of the DSF overlap in an en-echelon pattern. This situation is quite rare along the DSF. It is suggested that in these places an isolated block of lithosphere has dropped into the mantle. Simulations of this mechanism indicate that the resulting basin is rhomb-shaped and that with time it grows by the addition of distinct segments to its edges.

Mechanisms of Geodynamics and Earthquakes

Carlo Doglioni

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Sapienza University of Rome, Rome, Italy

The processes occurring on the Earth are controlled by several gradients. The surface of the Planet is featured by complex geological patterns produced by both endogenous and exogenous phenomena. While large part of the scientific community agreed that either bottom-up or top-down driven mantle convection is the cause of lithospheric displacements, geodetic observations and geodynamic models also support an astronomical contribution to plate motions. Moreover, several evidences indicate that tectonic plates follow a mainstream and how the lithosphere has a roughly westerly drift with respect to the asthenospheric mantle, generating evident signatures of asymmetric plate boundaries as a function of the subduction polarity. An even more wide-open debate rises for the occurrence of earthquakes, which should be framed within the different tectonic setting, which affects the spatial and temporal properties of seismicity. In extensional regions, the dominant source of energy is given by gravitational potential, whereas in strike-slip faults and thrusts, earthquakes mainly dissipate elastic potential energy indeed.

Influence of Deep Geodynamics on the Subsurface Features in the North African-Arabian region

Lev Eppelbaum[1], Zvi Ben-Avraham[1], Youri Katz[2]

[1] *Department of Geophysics, Tel Aviv University, Israel*

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The tectonic–geodynamic characteristics of the North African–Arabian region are complicated by the interaction of numerous factors. To study this interaction, we primarily used satellite gravimetric data (retracked to the Earth's surface), which has been acknowledged as a powerful tool for tectonic–geodynamic zoning. The applied polynomial averaging of gravity data indicated the presence of a giant, deep quasi-ring structure in the Eastern Mediterranean, the center of which is located under the island of Cyprus. Simultaneously, the geometrical center of the revealed structure coincides with the Earth's critical latitude of 35o. A quantitative analysis of the obtained gravitational anomaly made it possible to estimate the depth of the upper edge of the anomalous body as 1650–1700 km. The GPS vector map coinciding with the gravitational trend indicates the counterclockwise rotation of this structure. A review of paleomagnetic data on the projection of the discovered structure into the Earth's surface confirms its mainly counterclockwise rotation. Analysis of the geoid anomalies map and seismic tomography data commonly prove the presence of this deep anomaly. The structural and geodynamic characteristics of the region and paleobiogeographic data are consistent with the proposed physical–geological model. A comprehensive analysis of petrological, mineralogical, and tectonic data suggests a relationship between the discovered deep structure and near-surface processes. The generalization of all these factors testifies that the probability of a random coincidence is extremely small. The recognized deep structure also sheds light on specific anomalous effects in the upper layer of the crust, including the high-intensity Cyprus gravitational anomaly, counterclockwise rotation of the Mesozoic terrane belt (MTB), the configuration of the Sinai Plate, and asymmetry of sedimentary basins along continental faults. The existence of the mentioned above phenomenon is confirmed by an examination of numerous publications by different authors. Besides this, the last catastrophic geodynamic events in Eastern Turkey prove this concept.

Formation of the Levant Basin and its Place in the Large-Scale Regional Tectonic Framework

Zvi Garfunkel

Institute of Earth Sciences, The Hebrew University, Jerusalem, Israel

The Levant basin formed in the Triassic (Late Permian?) by rifting and detachment of blocks from the northern margin of the Arabian-NE African platform that led to much ca. W-E stretching of the Levant margins and addition of igneous material. The stretching was for some time related to sinistral slip along the NE African margin. Coevally the tectonic behavior of the adjacent platform changed considerably: the pattern of its vertical motions was reorganized, and local deformation accompanied by sporadic igneous activity affected its margin. By mid-Jurassic times up to 7-8 km thick sediments accumulated in the basin and a >1 km high slope developed along its margins. These developments express widespread Permian-Triassic tectonic activity. West of our area African margin was modified, and marine Permian-Triassic sediments derived from Africa, and some volcanics accumulated next to it. Then rifting that created the oceanic crust of the Ionian-Herodotus basin separated these series (now included in the Hellenides) from Africa. The structural development of the Variscan edifice also changed before the end of the Permian, and in the Triassic much of it was affected by normal faulting and by magmatic activity. Eventually this led to rifting the fragmentation of the Variscan edifice in central and SE Europe, and also to significant seafloor spreading in the central Atlantic. Thus, the formation of the Levant basin expresses a new stage, 70-100 Ma long (Late Permian-Triassic), of widespread extensional tectonism and magmatic activity, which developed within a short time interval in a large area. Most likely, this records a major reorganization of the flow and temperature distribution in the mantle in a large area that changed the stress and deformation close to the surface and allowed magma production in many places. How this happened within the observed time framework is a challenge for future research.

Limited Mediterranean Sea-Level Drop During the Messinian Salinity Crisis Inferred from the Buried Nile Canyon

Zohar Gvirtzman[1,2], Hanneke Heida[3], Daniel Garcia-Castellanos[3],
Oded Bar[1], Elchanan Zucker[1,2], Yehouda Enzel[1,2]

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The extreme Mediterranean sea-level drop during the Messinian salinity crisis has been known for >50 years, but its amplitude and duration remain a challenge. Here we estimate its amplitude by restoring the topography of the Messinian Nile canyon and the vertical position of the Messinian coastline by unloading of post-Messinian sediment and accounting for flexural isostasy and compaction. We estimate the original depth of the geomorphological base level of the Nile River at ~600-m below present sea level, implying a drawdown 2-4 times smaller than previously estimated from the Nile canyon and suggesting that salt precipitated under 1-3-km deep waters. This conclusion is at odds with the nearly desiccated basin model (>2 km drawdown) dominating the scientific literature for 50 years. Yet, a 600-m drawdown is ca. five times larger than eustatic fluctuations and its impact on the Mediterranean continental margins is incomparable to any glacial sea-level fall.

Initiating Salt Tectonics by Tilting: Viscous Coupling Between a Tilted Salt Layer and Overlying Brittle Sediment

Itzhak Hamdani[1,2], Einat Aharonov[1], Jean-Arthur Olive[3],
Stanislav Parez[4] , Zohar Gvirtzman[1,2]

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Salt basins often exhibit a shelf/slope region of extension and a deeper domain of contraction. The up-slope normal faults in such salt tectonics systems are often associated with the pinchout edge of the buried salt layer. Although the spatial correlation between the normal faults and the salt pinch-out was previously observed, the mechanism was not fully explained. The Levant basin, which is a young and mildly deformed salt basin with a relatively thin overburden, provides an opportunity to analyze a simple salt tectonics system driven by basin margin tilt, and the formation of the normal faults. I present analytical and numerical modeling of the coupled viscous salt and overlying viscoplastic sediment layer. Results suggest the viscosities of both the sediment overburden and salt, as well as their thicknesses, control the deformation of the coupled layers. The visco-plastic deformation mechanism explains quantitatively the position of faulting and observations of the temporal evolution of brittle deformation in the Levant basin margin. It predicts that the largest stress in the overburden arises above the salt edge, driving normal faulting at that location. Our model also places quantitative constraints on the effective viscosity of the overburden, which is consistent with experimentally determined creep laws. Our results contribute to the understanding of halokinematics in salt basins during the early stages of deformation and will allow better assessment of geological hazards related to salt related deformation.

East European Sedimentary Basins Stewed Over an Ancient Mantle Upwelling

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A strong negative anomaly of seismic wave velocities at the core-mantle boundary beneath the East European platform (the Perm Anomaly) is attributed to a remnant deep mantle upwelling. The interaction between the upwelling and the East European lithosphere in the geological past and its resulting surface manifestations are still poorly understood. Using mantle plume modelling and global plate motion reconstructions, we show here that the East European lithosphere has been situated over the weakening Perm Anomaly upwelling for about 150-200 million years. As the East European platform moved above the Perm Anomaly in post-Jurassic times, the vertical tectonic movements recorded in sedimentary hydrocarbon-rich basins show either hiatus/uplift or insignificant subsidence. Analytical modelling of heat conduction through the lithosphere demonstrates that the basins have been thermally stewing above the Perm Anomaly upwelling, creating suitable conditions for hydrocarbon maturation. This establishes a profound relationship between mantle plume dynamics, basin evolution, and hydrocarbon generation.

Assessment of Hydrocarbon Resources Using Basin Modeling
Phase 1 of the Eurasia Project

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The object of the study and basin modeling was the area of the Pricaspian Basin and surrounding areas. According to the results of the work performed, more than 70% of all accumulated hydrocarbons are contained in the Visean-Bashkir and Upper Devonian deposits. The Lower Devonian deposits are productive at the Chinarevskoye field and in the northern-northwestern parts of the depression. Basin modeling showed the following features of the hydrocarbon accumulation. In the west, the simulated field is characterized by an increased content of gaseous hydrocarbons (80-100%) correlating with data, for example, the Astrakhan gas condensate field. In the east and south-east proportion of a liquid fraction increases to 60-80% reflecting a known pattern of higher oil potential of the eastern side of the Pricaspian Basin. In the northern flank, we obtained an increase in the content of liquid components relative to the central part of the basin. The model mainly reproduces known fields, although various scenarios have been calculated during the modeling process, one of which made it possible to assess the possibility of fields in the deep-water fans in the central part of the Pricaspian Basin, without adjusting standard basin modelling algorithms. The total estimated potential of the generated hydrocarbons is 4.60 trillion tons (in place). The average accumulation coefficient is usually estimated at about 5% of the total volume of generated hydrocarbons. Thus, the volume of localized hydrocarbons is very conditional, which in our case is about 200-250 billion tons with the geological exploration maturity about 20-25% or lower. The model demonstrates prospects in layers and regions, where there are currently no discoveries or exploration. This is exactly the potential of the future, for which the Eurasia project has been initiated.

From Evaporation to Evaporites: Lessons from the Dead Sea, the Closest Modern Analog for Deep Evaporitic Basins

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Thick halite sequences are common in the Earth's geologic record; they were accumulated in deep perennial hypersaline water bodies, saturated to halite and subjected to negative water balance. For decades, evaporites research gained insights from exploring modern shallow hypersaline environments, including the relations between the hydroclimatic forcing and the deposited halite layers. However, there is a knowledge gap in understanding limnological controls on accreted halite sequences in deep water bodies. Such water bodies rarely exist today on Earth, but were common through Earth geological history, e.g. the Messinian Salinity Crisis in the Mediterranean. The Dead Sea is currently the closest and probably the only modern analog for such environments. Recently, based on direct field measurements, laboratory experiments, direct numerical simulations, and sedimentological investigation, we have shown that there are fundamental differences between deposition at deep basins versus shallow basins, specifically in the seasonal to multi-annual scales and variations of halite solubility with depth. We have found that during the dry summer the epilimnion is warmer, saltier and undersaturated to halite, and that double diffusion flux delivers dissolved salt from the epilimnion into the hypolimnion, resulting in the continuously supersaturated hypolimnion and seasonally undersaturated epilimnion. Thus the stratified structure of the lake's water column results in focusing of halite deposits into the deep parts of the basin and thinned deposits, or entirely dissolved, in the marginal parts. We further explore the role of laterally variable hydroclimatic conditions to the spatiotemporal dynamics of evaporitic deposits in a deep hypersaline waterbody. These can contribute to the study of the depositional environments of halite units throughout the geological record, following the concept of "the present as key to the past".

Azraq–Sirhan-Irbid Rift and Tectonics of the Northern Israel and Lebanon

Vladimir Lyakhovsky

Research Scientist Grade A+ (retired), Geological Survey of Israel

Propagation, evolution and geometry of plate-bounding faults such as the Dead Sea Transform are strongly related to interactions between major pre-existing fault systems and adjacent continental margins. We review, compile and evaluate the geological and geophysical data from major fault systems in the Levant, including the Azraq–Sirhan Graben and Irbid rift zone (northwest Jordan) and the Dead Sea Transform, in the aim of better understanding their structure, evolution and mutual relations next to the Levant continental margin. We study the pre-Dead Sea Transform re-activation and propagation of the Azraq–Sirhan-Irbid continental rift and its interaction with a continental margin utilizing a 3-D lithospheric model with a seismogenic crust governed by a damage rheology. We address a long-standing problem in rift-mechanics, known as the tectonic force paradox, is that the magnitude of the tectonic forces required for rifting are not large enough in the absence of basaltic magmatism. We also show that the style, rate and the associated seismicity pattern of the rift zone formation in the continental lithosphere depend not only on the applied tectonic forces, but also on the strength memory effects providing a feasible solution for the tectonic force paradox. Our modeling results also demonstrate how the lithosphere structure affects the geometry of the propagating rift system toward a continental margin, and consider the continental transform–rift interaction adjacent to a continental margin. The present-day asymmetric uplift of the Lebanon Mountains, located at the fringe of an active plate boundary, the Dead Sea Fault system, together with subsidence of the Lower Galilee in northern Israel provides an exceptional example of the complex deformational pattern associated with a restraining bend. Our modeling results suggest that the extension observed in the Lower Galilee region and the asymmetric uplifted pattern west of the Lebanese Restraining Bend is the outcome of three interacting factors, which are the sinistral strike-slip motion along the Lebanese Restraining Bend, the significant variations in the crustal structure (depth to Moho), and the slow extension of the Irbid-Azraq rift zone. The presented modeling approach might be useful to other plate bounding faults and sheds light on features of large strike-slip fault systems.

Multi-scale Depositional Successions in Tectonic Settings and Their Bearing for Quantifying Georesources

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Observations in sedimentary basins affected by significant amount of deformation shows that the fault-induced depositional space, at various spatial and temporal scales, is closely linked to the basin kinematics and influence the formation of conventional and sustainable georesources. The tectonically-driven sediment infill reflects the history of deepening and shoaling facies controlled by the activation and changes in the fault's offset rates. Simply stated, this translates as shifting sedimentary facies towards the basin center or towards the source area in response to increasing or decreasing depositional space. We developed a first-principle conceptual model for tectonic successions, controlled by the balance between the rates of creation of depositional space and sediment supply. These sediment bodies are bounded by succession boundaries and comprise basinward or sourceward shifting facies tracts that are separated at a point of reversal. Due to the relatively steep slopes associated with the evolution of faults, changes in sediment supply rates and mass-wasting is common phenomena in these systems and may complicate the normal rhythm of the shifting facies tracts. Once tectonic quiescence is achieved, and if the basin is connected to the open ocean, eurybathic or eustatic changes may take over and play a greater role in sediment deposition and cyclicity. The efficacy of the new concept is illustrated by examples from extensional, contractional and strike-slip basins and its success demonstrated by applications in syn-tectonic sedimentation worldwide. The basic tectonic succession model is applicable at all temporal and spatial scales and whether the tectonics cause subsidence or uplift, and in all types of tectonic settings that drive the evolution of sedimentary basins. The model is able to significantly increase the quantification of geo-resources by improved predictions of sedimentary facies in the tectonically controlled deposition of sedimentary basins.

Use of Sedimentary Basins for Sustainable Energy Supply

Frank R. Schilling

Karlsruhe Institute of Technology, Applied Geosciences, Karlsruhe, Germany

One of the major challenges facing society - as set out in the UN's Sustainable Development Goals (SDGs) - is to ensure a secure, affordable energy supply on the one hand and a climate- and environmentally friendly supply of energy on the other. There seems no doubt that an increasing population and increasing wealth on our planet will lead to an increasing Energy demand – will this last in a destruction of our drinking water supply? In the past, sedimentary basins were mainly used to extract energy resources such as coal, oil, and natural gas, and as an important source of resources such as lithium. In the future, we will very probably require an increasing portion of the space in basins to achieve our climate protection goals. Some of the solutions for a more climate friendly society can be hydrothermal geothermal energy, storage of Energy carrier (e.g. H2) and for negative emissions e.g. (Bioenergy) Carbon Capture and Storage (BE)CCS. Furthermore, sedimentary basins are and will further be used as a repository for nuclear waste and other (energy related) waste, such as high toxic energy saving lamps. In the presentation basic concepts for the use of the underground will be presented a conflict of interest while using the underground will be discussed. How can we use the underground, more efficient and in a synergetic manner? Let us discuss how we want to use this very precious resource to reach the SDGs.

SPEAKER BIOGRAPHIES

Einat Aharonov is Professor of Geophysics and Rock Mechanics at the Institute of Earth Sciences, Hebrew Univ Jerusalem, Israel. She received her BSc degree from the Tel-Aviv Univversity and PhD degree from MIT/WHOI Joint Program, Marine Geology & Geophysics in Cambridge, MA, USA in 1996. Einat worked as postdoc in the Lamont Doherty Earth Observatory (LDEO), Columbia Univ, NY, USA, before she moved to Weizmann Institute of Sciences to take a position of Senior Scientist (2000-2008). Since 2008 Einat is affiliated to the Hebrew Univ initially as Associate Professor, and since 2016 as Full Professor. Einat Aharonov studies coupled physical and chemical processes that control deformation and evolution of rocks, involving coupled fluid and solid deformation. Her group studies also larger scale coupled deformation, such as mechanisms of pockmark formation, modes of salt tectonics, karst formation, and the physics of subduction initiation. Einat works on the boundary between physics and geology, using mainly theoretical and numerical tools.

Yuval Bartov has received his PhD in the Hebrew University of Jerusalem after working on sequence stratigraphy and pleo-climate of the Dead Sea Basin. He worked at the Colorado School of Mines as a postdoc focusing on hydrocarbon, energy research, basin analysis, and CO_2 sequestration in the Piceance and Williston Basins. He moved to Israel as the Chief Geologist of Genie Oil and Gas and worked on oil exploration in Israel and Mongolia. Presently Yuval Bartov is the exploration manager of MOSESTRO Exploration focusing on the deep subsurface of the Northern Negev of Israel. He held teaching positions in Colorado School of Mines, The Technion in Haifa, and in the National University of Mongolia.

Zvi Ben-Avraham is a Professor of Geophysics in the Department of Geophysics, Tel-Aviv University, an Honorary Affiliated Professor at the University of Haifa, and an Adjunct Professor at Cyprus Institute, Nicosia, Cyprus. He is the Head of the National Steering Committee for Marine Affairs in Israel. Zvi established and headed for a long time the Minerva Dead Sea Research Center in Tel-Aviv University. He is also the founding director of the Charney School of Marine Sciences at the University of Haifa and the Founding Head of the Mediterranean Sea Research Center of Israel. In addition, he held the Max Sonnenberg Professor of Marine Geosciences in the University of Cape Town for many years. Zvi was the Scientific Advisor to the President of the State of Israel. Zvi Ben-Avraham received his Ph.D. in MIT and Woods Hole Oceanographic Institution (Marine Geophysics) in 1973. Since then, he gained extensive academic experience at various universities in the U.S. and Europe. He conducted scientific studies in the Atlantic, Pacific and Indian Oceans, the Mediterranean, the Red Sea, the Gulf of Elat, the Dead Sea and the Sea of Galilee. Zvi Ben-Avraham had published over 280 publications in scientific journals and ten books and special issues as author and editor. Zvi is Fellow of AGU and GSA, Member of the Israel Academy of Sciences and Humanities, Academia Europaea, Heidelberg Academy of Sciences, Netherlands Academy of Arts and Sciences, Russian Academy of Sciences, and Georgian National Academy of Sciences. He is a recipient of the Israel Prize and of the L. Meitner - A. von Humboldt Research Award.

Carlo Doglioni is Professor of Geodynamics at the Sapienza University of Rome since 1997, after having worked in the universities of Ferrara, Bari, and Potenza in Italy. He visited several international universities such as Basel, Oxford, Rice Houston, and Columbia Palisades. Since 2016 he is President of the National Institute of Geophysics and Volcanology (INGV). His research focuses mainly on the mechanisms of plate tectonics controlled by the combination of tidal forces and mantle convection, and the origin of seismicity, studies for which he has received numerous awards. He is Member of the National Academy of the Lincei, the National Academy of Sciences called the XL, and Academia Europaea.

Lev Eppelbaum is Principal Research Associate (Associated Professor) at the Dept. of Geophysics, Tel Aviv University. He is the author of about 420 publications, including 10 books, more than 175 articles, and about 70 papers in proceedings. His main research interests are geodynamics and tectonic reconstructions, applied, environmental and archaeological geophysics, and integrated interpretation of geophysical, geological, and related data. He is Associate Editor or member of the editorial Boards of several journals Lev Eppelbaum was selected as chairperson at 22 International Scientific Conferences. He is a member of the International Commission's "Rotation of the Earth" and the WebmedCentral Ecology Advisory Board. Lev Eppelbaum is a recipient of the Christian Huygens Medal of the European Geosciences Union and of the Medal dedicated to the 100th Anniversary of the ASOIU's foundation. He is Honorary Professor of the Azerbaijan State Oil and Industry University. Lev Eppelbaum is an Israeli Correspondent to the International Association of Geomagnetism and Aeronomy of the IUGG.

Zvi Garfunkel

Zvi Garfunkel is Professor Emeritus of the Institute of Earth Sciences, The Hebrew University of Jerusalem, Israel, which he joined after obtaining his PhD degree. He is the principal author or co-author of more than 120 peer reviewed scientific publications. His research interests included many geologic problems, emphasizing tectonics and geodynamics, mainly: geology and plate tectonics of Israel and neighboring countries, emphasizing the Cenozoic rift system, especially the Dead Sea Transform; origin and development of the Eastern Mediterranean Basin; structural relations of strike-slip fault systems and transform faults, salt tectonics and slumping in the Levantine basin; flexure of continental lithosphere, foreland basins; tectonically driven landscape evolution in Israel; retreat (roll back) of subducted slabs; intraplate magmatism and the thermal structure of the lithosphere; and the Pan-African and Cadomian Orogenies. Zvi Garfunkel served as Chairman of the Institute of Earth Sciences, and President of the Geological Society of Israel. He received several awards of the Geological Society of Israel and was elected as Honorary Member of the Society. He received the 2006 EMET Prize handed out by the Prime Minister of Israel. He is GSA Honorary Fellow.

Zohar Gvirtzman is the Director of the Geological Survey of Israel (GSI) and an adjunct professor of geology at the Hebrew University of Jerusalem. He received a B.Sc. in Geology and Computer science; M.Sc. in Geology; and PhD (1997, summa cum laude) in Geology, all from the Hebrew University. After a post-doc (1999) at Stanford University, he joined the GSI (2002), where he established the seismic interpretation laboratory and served as the head of the stratigraphic and subsurface division before appointed as the Director of the Survey. Gvirtzman is a tectono-stratigrapher in training, focusing on sedimentary basins; vertical motions of the lithosphere; and crustal structure. He specializes in the geology of the Mediterranean Sea, Levant continental margin, and geo-hazards related to the marine environment and particularly to salt tectonics. In recent years he joined an international group exploring one of the extreme and enigmatic events in Earth history - the Messinian Salinity Crisis (MSC). He identified the opportunity arising from the Levant Basin, which is the only deep basin in the Mediterranean, where the entire evapotitic sequence was penetrated by industrial wells. Based on the new data he led a series of studies challenging the desiccation paradigm which is dominating the literature for >50 years.

Alik Ismail-Zadeh is Senior Research Fellow at the Karlsruhe Institute of Technology, Germany. He has been a scholar/research professor at academic institutions in Azerbaijan, China, France, Italy, Japan, Russia, Sweden, UK, and USA. His scientific interests cover mathematical geophysics, computational geodynamics, seismology, volcanology, natural hazards, and disaster risks. He is principal (co)author of over 140 peer-reviewed research papers, book chapters, and 10 books and special issues as author and editor. Alik Ismail-Zadeh has been elected to the position of the Secretary-General of the International Union of Geodesy and Geophysics (IUGG, 2007-2019) and inaugural Secretary of the International Science Council (ISC, 2018-2021) He served on advisory committees of several professional, international and intergovernmental organizations. Currently, Alik Ismail-Zadeh chairs the IUGG Commission on Mathematical Geophysics. He is a Member of Academia Europaea, Fellow of AGU, ISC, IUGG, Honorary Fellow of the Royal Astronomical Society, and honored by several awards and medals.

Sergey Khafizov is Professor and Head of Petroleum Systems Analysis Department at the Gubkin Russian University of Oil and Gas. He has 40-year experience in exploration and development geology. He contributed to the discoveries of more than 15 oil and gas fields. He is an author and co-author of more than 100 publications, including 8 monographs, and 4 textbooks. He was a co-organizer of Gazprom Neft R&D Center LLC (2008-12), project manager of Uvat E&A project (2005-2008, Western Siberia, TNK-BP), Chonsky E&A project (2011-12, Eastern Siberia, Gazprom Neft). Sergei Khafizov was Director General of the Gazprom Neft Middle East B.V., Erbil, Kurdistan (2012-13) and Chief-Business Development Officer at Nostrum Oil & Gas PLC (2015-20). His research interests cover regional geology, regional and local forecasting of oil and gas potential, risk assessment of oil and gas projects, Oil & Gas Exploration & Appraisal activity, reserve estimation, and assessment of ultra-deep horizons prospective.

Baltabek Kuandykov is a discoverer of a number of oil and gas fields in Kazakhstan, including a giant Kashagan offshore field. He was a Deputy Minister of Geology and a Deputy Minister of Energy and Fuel Resources of the Republic of Kazakhstan (1991-1994), President and founder of Kazakhstancaspishelf, a company formed to carry out first offshore oil operations for development of the Kazakh sector of the Caspian Sea (1993-1997), President of the National Oil & Gas Company "Kazakhoil" (1997-1998). He worked as an executive consultant at the head office of Chevron Overseas Petroleum Co., USA (1998-2001), President of Canadian Company Nelson Resources (2001-2005). Since 2006 Kuandykov works as the President of Meridian Petroleum – oil and gas assets managing company, since 2009 president of Kazakhstan Society of Petroleum Geologists, and since 2013 general coordinator of the International Eurasia Project. He is an author and co-author of more than 110 scientific papers, including 10 monographs. He was awarded "Kurmet", "Parasat" and "Barys" State Orders, Laureate Kazakhstan State Prize in Science and Technology, Honored Worker of Industry of the Republic of Kazakhstan. He keeps a PhD and Habilitation degrees in Geology and Mineralogy, and is Member of the International Academy of Mineral Resources and AAPG Member.

Nadav Lensky is a Research Scientist and Head of the Dead Sea Observatory at the Geological Survey of Israel, and Adjunct Associate Professor at the Institute of Earth Sciences of the Hebrew University of Jerusalem, Israel. His research focuses on basic questions regarding the controlling processes of large scale Earth environments, and the relations between climatic/environmental conditions and the formation of geological records in unbalanced systems. The Dead Sea, a deep hypersaline lake subjected to negative water balance that precipitates salt layers, is a unique aquatic system on Earth today, which provides a rare opportunity to explore the formation of "salt giants", i.e. ~kilometer thick salt layers in wide sedimentary basins that were common aquatic environments in the past. His main scientific interests covers (i) evaporation and surface heat fluxes, and gas exchange over water bodies along the Dead Sea Rift, (ii) limnology, thermohaline stratification, and diapycnal double diffusion fluxes, (iii) evaporitic sedimentology and halite deposition processes, (iv) geomorphological processes as a response to base-level decline, as well as (v) physical volcanology.

Vladimir Lyakhovsky retired from the position of Research Scientist Grade A+ of the Geological Survey of Israel. He graduated the Dept. of Applied Mathematics of the Moscow University of Gas and Oil Industry in 1981 (thesis *Spectral analysis of the stochastic processes*). He got his PhD in Earth Sciences at Institute of Physics of the Earth, USSR Academy of Sciences in Moscow (thesis *Mechanics of fractured rocks: fault evolution and rheological nature of some seismic boundaries*). Vladimir worked as senior Researcher at the Geological Institute, USSR Academy of Sciences, Moscow (1987-1990), Research Scientist of the Dept. Geophysics and Planetary Sciences of the Tel-Aviv University (1991-1994) and visited Uppsala University and UCLA in 1992-1993 before assuming the position of the Research Scientist at the Institute of Earth Sciences of the Hebrew University of Jerusalem in 1994. In 2001 he moved to the Geological Survey of Jerusalem and worked there before his retirement.

Liviu C. Matenco is Professor of Tectonics and Sedimentary Basins, head of the Tectonics Group in the Utrecht University, Department of Earth Sciences, Faculty of Geosciences at Utrecht University, the Netherlands. He has a PhD degree in Tectonics from VU University Amsterdam, has worked in the university system in Romania and the Netherlands. His research interests are related to sedimentary basins formation and evolution, long-term sediment dynamics and coupling with anthropogenic systems, orogenic structure and coupling with sedimentary basins, lithosphere dynamics, evolution of tectonic-driven sedimentary sequences and source to sink systems. He is author and co-author of more than 130 publications in international refereed journals, eight special thematic volumes of international journals such as Global and Planetary Change or Tectonophysics, Liviu Matenco is Editor in Chief of Global and Planetary Change, Leader of the International Lithosphere Program Task Force Sedimentary Basins, he is Member of Academia Europaea, has received the Burgen Award of Academia Europaea and the "Grigore Munteanu Murgoci" Geosciences award of the Romanian Academy of Sciences.

Frank R. Schilling is Professor of Petrophysics at the Karlsruhe Institute of Technology (KIT), Germany. He has been Heisenberg Fellow of the German Science Foundation and Fellow of the German Academic Scholarship Foundation. He has been asked as expert for European Commission and Parliament, as well as for German Government and authorities. His scientific interests cover mineralogy, geomaterial properties at elevated temperatures and pressures, phase transitions and mantle discontinuities. In the last years he focused more on a sustainable use of the subsurface. Major projects as a project leader had been and are the first onshore storage site for CO_2 in Europe, storage of natural gas and H_2, extraction of natural gas and geothermal energy. He has been Dean of the Faculty of KIT Department of Civil Engineering, Geo and Environmental Sciences, Spokesman of the KIT Climate and Environment Center, and is head of the State Research Center for Geothermal Energy.

GREETINGS

КАЗАХСТАНСКОЕ ОБЩЕСТВО НЕФТЯНИКОВ-ГЕОЛОГОВ
KAZAKHSTAN ASSOCIATION OF PETROLEUM GEOLOGISTS
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Dear Yuri Abramovich!

On behalf of all petroleum geologists of Kazakhstan and on my own behalf, from all my heart I congratulate you on your 85th birthday! On this special day, we are pleased to welcome you - ONE of the leading experts in the areas of petroleum geology science and study of hydrocarbon sedimentary basins. You made a great contribution to the formation and development of the Government Oil and Gas Geological Survey and whole petroleum industry of our country, Doctor of Geological and Mineralogical Sciences, discoverer of many oil and gas fields.

After graduating from the geological faculty of our Kazakh State University in 1959, you worked for about 30 years in various geological and research organizations in Kazakhstan, engaged in the study, interpretation and generalization of regional geological data of complex and poorly studied areas of the Caspian, South Mangyshlak, Ustyurt, South Turgai, Aral and other oil and gas bearing sedimentary basins of the Republic of Kazakhstan. During that period the number of new oil and gas fields were discovered – the Uzen and Zhetybai (Mangyshlak), the Kenkiyak and Prorva. For the first time in the former USSR, you organized a seismic stratigraphic research laboratory at the Institute of Geological Sciences of the Academy of Sciences of the Republic of Kazakhstan, developed the scientific foundations for seismic stratigraphic and sequence stratigraphic analysis with the introduction of these methods into the actual work practice of oil and gas deposits exploration. The following big event in your career was the triumphant completion of the "Turgai epic" with the discovery of new South Torgai oil and gas basin, where a large oil field Kumkol was discovered, the one where are the discoverer.

Based on seismostratigraphic analysis, in 1990 you defended your doctoral degree on the theme "Sedimentary basins of Western Kazakhstan". Your work at the Geological Institute of the Russian Academy of Sciences since 1991 has been crowned with interesting scientific discoveries and research on the territory of the Russian Federation, especially the unique research of the Astrakhan arch, Western Siberia and the discovery of the Zapadno-Astrakhanskoye field in the Astrakhan region and Khongr field in Kalmykia. Many scientists and subsoil user companies of our country use the results of your scientific research of the Precaspian and Northern Ustyurt basins. At present, you are also actively involved in the geological study of the offshore and onshore territories of The Israel.

In 2022 you as a foreign consultant, carried out the active work, provided great assistance in compiling the Final Report "Study of the deep geological structure of the pre-salt deposits of the Kazakhstan part of the Precaspian Basin using advanced and innovative technologies for reprocessing and reinterpreting the available geological and geophysical data in order to implement the program Phase-1 of the international project "Eurasia".

Despite your venerable age, you, Yuri Abramovich, continue to work tirelessly today, provide assistance and advice to various oil and gas companies in every possible way, are a permanent and active participant in many conferences, seminars and forums that are conducted by the Kazakh Association of Petroleum Geologists, constantly publish your scientific papers on geology and geophysics in our country oil and gas press. We know YOU as a respected scientist, the author of more than a hundred scientific papers on the geological structure and oil and gas potential of various regions, the author of four monographs, the author of a number of tectonic maps and maps of oil and gas potential of Kazakhstan and the former Soviet Union territory. Many of your works are still actively used by subsoil user companies in order to solve their problems during oil production.

Dear Yuri Abramovich, for the geologists of Kazakhstan, you remain a generator of new ideas and an innovator who has rallied a powerful cohort of like-minded people around you. With selfless work, you have earned a well-deserved respect among fellow petroleum engineers, geologists and the management of the oil and gas industry of our republic.

Considering your great merits in the geological study of our country, you, Yuri Abramovich, were awarded the medal of the Ministry of Energy of the Republic of Kazakhstan "For merits in the development of the oil and gas industry of Kazakhstan" and the medal of the National oil and gas company JSC "NC"Kazmunaygas", "100 years of JSC "Embamunaygas". You have been awarded the high titles of "Honorary Explorer of the Subsoil of the Republic of Kazakhstan" and "The hydrocarbon field discoverer of the Republic of Kazakhstan" for the discovery of the Kumkol gas and oil field, etc.

From all of our hearts, we congratulate you, Yuri Abramovich, on your glorious 85th birthday! We appreciate you and are proud of you. Be healthy, happy and have a long life.

President

Kazakh Association of Petroleum Geologists

Baltabek Kuandykov