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Contents

The Morphology of the Continental Terrace of Northern Israel and Northern Lebanon: Structure and Morphology

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The continental terrace of the southeastern Mediterranean is the product of (1) Nile-derived sediment accumulation, whose bulk and rate of deposition decrease along the Levant continental margin with increasing distance from the Nile mouths, and (2) of the vertical tectonic uplift of continental Israel and Lebanon versus the subsidence of the adjacent Levant Platform which intensifies to the north. The continental terrace in the study area is made of about 1-km-thick Pliocene-Quaternary sediment wedge that narrows (20–5 km), steepens (average slope: 6–14°) and deepens (1,200–1,500 m) from south to north. Collapse of the entire seaward-facing portion of the continental slope off northern Israel and southern Lebanon, caused by halokinetic rotational slumping, has further accentuated this steep and narrow wedge.

Canyon incision has deeply furrowed the steep continental slope. The canyons trend to the NW, W and SW. Nine major canyons were mapped in the study area, and additional large canyons were detected further north. The canyons are fault-controlled, the faults being submarine extending offshoots of the Dead Sea-Jordan-Beqa'a Transform that has controlled the tectonics and structure of Israel and Lebanon since the Late Miocene.

Although the heads of the canyons lie opposite the mouths of the continental rivers, the latter, which originate in the high Lebanon Mountain range, flow westward with no regard to the major fault lines which they cross. Direct seaward flow of water over the steep seaward slope of the mountain range probably dominates over flows along diagonal fault lineations across this terrain. The submarine origin of the canyons of the continental slope (and not fluvial erosion of the emergent continental shelf during the last Glacial lowered sea-level stand) further supports this conclusion.

The Glacial Stages in the Red Sea as Inferred from the Marine Record

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A continuous sedimentary record presenting the last 380,000 years was studied in core material taken in the central Red Sea by the R/V Meteor cruise 5, leg 2. Four glacial-interglacial cycles were analyzed along the sequence by a multidisciplinary approach enabling us to recognize proxies of surface, intermediate anddeep water properties. Due to the marginal nature of the Red Sea, the hydrographic variations are largely regulated by the interplay between strait dynamics (global sea level fluctuations) and the regional climate. During the glacial stages the increasing isolation of the Red Sea is driving its hydrography to an extremity which is reflected by the biota, lithology and the stable isotope record. A reduced sea-water exchange through the Bab Al Mandab straits result in a pronounce increase in surface and deep water salinity. The high salinity levels seem to cause a pronounced decrease in productivity. In addition to that a remarkable decrease in the abundance and diversity of the main calcareous groups, the planktic foraminifers and pteropods was found compared to interglacial conditions. The most extreme glacial conditions during the last 380,000 years occured during the last glacial maximum (LGM) between 26,000–13,000 years ago when the salinity reached its highest level throughout the studied period. During the LGM almost all the calcareous taxa were excluded from the Red Sea except a monospecific pteropod population. Intensive precipitation of authigenic aragonite took place in the bottom during this period.

Pedogenic Processes in the Interdunal Area of Nizzana Sand Dunes During the Quaternary

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Calcic and gypsic soils have developed under extremely arid conditions in the interdunal areas of the Nizzana longitudinal dunes. The occurrence of these soils raises two major points; calcic soils have not previously been described forming under such extreme climatic conditions, and it is unusual to find both calcic and gypsic soils forming adjacent to one another. The calcic soils are forming on the sands, and the gypsic soils form on fine textured playa deposits. The traditionally accepted theories of pedogenesis suggest that these soils form in different climates with the calcic soils forming in areas of higher rainfall than the gypsic soils. The aims of this study are to clarify the pedogenic processes operating in these soils and to attempt to resolve the influence of climate in the pedogenic processes. It was found that the deposition of calcium carbonate is associated with microbiological activity around roots and burrows rather than at the maximum leaching depth in the sands. As a result, calcrete horizons which are found more than 1 m below the surface of the sands are paleosols and indicate the level of ancient surfaces. The gypsic soils have formed in the silts and clays of the playas. These fine grain deposits have a different moisture regime and high values of salinity which results in the formation of gypsic and salic soils rather than calcic soils. These findings highlight the fact that the amount of available water and the eolian addition of dust to the soil surface is not the major factors forming pedogenic features in arid soils.

Alkaline-Waste-Storage Potential of the Helez Reservoir Rocks

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The geochemical interactions of alkaline industrial wastes with the reservoir rocks of the Helez Formation, were studied in order to evaluate the suitability of the Helez reservoir to be an environmentally safe underground storage for alkaline wastes.

Laboratory experiments were conducted in order to trace possible mineralogical and morphological changes in the reservoir rocks caused by interaction with a solution of NaOH, and to establish the influence of these interactions on the permeability and porosity of the reservoir. Sandstones and ankerites from the Helez Formation were ground and mixed with NaOH. The experiments were carried out for 1–28 days, at room and reservoir temperatures, 25 °C and 60 °C, respectively. The results indicate that new minerals were formed at the expense of some of the original ones. Major changes occurred in ankerite dominated samples. In the presence of NaOH, progressive elimination of ankerite was followed by the growth of calcite, brucite, portlandite, hydrotalcite and pyroaurite. Quartz and clays were only slightly affected.

In order to determine the influence of these reactions on the physical properties of the reservoir rocks, NaOH-solutions were injected into small core samples. It was found that in carbonates and ankeritic sandstones with low to moderate primary permeability and porosity, there is a decrease in the values of these properties, while in ankerite-poor sandstones the permeability increases significantly. Formation-water, which react with NaOH to form brucite or portlandite, cause a decrease in permeability with no significant change in porosity.

These experiments confirmed the assumption that the Helez rocks may reduce and neutralize the high pH of NaOH-solutions but at the same time show that the injection of alkaline wastes into the reservoir may reduce reservoir characteristics. The growth of new minerals, as a result of ankerite elimination or reactions with formation-water will cause a decrease in permeability. Only high permeability zones are suitable for wastes isolation. The underground migration rate of the wastes will gradually reduce with time and eventually be blocked. Additional experiments are necessary in order to quantify the changes in the reservoir properties.

Intermediate Term Earthquake Prediction in the Dead Sea Transform

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The possibility of intermediate term earthquake prediction in the Dead Sea transform region is explored. An algorithm proposed by Keilis-Borok and colleagues is implemented, after a slight change in one of its parameters, in order to adapt it to the regional specific seismicity. The feasibility of this algorithm for the studied area has already been shown by retrospective diagnosis of the Time of Increased Probability (TIP) of the occurrence of two of the three relatively strong earthquakes ($M \geq 5$) which took place during the period 1964–1990. It should be emphasized that the TIP duration was only 13% of the total checked time and that false alarms did not occur at all. Moreover, a similar slight change in the algorithm parameter facilitated efficient diagnosis of TIPs of strong earthquakes in two regions with seismicity similar to that studied, namely the Lower Rhine graben and the North Appalachian area.

The introduction of a slight change in another parameter of this algorithm facilitates the identification of the TIP of all strong regional earthquakes which occurred during the last 26 years. This amendment, however, is as yet impractical since it also triggers four prolonged false alarms of a total duration of about 5.5 years.

We are currently seeking signs of a TIP of a strong earthquake after any pronounced variation in the local or regional seismicity. When such a TIP is identified, the possibility of short term precursors is scrutinized applying available methods of forerunners analysis. The joint implementation of intermediate and short term prediction approaches may diminish the number of false alarms and may also reduce the uncertainty of the time factor in earthquake forecasting.

Teaching Science Combined with Scientific Research — An Example from Backward-Erosion Research

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A scientific teaching program, known as 'GEOTOP', is a part of the geological studies in the high schools in Israel. In this program small groups of students are exposed to a large number of geological and geomorphological phenomena.

The research presented here focused on the ecological and hydrological implications of backward erosion which takes place in the majority of the valleys in the Negev Highlands. The upper parts of the valleys are drained by a wide stream and are cultivated, where the lower parts are drained by narrow channels that dissect the valleys. In each valley, a waterfall, 2–3 m high developed between the two segments. During the research the rate of the backward erosion was estimated using benchmarks that were placed in several valleys.

One of the results of this research was that the rate of the backward erosion can exceed several meters per year. A rate of 20 m during one single event was also reported.

The parameters that were checked, such as the change of the biomass and the distribution of the plant species, shows very clearly that this process changes the natural conditions of the Negev toward desertification. This process is not related to recent changes of the climate, and it may reflect the ongoing geomorphological process that began at the end of the Pleictocene and is still active in the Negev Highlands today.

Using small groups of students, several different scientific subjects can be examined simultaneously, and in this way complicated and interdisciplinary research can be done.

The Influence of the Plio-Pleistocene Fault System on the Tectonic and Geomorphological Structure in the Margin of the Arava Valley

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In the southern and central Negev, a system of previously unknown four major faults was identified. The faults (the Halamish, Zihor, Barak and the northern part of the Milhan fault) are sub parallel, striking N 35°– 40° E. Each fault comprises several en-echelon straight segments, each a few kilometers long. The fault plains are almost vertical. Slickensides are either horizontal or steep (normal faults). In addition, between the main fault lines, minor faults and connecting segments (like the Hiyyon fault, striking N-NW) are present. These faults displace by more than 100 m the fluvial-lacustrine units of the Arava Conglomerate, assumed to be of Late Pliocene to Early Pleistocene age. In places, these sediments show flexures having the same trends as the main faults.

The faulting activity is accompanied by a regional eastward tilting that affected a wide area located between the Negev - Sinai border in the west and the Arava Vally in the east. The maximum width of this area exceeds 60 km in the Southern part, near the place where the Paran drainage system crosses the Egyptian border. This area narrows towards the North - East and joins the Arava Valley, a few km north of Ein Yahav.

The regional uplifting of the Negev during the Pliocene caused an intensive erosive response that shaped the landscape and created wide valleys in which the Arava Conglomerate was deposited. The tectonic activity of the faulting and tilting postdates this stage of landscape evolution and led to incision of a new drainage system that drained the area directly to the Arava Valley in the east, cutting in some cases the older valleys at a right angle. This change in the landscape is typical to the whole western margin of the Arava Rift Valley.

The Mechanics of the Dike Emplacement into Fractured Basement Rocks, Timna Igneous Complex, Israel

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Dikes commonly form arrays of parallel segments that dilate perpendicular to the least compressive stress. We present here dikes, in which the orientations of the segments in a single dike range over 100°. This irregular geometry is interpreted as a result of dike emplacement into pre-fractured host rock. We examined the detailed relations between dikes and fractures and the trend and thickness variations along four Late Precambrian dikes. The dikes intruded the fractured Arabian-Nubian basement in the Timna Igneous Complex, southern Israel, which is now uplifted at the margins of the Dead Sea rift. The studied dikes include a dolerite dike with exposed length of 2.3 km and thickness of 1 m to 30 m, an andesite dike, 0.6 km long and 0.5 m to 3 m thick, an andesite dike, 1 km long and 3 m to 7 m thick, and an andesite dike, 1.5 km long and 4 m to 8 m thick. The thickness variations of the dike segments correlate better with their trend variations than with the position along the dikes. To explain the observed thickness variations, we analyzed the dilation of dikes from three different types of initial crack geometry; the dilation is under uniform internal pressure, in a uniform elastic medium, and under plane-strain conditions. The initial geometries are: (a) a single linear crack; (b) an array of non-interacting, non-parallel cracks; (c) an array of interconnected, non-parallel cracks. Each of these types predicts a different pattern of thickness variations along the dike. In Timna, the thickest dike fits best the predictions for the dilation of an array of interconnected, non-parallel cracks (type (c)), whereas the thinner dikes fit better the predictions for the dilation of type (b) initial cracks. These differences between thin and thick dikes are interpreted as different stages of dike dilation. The observed trend-thickness variations are also used here to infer the directions of the stress axes and the ratio of magmatic pressure to tectonic shear stresses during the emplacement of the Timna dikes.

Detailed Characterization of a Fault Termination

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A unique combination of a primary fault, a secondary fault and a set of joints adjacent and genetically related to these faults from Ramat Hovav, were mechanically analysed. In this analysis the joint orientation provided the directions of the horizontal principal stresses which caused the secondary faulting.

We use the Green's Function method of Stekete as developed by Chinnery to determine the stress field existing at the inception of a secondary fault from the tip of a given primary fault. The specific geometry of the secondary fault is the basis for this analysis. Our results show that in general the geometry of the secondary fault is mainly influenced by the following parameters :

a. The depth of the primary fault;

b. The ratio between the magnitudes of the two horizontal principal stresses;

c. The exact initiation angle of the secondary fault.

On the other hand, the influence of the length of the primary fault, the values of the elastic constants of the rock and the absolute magnitudes of the horizontal principal stresses are of lesser importance.

A Preliminary Investigation of the Soreq Cave Speleothems as Indicators of Paleoclimate Variations

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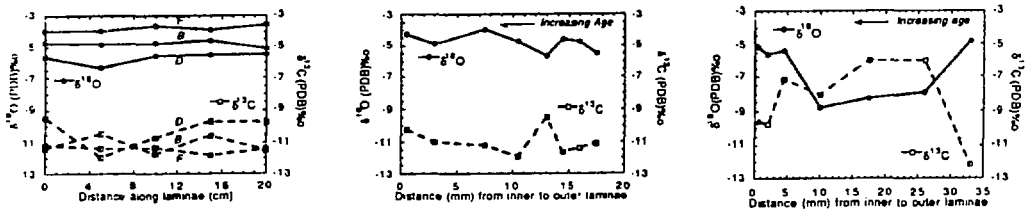
This work presents the results of a preliminary study on using the stable isotope compositions of the Soreq cave speleothems and cave waters as paleoclimatic indicators. Present-day waters in the cave sampled over a period of eight seasons give an average $\delta^{18}O$ (SMOW) of −4.5‰. This value is close to that of the local groundwater, which averages at −5‰. Present-day surface carbonate deposits in the cave have a $\delta^{18}O$ (PDB) of −3.5‰, which is calculated to be in equilibrium with the above waters at present temperatures. During the extremely rainy winter of 1992, $\delta^{18}O$ of the cave water dropped to about −6‰; a value close to that of the local average precipitation (−7‰). Four months later, the isotopic composition had recovered to the average value. The fast rate of recovery demonstrates that the cave system is resilient to strong seasonal fluctuations in rainfall and that average isotopic composition of cave water will be close to that of the ground water at that time.

Speleothems associated with ancient high water levels provide direct evidence to higher influxes of water to the cave. The $\delta^{18}O$ of the speleothem deposit at one of these ancient levels is −6‰, which is 2.5‰ lower than present day deposits. The lighter isotopic composition thus may also be indicative of rainy periods bringing water with lower $\delta^{18}O$ to the cave.

Stalagmites show constant $\delta^{18}O$ and variable $\delta^{13}C$ when sampled along individual laminae. This is illustrated in Fig 1a for three representative laminae of a single stalagmite. These criteria are considered to indicate that the stalagmites were precipitated in equilibrium with the parent waters, and therefore are suitable for paleoclimate studies. Profiles across series of laminae representing time sequences are given in Figs. 1b and 1c. Fig 1b is taken from the same stalagmite as in Fig 1a and shows $\delta^{18}O$ to vary from −6 to −4‰ and $\delta^{13}C$ from −12 to −9‰. These variations may indicate elements of major time trend. Significant deviations from the trend shown in Fig 1b also occur, as is illustrated in Fig 1c for a different stalagmite in which $\delta^{18}O$ drops to about −9‰ and $\delta^{13}C$ increases to −6‰. These isotopic excursions should reflect paleoclimatic changes: for example, the lowering in $\delta^{18}O$ could represent either an increase in temperature or a decrease in the $\delta^{18}O$ of the cave waters, and the rise in $\delta^{13}C$ could represent a change from C_3 to C_4 vegetation.

Dating, and further isotopic studies of these features will place these phenomena in the correct time framework and help constrain the paleoclimate record.

(a) (b) (c)



New Observations on the Structure and Evolution of the Arava Rift Valley

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Geological studies, including geological mapping, sub-surface stratigraphy based on water wells data and high resolution seismic reflection survey were gathered recently in the eastern Arava Valley, between N. Paran and Hazeva area. These studeis revealed new observations on the structure of this area, and on its geological history.

The well-known sequence of the Hazeva Formation, overlying the Avedat Group at the eastward tilted Arava flexure, attains a thickness of ca. 150 m. East of Nahal Ha'Arava a 2000 thick sequence is exposed in a series of highly tilted blocks, comprised of alternating beds of sandstones, shales, conglomerate and marls. this sequence is not known elsewere in the Negev, excluding the expose Hazeva Formation at the Karkom Graben and several drillholes in the vicinity of the Dead Sea (e.g. Arava 1). The seismic reflection survey revealed the wide extention of the thick sequence of the Hazeva Formation within the Rift Valley, representing a wide sedimentatin basin, which is presently undefined. This local basin predates the Central Negev-Sinai Shear Zone, and the initial development of the Dead Sea Rift Transform.

The Dead Sea Transform is presented by a zone of parallel faults. The westernmost fault of this zone was recently traced east of Nahal Ha'Arava. The cummulative left-lateral displacement, based on thickness variations of Cretaceous units and their correlations in water wells in the souternmost part of the studied area, reachs some 60 km. This estimate does not take into account the amount of displacement on the Eastern border Fault of the Rift. The latest activity on thse faults postdates the Plio-Pleistocene Arava Conglomerate.

Several domal structures, in which the Hazeva Fm. and the Arava Conglomerate are deformed, exist along the major faults, and are typical of areas where the faults change their general trend. Examples for such structures exist at Gebel e Risha, south of Nahal Paran, and at Gebel Hufeira, east of En Yahav, both representing local compressional regimes.

Feasibility Study of the TDEM Method in Solving Geological Problems in Israel: Structure of the Central Arava

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The aim of this project is to conduct a feasibility study for the TDEM (Time Domain Electromagnetic Method) in solving geological problems in Israel. This method is based on electromagnetic induction from the surface,in order to inject electrical currents into the subsurface. These eddy currents generate a magnetic field. The changes with time of this field, give the change of the electrical resistivity vs. depth, at the point of measurement. In its initial stage the aim of the survey was to define electrical conductivity contrasts between rock units in Israel, in order to plan applications for deep probing electromagnetic methods. Measurements were conducted on outcrops, using a standard conductivity meter (EM-34). For some of the units rather consistent results were obtained.Among these were contrasts between rock units exposed in the Arava Rift Valley. At the second phase we tried to locate these contrasts in the subsurface. TDEM soundings were carried out close to water drillholes, where the above mentiond units were defined. Comparision with the borehole data proved the feasibility of the TDEM method for mapping these units (a typical resistivity section for the rock units exposed in the area is presented in Fig. 1). At the third stage the main aim was to explore the subsurface structure at the Central Arava Rift Valley. In order to increase the investigation depth, and to improve the accuracy of the interpretation, several measurements were made using different transmitter loops.

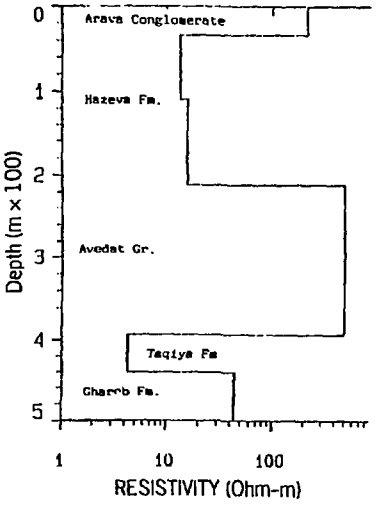

Fig. 1. A typical resistivity section in the Arava Rift.

The Sir-10 Ground Penetrating Radar System — Application Survey

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The Ground Penetrating Radar technique is based on transmission of high frequency electromagnetic waves (100–1000 MHz) to the subsurface and reception of the reflected waves. The electromagnetic waves are reflected back from the interfaces between the layers of differing electrical properties (mostly conductivity and dielectric constant). The transmission and reception of electromagnetic waves are carried out using an antenna which receives and transmits the signals on a time sharing basis. The antenna is towed along by a man or a vehicle at a speed of 2–20 kmh. The resolution rate of the radar system is a function of the electrical properties of the subsurface and the frequency of the antenna (100, 500 or 1000 MHz). Primary interpretation is made possible during field acquisition of data owing to a pseudo cross-section color display. The data are stored on tape for further processing and interpretation.

The following four case studies are shown:

a) *A radar study of a highway:* the thickness and structure of the various layers, i.e. asphalt, densely packed aggregate, rock (or clay). The survey required a 1000 MHz antenna with a high resolution of 5 cm and a penetration depth of up to 1.5 meters. The rate of production was 10–15 kmh.

b) *Void detection in the subsurface:*
   1. A tunnel at a depth of 7 m, 4 m in height and 5 m wide.
   2. A tunnel at a depth of 3.5 m with smaller dimensions, 0.8x0.8 m.
      The survey was conducted using a 100 MHz antenna.

c) *Stratigraphy:* mapping the structure of a layer in the subsurface with dip changes along the cross-section, probably a paleo-channel.
   The survey was carried out using a 100 MHz antenna towed at a speed of 10–15 kmh.

d) *The structure of reinforced concrete:* the thickness of a concrete wall and the location of reinforcing bars. It is possible to detect voids in the concrete and to interpret the subsurface beyond the concrete.

The Ground Penetrating Radar technique can be used in a wide variety of applications to help solve complex subsurface detection problems in civil or structural engineering, environmental preservation, or for geotechnical, transportation, military or archaeological purposes.

Bedding Slip in the Ramon and Arif-Bator Fault Zones (Negev, Israel)

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Small-scale tectonic features reveal widely-distributed bedding-parallel shearing in the Mesozoic sedimentary cover of the Central Negev. Orientation of the features indicates the displacement along bedding surfaces in the top-to-the-south direction. Wide spread and extension of the bedding slip structures in the central Negev suggest the possibility that continuous detachment surfaces exist within sedimentary cover. These surfaces are mostly located at the contact between rocks with high mechanical contrast (e.g. at the contact between chert and chalk or at the contact between well-bedded and thick-bedded limestones). It is possible, that the bedding slip in the sedimentary cover could evolve as multiple bedding-parallel faults with diverse displacement rates.

Intensity of the bedding slip did not depend on the vicinity of regional-scale pre-existed faults, such as the Ramon Fault and the Arif-Bator Fault. These faults exerted passive influence on the peculiarity of younger tectonic patterns. The Ramon and Arif Bator faults have uplifted northern flanks and downthrow southern ones with southward bedding inclination of the adjacent to the fault tilted blocks. The southward bedding slip over the tectonic steps at the fault zones was accompanied by normal faulting and bedding-parallel faulting above the local extensional zone. The drag folds were localized in the zone of transition from slopping to horizontal bedding slip, which was characterized by local compression. Drag folding at the lower bends of the tilted blocks was accompanied by the small-scale twin normal fault development with reverse to the bedding slip direction of displacements. Following fault blocks rotation took place in the same top-to-the-south direction. A result of this process was an appearance of overturned blocks aligned along the lower change of dip of the tilted block in the Ramon Fault zones.

The bedding slip structures were found in the sedimentary rocks from Triassic and up to Eocene. The intensity of bedding slip structures increases eastward, toward the Dead Sea Transform, and southward, i.e. in the direction of decreasing sedimentary cover thickness. Probably, the bedding slip and scattered detachment, observed in the region of Arif-Bator and Ramon Faults are related to large-scale northward crust motion along the Dead Sea Transform, and represent the shearing of cover sheets in opposite direction.

Structure and Tectonics of the Eastern Cyprean Arc

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The geometry and nature of the eastern segment of the Cyprean Arc are little understood. Several hypotheses were put forward to explain the tectonic situation here. Newly collected geophysical data for this region mapped several deep and shallow structural elements.

The most prominent element is a ridge, the Latakia Ridge, which extends from the Syrian coast near Latakia southwestward to meet with the Hecateus Ridge, an east-west trending bathymetric escarpment. The new seismic profiles suggest that these two elements mark the present plate boundary along the Cyprean Arc.

The Latakia Ridge is a young and still active feature of post Upper Miocene. It was formed by the southward migration of the plate boundary. The ridge was probably originated as a large thrust sheet, which later on, when the convergence direction was changed, become a zone of wrench faulting. The ridge is still forming today and serves as a dam to the sediments north of it.

Pleistocene Strata in the Central Plain as it Appears on High Resolution Seismic Profiling

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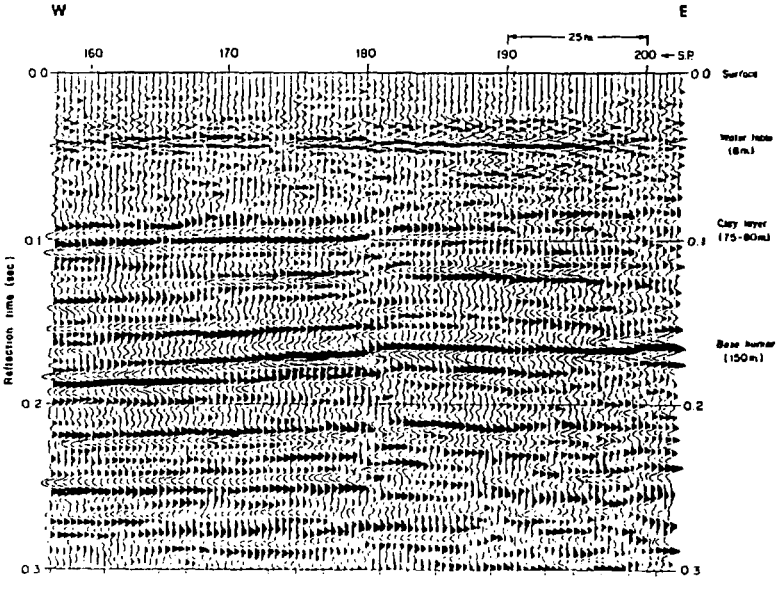
The study of the Neogene-Quaternary section in the coastal plain has been extended in recent years as a result of renewed interest in shallow gas exploration and the operation problems of the coastal aquifer. The high resolution seismic reflection method is by far the best for imaging the subsurface geometry at shallow (tens of meters) and mid-range (hundreds of meters) depths and may also provide some lithological information.

The purpose of this work is to examine the resolving power of tools currently available for the study of shallow targets in the coastal plain. The area chosen for this study is in the vicinity of the Palmahim-1 deep well, which is transected by previous conventional and semi high resolution seismic profiles.

The composite log of the Palmahim-1 well indicates a single, 4 meter thick clay layer at a depth of 75 meters within the calcareous sandstone Kurkar group. Base Kurkar is encountered at a depth of 150 meters. The Yafo Formation underneath is composed of Nile derived claystone, intercalated with thin layers rich in fossil shells and sand.

Fig. 1 presents a portion of a seismic profile acquired in this study. The main reflectors are indicated at the right. The depth (from the surface) was obtained from the well logs and the seismic velocities. This section shows that the main stratigraphic units in the area can be detected and consequently mapped by the method presented here.



Paleobathymetry of the Eocene of Israel

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Broad facies patterns of the Lower and Middle Eocene in Israel, taking into account new studies in the Negev and Samaria, demonstrate the predominantly pelagic milieu in which deposition took place. Neritic interludes must be understood within this framework. With few exceptions, the following are the general characteristics of Eocene sections in Israel which support this broad interpretation:

1. Pelagic plankton is nearly always present, not only in chalk facies, but in most neritic facies as well.

2. Smaller benthic foraminiferal populations in the chalks are characteristic of outer neritic to upper bathyal environments. Even in the environment dominated by larger benthic forms, inner neritic benthics (miliolids, lituolids) are rare.

3. Nearly all neritic facies interfinger with, or are emplaced within, the pelagic facies.

4. Rounding, sorting, and spar - cemented grainstones are rare. Oolites are absent. Early diagenetic features characteristic of subaerial vadose and phreatic environments are lacking, as are caliche and karst features. These features are lacking even in material transported downslope.

5. Mass transport and debris flows are characteristic of many Eocene sequences and have been used to invoke a specialized tectonic regime. Recent studies of modern and ancient deep-water carbonate environments have shown that these features are common, indeed characteristic, of many outer neritic environments.

6. In the shallowest neritic facies, generally allochthonous but occasionally in-situ, calcareous algae, when present, is predominantly rhodophycean as opposed to chlorophycean, indicating the deeper end of the photic zone. Similarly, larger benthic faunal assemblages are significantly impoverished relative to characteristic platform assemblages of the Tethys.

7. Primary or early diagenetic dolomite, algal mat facies, evaporites, and other 'Judea Group' attributes characterize Arabian platform facies in the Gulf region. Between this region and the local section, a pelagic chalk facies with subordinate phosphatic facies, indicating upwelling, is developed. In Egypt, the transition from predominantly pelagic and outer neritic facies to nearshore, clastic rich sequences, develops over distances of hundreds of kilometers.

The Geochemistry of the Doleritic Dyke of the Timna Igenous Complex

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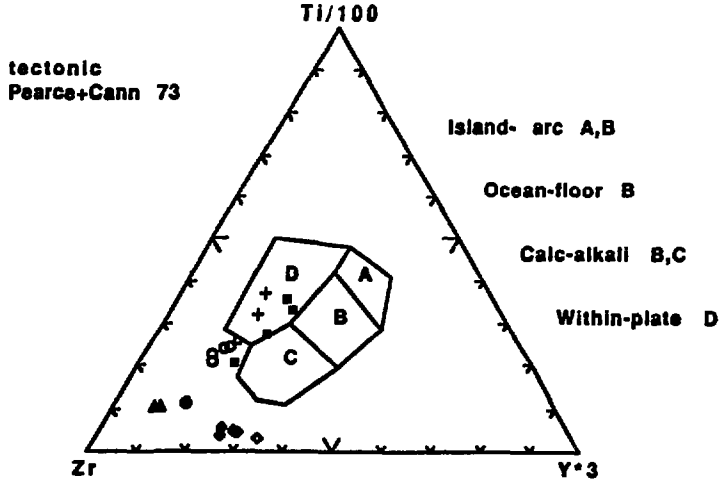
The geochemistry of the doleritic, youngest dyke in the Timna igneous complex was studied. Its' composition is transitional between alkali basalt and tholeiite, approximately saturated in silica, with Mg#=40–45 (Mg#=100•Mg/(Mg+Fe)). It is very rich in Ti, Nb and Ta; when the geochemical data are plotted on "spider diagram", the patterns show no depletions in Nb such as is commonly found for other igneous rocks from the Timna complex and elsewhere in the Arabian-Nubian Shield. The dolerite is strongly LREE-enriched but has no Eu-anomaly. Isotopic data (corrected for radiogenic growth) indicate derivation from depleted mantle (ε–Nd=+5.1±0.4 (550 Ma?); $^{87}Sr/^{86}Sr$=0.7028), similar to older rocks of the Arabian-Nubian Shield. These features make it a unique magmatic phase which terminates the magmatic evolution of the Timna complex. The Timna dolerite records the transformation of the subcontinental mantle from one characterized by arc-like geochemical signature (silica oversaturated, low Ti content and strong Nb depletion) to one that is overwhelmingly intraplate in character (marginally saturated in silica, high Ti content and no Nb depletion) during the Late Proterozoic. Dykes of similar setting and composition have also been reported in Sinai.



+: the doleritic dyke (2 samples).
others: the different magmatic rocks of the Timna complex.

Maximum Altitude of the Lisan Stage Reevaluated

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The Lisan Lake, the precursor of the Dead Sea, dates from 50,000 years BP to 14,000–12,000 years BP. Picard (1943), Zak (1967), Neev and Emery (1967), Bowman (1971), Begin (1975) and Horowitz (1979) refer to the level –180 m as the maximum altitude of the Lisan stage.

A series of longitudinal and level sedimentary bodies, which encircle the south western corner of the Lisan deposits in the Hazeva area, have been mentioned by Dan (1981) and by Yechieli (1987) as shoreline terraces and berms, but were not studied further. These features are several hundreds of meters to over 1 km long. They are linear and asymmetric. Their appearance as a system, their longitudinal shape, levelness, smooth surface, as well as their rounded and sorted pebble-veneer, suggest that they are abandoned shorelines, probably beach ridges and swash bars. We wish here to focus on the significance of the maximum altitude of these beach features, which was determined by projecting the 1:50,000 topographic map onto air photos.

The highest bars in the system, previously unknown, are located to the west of the Arava road, up to an altitude of 150–160 m below MSL. They show only a very initial pedogenic reg stage development and have a very low weight percentage of Fe_2O_3 coating the sand. Electric conductivity of soil samples from these highest bars is EC = 26.88 mmho/cm, all from soil samples taken at 10–20 cm depth. Conductivity at the highest bars thus falls exactly in the 10–50 mmho/cm range, typical to the entire Lisan bar sequence and indicating Holocene alluvial surfaces (Gerson et al., 1985; Dan, 1981).

Based on field evidence and laboratory data, it is concluded that the entire sequence of raised bars relate to the same lake and is of Lisan age, with the uppermost level 150–160 m below MSL. There is thus no justification for relating the highest bars to a former (Samra) Lake.

Sediments similar to the upper Lisan section were found at –150 m (Yechieli, 1987) and point to the same conclusion. Beach ridges of Lake Lisan were also encountered by Macumber and Head (1991) at about –150 m in Wadi al-Hammeh. It is only natural that a few high relicts will always be preserved somewhere during the denudation process. The figure –150 m should replace, from now on, the traditional –180 m level, quoted so far in the literature.

The Quaternary Tectonic Evolution of the Kinnarot Valley

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Pliocene to Upper Pleistocene sediments are exposed in the Kinnarot Valley south of the Sea of Galilee. The age and the rate of tectonic activity can be estimated by examining the sediment thickness, the geometry of structural elements, and by dating basalt units exposed within the sedimentary sequence.

Limnic sediments of the Erk el Ahamar and Ubeidiya formations were accumulated at a rate of 1–2 mm/y (several hundred meters), indicating rapid subsidence. These sediments were then uplifted and tilted as a result of compression. Two flows of the Yarmouk Basalt uncomformably overlie the sediments and thus indicate the end of the compressional phase. The flows were dated by K-Ar as 0.78 ± 0.12 Ma and 0.68 ± 0.24 Ma. During the Middle and Upper Pleistocene, only 2–10 m of fluvial sediments of the Naharayim Formation were accumulated, indicating that the area was relatively high during that period. Up to 25 m of marls of the Lisan Formation accumulated during the Upper Pleistocene.

The tectonic evolution of the Kinnarot Valley can therefore be divided into four stages:

a. Rapid subsidence during the Upper Pliocene and Lower Pleistocene.

b. Uplifting and tilting during the Middle Pleistocene.

c. Preservation of a raised area during the Middle to Upper Pleistocene.

d. Subsidence of the basin during the Uppermost Pleistocene.

An examination of the geometry of the structural elements in the Kinnarot Valley in the light of theoretical deformation models, suggest that the eastern side of the valley fits a model of ductile rock deformation.

Upper-Oligocene Lowstand Deposits in Israel

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Two successive members with contrasting paleoenvironmental signatures are distinguished in the Oligocene Lakhish Formation in the Lakhish area. The lower member (15 m) includes: 1. debris flows, with poorly sorted clasts in a matrix of remoulded chalk. Clasts include Eocene and Oligocene chalks and marlstones and Oligocene Lepidocyclina packstones; 2. alternating beds of transported chalk and marlstone at aberrant angles; 3. calcarenite turbidites, with a-b or a-b-c combinations of Bouma divisions. The upper member (10 m) consists of bioclastic limestone sharply separated from the underlying chalk or mass-flow deposits. It consists of fine-grained sandy packstone and grainstone with planktic and bethic foraminifera, coarsening upwards into Operculina-Lepidocyclina grainstones and packstones with coralline algae and echinoderm debris, representing amalgamated storm deposits (tempestites).

The Lakhish Formation appears to be a lowstand deposit of third order cycle 1.1 (Haq et al. 1987), unconformably overlying either Upper Eocene or lowermost Oligocene hemipelagic marls and chalks. The lower member is an allochthonous debris of eroded shelf-edge material carried down slope during the initial, rapid fall of sea level. The upper member is an autochthonous lowstand carbonate wedge that displays continuous shallowing.

Northwestward in the Ashdod area, a 300 m Oligocene clastic section was encountered in boreholes, consisting of debris flows and sandy turbidites featuring Bouma Tb and Tc divisions. The section contains three hemipelagic marly intervals reflecting three cycles of lowstand submarine-fan deposition. The micropaleontological resolution of the sections at Lakhish and Ashdod is not refined enough to date the Oligocene lowstand at 30 my (as proposed by Haq et al, 1987, 1988) since the G. opima opima zone (which characterizes these sections) spans the time range of ca. 28–32 my.

The Diagenetic History of the Heletz Formation and the Timing of Hydrocarbon Accumulation in Heletz-Kokhav Oil Field

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A geochemical, thermal, and paleohydrological model of the diagenetic evolution of the Lower Cretaceous Heletz Formation is presented. In addition to chemistry, mineralogy, and morphology, the model was based on paragenetic sequence and stable isotope data of authigenic minerals. A special effort was made to establish the relationships between hydrocarbon accumulation and mineral precipitation.

The chemical and isotopic composition, along with the paragenetic sequence of the carbonate minerals, point to the formation of the siderite from meteoric water at surface temperatures early in the diagenesis. Calcite appears in various forms which precipitated in three stages along the diagenetic history. The skeletal calcite was recystallized during early diagenesis from water with $\delta^{18}O$ of sea water at surface temperatures. During an advanced stage of diagenesis, calcitic cement developed, mainly in the Kokhav Sands from the formation water, which had at this time $\delta^{18}O$ SMOW values of up to +2‰, and at 40 °C. Late vein calcite, mainly in the Kokhav Dolomite, was formed from water with $\delta^{18}O$ values of up to +5‰, and at 60 °C. Ankerite, which is the dominant cement phase in the Heletz Formation, was formed at an advanced stage of diagenesis, concurrently with and right after the calcitic cement. The ankerite formed from water with $\delta^{18}O$ values of up to +3‰, and at 50 °C at the beginnig of hydrocarbon accumulation.

Other authigenic minerals found in Heletz Formation include quartz, alkali-feldspar, pyrite, kaolinite and illitic clays. The quartz and the feldspar which are cogenetic formed early in the diagenetic history. The feldspar formation, according to K/Ar radiometric dates, occurred some 90 Ma ago. At a later stages of the diagenesis, after the ankerite formation, first kaolinite and then some illitic clays were formed. The illite formation, according to K/Ar radiometric dates, took place 76 Ma ago.

The radiometric dates, the $\delta^{13}C$ values of the carbonate minerals, and the paragenetic sequence between the authigenic minerals and the hydrocarbons, suggest that the hydrocarbon accumulation in the Heletz Oil Field started during ankerite precipitation, some 76 Ma ago. With the exception of vein filling, no significant authigenic minerals precipitation took place since the formation of the illite some 76 Ma ago. It is believed that mineral precipitation ceased either because the formation water was stagnant and at chemical equilibrium with the minerals, or because the minerals and grains were coated by a film of hydrocarbons.

Fluid-Rock Interactions During the Formation of Metamorphic Dike-Schists, Elat Igneous Metaorphic Complex

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Fluid-rock interactions are fundamental processes of geological evolution, potentially controlling the petrological and geochemical development of many phenomena and influencing thermal and tectonic histories. This research seeks to determine the nature of the fluid-rock interactions during the formation of metamorphosed dike schists in the Elat igneous-metamorphic complex and to characterize the processes of igneous intrusion and subsequent metamorphism and deformation of the dikes. The fluid-rock interactions will be analysed by studying oxygen isotope, major and trace element profiles sampled perpendicular to the contacts between the dike schists and the country rocks enclosing them. Initial results are based on cross sections between a 4 m wide dike-schist and Elat granite gneiss.

The major element chemical composition of the dike schist at the sampled locality changes from a basaltic composition at the margins of the dike into a dacitic one at its center. The pattern of chemical variation (as for instance shown by variation diagrams) is compatible with magmatic differentiation during the intrusion of the dikes. The SiO_2 concentration varies between 51 wt% at the margins of the dike to 63 wt% at its center.In the greenschist-lower amphibolite facies the assemblages which developed as a result of the metamorphism of these dikes, have different silica content. The change in the silica content is primarily expressed by a systematic increase in the quartz content from the margins to the center of the dike. The involvement of water in the metamorphism is indicated by a comparison of the typical water content of <1% of basic to intermediate volcanics with the 2 wt% water content of the metamorphosed dikes.

A depletion in potassium was observed in the granite gneiss close to the contact with the dike-schist. In contrast the potassium concentration in the dike schist is constant across the dike-schist and shows no matching increase near the granite gneiss. The preferred explanation of this phenomena is that fluid flow mainly occurred along the dike schist and parallel to the contact,but that a small component moved into the granite gneiss leaching potassium from it.

Our initial results therefore seem to indicate that the geochemical trends are a function of the initial chemistry of the igneous dikes and various degrees of element mobilization brought about by fluids.

Water Flow and Solute Migration Through Unsaturated Chalk — Avdat Group, Ramat Hovav

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Ramat Hovav is located 15 km south of Beer Sheva, on outcrops of the Eocene Avdat group chalk. Chemical industries and the national site for isolation and treatment of hazardous waste have been in operation there since 1975. Geological investigations preceding the construction of the various industries concluded that the chalk was adequately impermeable. This conclusion, combined with the arid climate of the area, led to the assumption that contaminant migration from the surface downwards would be very slow. Today, 17 years after the site's establishment, high rates of percolation to, and pollution of, the groundwater have been observed, both next to, and far from the site. These observations indicate that the Eocene chalk at Ramat Hovav is not the effective hydrological barrier assumed by the site's designers. Although the chalk matrix does have low permeability, rapid water flow and solute migration occur along the abundant fractures and joints in the chalk. Our study focuses on the flow mechanism of water and solutes through the unsaturated chalk and into the groundwater. Five dry boreholes were drilled through the entire vadose zone of the chalk. Rock samples were continuously collected at constant intervals from the boreholes. Thee rock samples were used for chemical and isotopic analyses, enabling construction of the following profiles: (1) a tritium profile, to estimate the rate of water flow through the unsaturated zone, (2) oxygen-18 and deuterium profiles to estimate the evaporation rate of water at land surface before percolation, and in the upper part of the vadose zone after infiltration, (3) profiles of bromide and chloride as tracers for conservative solutes, and (4) profiles of heavy metals, organic matter and pesticide residues, to monitor the migration of pollutants specific to the Ramat Hovav industries.

The Gypsun-Hemihydrate (Soluble Anhydite) Transition

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Gypsum, the mineral name of Ca-sulphate dihydrate, is not the only phase in the Ca-sulphate - water system. Two other phases, alpha and beta hemihydrate (commercial gypsum) are also known; furthermore at least three anhydrite phases occur.

The phase transition gypsum - hemihydrate (soluble anhydrite) was studied by DTA & TG, XRD, and IR in samples of natural gypsum (selenite and satin spar) as well as in three synthetic gypsum (chemicals) from Merck, British Drug House (BDH) and Johnson Matthey Co (JMC). DTA and TG were carried out under both dry and wet atmospheres.

The x-ray diffractograms of all the used samples are very similar and they consist mainly of the gypsum pattern (JCPDS-ICDD card 33-311). Nevertheless for the JMC and Merck samples, weak peaks of hemihydrate (soluble anhydrite) phases were identified in the starting material.

The kinetics of the transition for the samples were found to be very different. The JMC gypsum was transformed almost entirely to hemihydrate after 10 hours at a temperature of 50 °C (under dry air conditions). The BDH sample showed no change whatsoever even after 24 hours at this temperature. No direct correlation was found between particle size, as seen in SEM observations, and thermal reactivity.

All samples were transformed into soluble anhydrite in ten hours (or less) at 90 °C; no clear-cut transition could be observed for the hemihydrate — soluble anhydrite transformation.

Mesozoic Plant Kingdom and Plate Tectonics

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During my work in the Moscow Geological Institute, I studied Triassic floras of Eurasia. More recent and more ancient floras were investigated by other specialists in the same Institute, so we received a full picture of development and distribution of fossil floras during the whole Phanerozoic.

A comparison between conclusions of palaeobotany and plate tectonics concerning position of Mesozoic continents was made by me. Existing palaeomagnetic reconstructions differ one from another as well as from the picture, received on the base of palaeobotany.

Palaeomagnetic reconstructions of one kind show us either compacted Pangea, or Pangea with large Tethys ocean, or Pangea with Cathasia more or less separated from her. Reconstructions of another kind show many isolated plates of different size, which gradually united into recent continents during the Phanerozoic. In these reconstructions in the area of recent Eurasia we see, in the Permian, at least five big plates and many small plates. Three of these big plates joined to become one Siberian plate in the Triassic, but the West European and Cathasian plates were still isolated from one another as well as from Siberian plate. During the Jurassic and Cretaceous we do not see any remarkable difference in this picture.

Palaeobotanical investigations show us that there were four plant kingdoms in the northern hemisphere in the end of the Palaeozoic with some areas of second and third order: North-American, Atlantic, Cathasian and Angarian kingdom. Each of them was characterized by specific flora, which differed very much from the flora of other areas. It is possible to explain the high isolation of the Late Palaeozoic floras by existence of isolated plates, isolated continents at that time. This idea corresponds more or less to some reconstructions of Late Palaeozoic continents.

Isolation of floras of different areas disappeared in the beginning of the Triassic. The floras of Europe, Middle Asia, China and Indo-China and also of North America became very similar. A new united Laurasian kingdom originated. Floras of Siberian and European-Sinian areas became similar. Differences in them now depend only on climate. Tetrapods of Europe and Africa as well as tetrapods and insects throughout all Eurasia were also very similar at this time.

Beginning from the Triassic new boundaries between phytogeographical areas appeared in meridional direction. They depended on the centers of origination of new plant groups. These boundaries are seen until the end of the Jurassic, but with time the floras became more and more similar because of migration and exchange of plants between different sectors. All these differences in composition of floras in different phytogeographical areas do not show the isolation of areas as it was in the Palaeozoic.

Distribution of plants in the Mesozoic suggests the existence of united continent Laurasia from the beginning of the Triassic. Separation of North America from Laurasia took place after Triassic. United Eurasia existed from the Triassic till now.

From this point of view all reconstructions showing isolated plates (similar to Palaeozoic ones) instead of united Eurasia are doubtful, as well as all reconstructions showing isolation of Cathasia from other Eurasia. From this point of view the scheme of gradual union of isolated plates to united Eurasia during the Mesozoic and Cainozoic is also doubtful.

Isotopic Composition Relationships Between Rainfall and Runoff in Rocky Basin in an Arid Zone

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The isotopic composition of rainfall and runoff has been studied for three winters (1988–89, 1989–90, 1990–91), in a first order basin at the experimental site in the Haluqim anticline near Sede Boker. Sequential samples of rainfall 1.5–2 mm. and runoff samples at 5 minute intervals were obtained for each storm. The major objective of this research is to establish the isotopic pattern associated overland flow in an arid rocky terrain.

The results show that the isotopic composition of the runoff fraction in known time unit, is not always the same isotopic composition as in the rain fraction at the same unit time. Two possibilities for explanation are:

(1) Mixing runoff from two sequential showers with a different isotopic composition i.e., runoff from the second shower is mixed with the stored water in small depression storage from the first shower (including water in the fissures), to create an weighted average isotopic composition.

(2) Mixing during the shower, while the isotopic composition of the rainfall changes during the storm, so that runoff from the edge of the basin is mixed with the flow from the new rain and therefore the runoff has a different isotopic composition.

Using isotopic tracers in rainfall and runoff relationship improves the understanding of hydrology and the process of runoff developing on slopes and channels in the first order arid watershed. Intermediate results of isotopic composition shows that most of the runoff volume is generated from only 1 mm (or even less) of rainfall with high intensity and depleted isotopic composition.

Indications of Past Environmental Changes at the Kalanit Waste Disposal Site, Bet Guvrin

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The Kalanit waste disposal site (WDS) is planned to be built in the Nahal Zafnan drainage basin which is located about 2.3km in a direct line west of the Bet Guvrin Police Station. The length of the site is 1.9km., and width 0.5–1.2km., covering an area of about 2 sq. km. Nahal Zafnan and its short tributaries cut through smectitic and kaolinitic brown soils which are widespread outside of the site, forming part of a regional plain. The kaolinitic soils are concentrated in the northwestern corner of the basin and the smectitic soils cover the rest. The Nahal Zafnan basin is surrounded by ridges enclosing it on all four sides, with the valley breaking through the northwestern ridge. The ridges are covered by the same soils at the level of the regional plain. The maximum elevation of the site (+274m.) is found on the southeastern ridge and the lowest elevation (+220m.) at the outflow of the valley. The direction of flow is from southeast to northwest forming a tributary of the larger Nahal Guvrin course which is one of three main courses of the main Nahal Lakhish drainage basin.

The following surveys were carried out at the site and in its vicinity:
Geological mapping, shallow seismic refraction, boring and geotechnical testing.
The geological section in the basin, from base to top is:

Middle Eocene	Zora Fm., Maresha Mbr.	white soft chalk
Plio-Pleistocene	Ahuzam FM.	conglomerate
Pleistocene (?)	—	soils

The isopach map of soil cover, based on the above surveys, shows a maximum thickness along the northeastern (14m.) and southwestern (15m.) ridges of the basin and thins out in a southeastern and northwestern direction on all the bounding ridges.

Indications of environmental changes are seen in the change of soil types and flow direction.

These changes apparently occurred in the following order:

a. Kaolinitic soils formed from chalk of the Shefela Group were transported from north to south and accumulated over the Ahuzam Fm., forming a regional plain.
b. Tectonic uplift and subsequent erosion of the kaolinitic soils, a reminent of which is found in the northwestern corner of the site.
c. Tectonic stability leading to further soil accumulation of smectitic soils arising from limestone and dolomite of the exposed Judea Group, rebuilding the regional plain.
d. Renewed tectonic uplift with tilting to the north causing changes in the direction of drainage from the previous north-south direction to the present flow, to the west, and renewed erosion and incision of the regional plain.

Paleoflood evidence for a Natural Upper Bound to Flood Magnitudes: An Example from the Colorado River Basin

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The existence of an upper limit to the magnitude of floods is a long-standing hypothesis in studies seeking regularities in flood hydrology. This hypothesis can be traced to early studies and stated as "Flood magnitudes always continue to increase as the recurrence interval increases, but they increase toward a definit limit and not toward infinity" (R. E. Horton). The duration of the conventional record of observation limits any significant advances for testing this hypothesis. It was suggested however, that stabilization of envelope curves with the incremental increase in the duration of observation hints to the existence of such an upper limit to flood magnitudes. The only way to further increase the duration of observation is through studying the records of the large floods of the past. In the last several years, 25 paleoflood studies in the Colorado River basin extended the duration of observation on the largest floods by hundreds to thousands of years. Even with such large increase in the observational period, the largest paleoflood discharges do not exceed the upper bound of maximum peak discharges delineated by the envelope curve derived from the available gaged and historical records. This result accords with the hypothesis of an upper limit for flood magnitudes and suggests that, for the Colorado River basin, the upper limit can be approximated by present data for large floods. Similar relationships also hold when paleoflood and gaged data are presented for the subregion of southern Arizona.

The Development of the Metamorphic Basement of the Sinai Massif as Revealed by the U-Pb Ages

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Four stages were distinguished in the evolution of the Precambrian magmatism in the Arabian-Nubian Shield (950–550 Ma), of which the last three are represented in the Sinai Massif and Elat area. I. Ocean assemblage (~950–850 Ma); II. Island arc stage (~850–650) Ma) which is represented in Sinai and Elat by metasediments of the Elat Group, the meatavolcanic and metasedimentary rocks of the Saal and Kid groups, and by orthometamorphic rocks of various compositions; III. Calc-alkaline stage (~650–580 Ma), represented by volcanic and sedimentary rocks of Feirani Group ranging from gabbro to granite; IV. Per-alkaline stage (~580–550 Ma), represented by volcanic and sedimentary rocks of the Elat Group and by granitic plutons.

Single zircon evaporation and U-Pb dating revealed the following tectonomagmatic events in the island arc stage:

1. First magmatic event – island arc volcanism ± plutonism (~830?–810 Ma). These rocks were the source for the Elat Schist.
2. Deposition and deformation of Elat Schist (820–800 Ma).
3. Second magmatic event – intrusion of quartz dioritic to granitic plutons and Saal volcanism (?) (800–720 Ma).
4. Deformation of the second magmatic event plutons (740–710 Ma?).
5. Third magmatic event – intrusion of mafic to granitic plutons, and Kid and Saal (?) volcanism (650–620 Ma).
6. Deformation during the accretion of the island arcs of the Arabian-Nudian Shield onto the African continent (620–610 Ma).

Detection of Near Surface Faults by Employing High Resolution Seismic Reflection

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The goal of the study was to develop a shallow high resolution seismic reflection method, to locate near-surface faults, which displace young sediments with no surface expression.

The applicability of this method was tested near trenches made across two faults: a normal fault which displaced alluvial sequence along the western margins of the southern Arava Valley (Gerson et al., in prep.), and the Jerico fault, near 'En Hogla (Gardosh et al. 1990). Seismic profiles were made along the trenches and the results were compared with the observed faulted sequences.

The next step was to measure profiles across three faults, where previous geological studies assumed Neogene to Pleistocene activity: The Carmel fault (Kafri, 1970: Achmon, 1986), Ayyelet HaShahar fault near Tel Hazor (Heimann, 1990) and the eastern fault of the Emeq Hula graben, near Kefar Szold (Heimann, 1990).

The survey employed the Common Depth Point (CDP) method. The investigation used a high-performance exploration seismograph (ES–2401) with 12 or 24 geophones. A number of profiles showing faults in the young sediments were obtained. The main achievement of the study is the detailed information obtained from depths up to tens of meters.

It is anticipated to apply this method to detect neotectonic activity along major faults, where deformed young sedimentary sequences exist.

The Use of Geophysical Methods for Reconstruction of Paleorelief and Analysis of Fluvial Sediments in the Region of Nahal Revivim, Central Negev Area

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The purpose of the present study is the utilization of geophysical methods in order to study the subsurface sediments and paleogeography in the Retamim area, northwestern Negev. Most of the study area is covered by redeposited loess and sand, which forms an extensive flat plain. A unit of gravels interbedded with sand is quarried along the channel of Nahal Revivim in the southern part of the area. The subsurface extension of this unit to the northwest is unknown.

The present study includes:

1. recognition of the paleorelief buried under Late Pleistocene sediments in the Central Negev area bordered by Nahal Revivim and Nahal Atidim.
2. investigation of the buried stratigraphy.
3. detection of buried gravel lenses which can serve as a local aquifer.
4. comparing of the results of varies geophysical methods which includes seismic reflection and electrical resistivity: vertical sounding and profiling of Wenner method.

After the field work, a combined analyses of all data has been done to interpret the paleorelief and paleochannel of the nahals and to create maps of the distribution of fluvial sediments in the study area.

A correlation between the results of the various geophysical methods, and between the borehole data was obtained. A model of the shallow (5–25 m) structure of the area was purposed.

Migrational Stratification of Hydrocarbons in Yam 1 and Yam 2

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5. **The Institute of Sedimentary and Petroleum Geology, Geological Survey of Canada, Calgary, Alberta, Canada**

The Yam 1 and Yam 2 wells drilled in the eastern Mediterranean encountered a sequence of gas shows in the Cretaceous and Upper Jurassic section and a liquid oil in the underlying Middle Jurassic.

The gases vary in the hydrocarbon composition with depth from dry to wet gas with condensates, in the stable carbon and deuterium isotopes, and in the non-hydrocarbon constituents. The data obtained reveal that despite the differences indicated, all the gas shows (including the dry gas) are oil associated and thermally derived at a maturity level between 0.7 to 0.9 %Ro equivalent. Stable carbon and hydrogen isotope data further suggest an admixture with variable amounts of biogenic gas, mainly methane. The concentration of the gas shows in the same vertical section and the fact that, despite the differences indicated, they are all oil-associated suggest a common source, possibly the underlying oil. In this respect, the differences in hydrocarbon composition between the shows and their systematic distribution in the vertical section are mainly attributed to molecular partitioning and geochromatographic effects with time and distance via migration of the gas phase from the parent oil. On the other hand, differences in the maturity indicated by the stable isotope composition possibly suggest different expulsion times.

Marked differences in the concentration and $\delta^{13}C$ of the CO_2 associated with the various shows suggest different origins for the CO_2. This implies that the presence of the CO_2 is a local phenomenon not related to the major oil source nor to the biogenic gas.

The oil discovered in the Middle Jurassic section is light and contains relatively large proportions of low molecular weight fraction. The chemical composition and the stable carbon and deuterium isotopes reflect, in general, high level of thermal maturity. Some of the characteristics suggest high maturity within the "liquid window" range (ca. 0.9 %Ro equivalent) whereas others appear to indicate "super" maturation. The present day temperature of the reservoir is ca. 180 °C. The composition of the oil, however, appears to represent no long term "equilibrium" with such a high temperature, suggesting a short lived, dynamic state for the studied reservoir. Further, the composition of the oil encountered reveals the possibility that it represents a migrating or "floating" phase separated from the bulk oil, whereas the "parent" reservoir had not been yet penetrated.

Analysis of Macroseismic Observations in Israel

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Macroseismic data of earthquakes which were felt in Israel and also recorded instrumentally were analyzed. The analysis yielded the following empirical relations:

$$I = 0.2 + 1.6M_L - 2.5 \log r - 0.003r \qquad \delta = 0.7 \qquad (1)$$
$$r^2 = R^2 + 15^2$$

$$M_L = 2.5 + 0.5\, I_0 \qquad \delta = 0.3 \qquad (2)$$

$$I_0 = 1.6M_L - 3.5 \qquad \delta = 0.5 \qquad (3)$$

$$M_L = 0.3 + 2.1 \log \Delta_3 \qquad \delta = 0.4 \qquad (4)$$

where M_L is the local magnitude, I is the seismic intensity (MSK scale), R is the epicentral distance, I_0 is the average seismic intensity in the focal area ($R < 20$ km) and Δ_3 is the radius of the area in which intensities of III or more were observed. δ indicates one standard deviation.

Using distance earthquakes which were felt in Israel and by correcting seismic intensities of local earthquakes in accordance with the attenuation function (Eq. 1), an attempt was made to identify areas in Israel with unusual response. We could not clearly identify a correlation between sites of enhanced or deamplified intensity and their geological conditions.

The Reflection of Geodynamic Process in the Variations of Radon Concentration in Earth, Before the Earthquake in Egypt, 12.10.1992

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Detection and analysis of the average hourly values of radon concentration emanating from the earth (with the WLM-200 system) and barometric pressure, have been carried out 5 Km North of Tel Aviv in tunnel of 9 m depth, 2 m height and length of 6m. The tunnel had been sealed in order to maintain, as much as possible, constant temperature and humidity levels during day and night. During the period of measurements (≈ 2.5 month) it was shown, that short-term monitoring period even for several days, may detect an unrepresentative peaks or vallies of radon concentration, causing a false interpretation of resultes. It is dependent on geophysical parameters (atmospheric pressure, temperature and others)and may give unknown temporary behaviour of Rn concentration in concretic geological region. It was establisted that the magnetic storm and special geodynamic processes, may be reflected in temporary behaviour of radon concentration. Fig. 1 is demonstration of radon prediction 5 days before the earthquake (M = 5.8). It can be ussed as short-term prediction method of seismic activity in region.

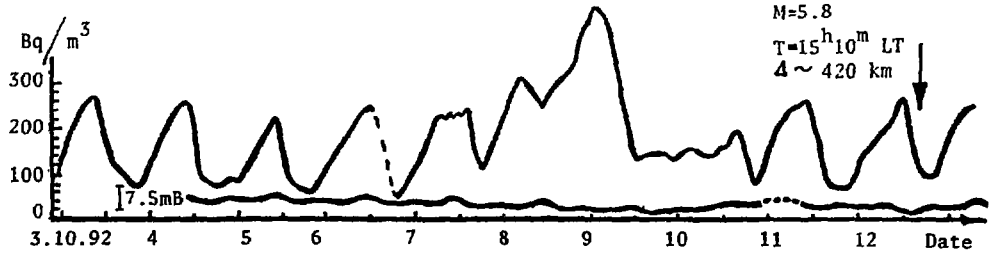

Fig. 1. Time series radon concentration and pressure at Tel Aviv station, showing an elevated value of Rn^{222} before earthquake of 5.8 on Richter scale in Egypt 12.10.92.

Lithological Trends in the Western Basin of the Judea Group Aquifer

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The lithology of the Judea Gr. aquifer extending from the Be'er-Sheva area to the foothills of Mt. Carmel was interpreted using electric log data from 100 representative oil wells. The data characterize the Judea Gr. rock units comprised of Albian (Yagur Fm.), Cenomanian (Negba Fm.) and Turonian age (Bina/Daliya Fms.). Based on the newly interpreted data, a series of isopach, isolith and ratio maps showing the above mentioned rocks subunits have been compiled. The main lithological trends of the Judea Gr. subunits are presented in the following table:

	YAGUR FORMATION	NEGBA FORMATION	BINA/DALIYA FORMATION
THICKNESS	* Truncation westward mainly in the Ashdod and Afiq Neogene channels. * Major thicknesses in Sa'ad, Givati, Caesarea areas.	*South of Tel-Aviv* * A thick belt along the Be'er Sheva-Yinnon-Be'er Ya'aqov axis. * Truncation by the Saqiye Gr. along the Coastal Plain. * Decreasing eastward *North of Tel-Aviv* * Conspicuous thickness in Caesarea area.	*South of Tel-Aviv* * Truncation by the Saqiye Gr. along the Coastal Plain. * Thickening from Nirim-Julie southwestward.
CARBONATE ISOLITH	* A thick belt along the Hazerim-Revaha-Petah Tiqva axis.	* A thick belt along the Haluza-Yinnon-Petah Tiqva axis. * Major thickness in Caesarea area.	*South of Tel-Aviv* * Gradually increasing eastward. * Significant decrease in the area of Nirim-Julie (facies change)
MARL+SHALE ISOLITH	* Increasing westward along the Coastal Plain.	*South of Tel-Aviv* * Gradually decreasing westward. *North of Tel-Aviv* * Increasing thickness in Ga'ash area.	* A thick belt along the Nir'Oz-Be'eri-Hoga axis. * Absent in the belt from Betarim to Gadera.
SAND ISOLITH	* Increasing from Julie-Ziqlag south-eastward.		

Ground Water Entrapment and Hydraulic Discontinuities within a Shallow Artesian System: Hazeva, Israel

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Common hydrological models assume flow of groundwater through confined artesian systems. In addition, aquicludes are commonly defined as bodies of impermeable rocks that act as hydrological barriers, but slow through flow of groundwater (leakage) is regarded as a common possibility. A competing model warrants examination (mainly in continental basins with lenses and interfingering of permeable and impermeable rocks), where: (a) certain confined artesian systems host paleo-groundwater that is entrapped, i.e. static, and (b) that groundwater systems may be separated by hydraulic discontinuities, i.e. highly efficient barriers that completely separate distinct aquifers.

As an example, let us have a look at a simple set of data from a nest of three observation wells (15/t) located in the Hazeva well field, the northern Arava (see Fig. 1 in the Hebrew abstract). The following data were obtained at the time of drilling during December 1971:

aquifer	screen, m	Cl mg/l	pressure, m
A	51 – 63	270	6.8
B	90 – 108	895	6.8
C	131 – 192	680	38.0

The wells were drilled into the Hazeva Formation, and the lithology in terms of permeable rock beds (sandstone) and impermeable rock beds (clay) is marked in the Figure (see Hebrew text). The following conclusions may be derived:

1. One deals with three distinct pressurized (artesian) aquifers.

2. The three aquifers are separated by hydraulic barriers that are highly efficient aquicludes and, as will be shown later on, constitute hydraulic discontinuities, preventing vertical flow (leakage). A and B are marked by significantly different Cl concentrations, whereas B and C are distinct by drastic differences of their pressures, as well as the different Cl concentrations.

3. No phreatic aquifer of any significance is reported for these and neighboring wells, indicating present local recharge is negligible. The terrain in the region is rather flat and so are the beds of the Rift Valley fill sediments of the type encountered in the 15/t well nest. Hence, aquifers A, B, and C have no active recharge and the water they host is trapped paleo-water.

The previous conclusions lead to the reconstruction by which aquifers A, B and C constituted each in its turn a local phreatic aquifer that as a result of the Rift subsidence was (a) covered by clay that sealed it from any further recharge, and (b) burial beneath the former base of drainage, coupled with sealing by shales prevented further discharge (this point warrants further studies).

The above conclusions were checked by tritium and C-14 measurements in water samples obtained in 1992 from aquifer C of well 15/t and aquifer A in the 100 m apart Hazeva 8 well. Both samples contained no tritium, and in A 58.1 percent modern carbon (pmc) were found, in contrast to only 1.8 pmc in C. As the hosting aquifers contain calcitic material, an initial C-14 concentration of 65 pmc is taken as a conservative value and the age of the water in A is around 1000 years, whereas the age of the water in C is >30,000 years (the limit of this dating method). Thus, the dating of the waters confirmed the model of groundwaters entrapped in aquifers that were sedimented in a subsiding system.

The artesian pressure is, accordingly, not the result of a water head in a phreatic aquifer connected to a confined aquifer. The pressure is rather a result of partial lithological compaction, a process that probably was instrumental also in turning the original clay deposits into shale beds forming the hydraulic discontinuities (the highly pressurized water of C did not leak into the overlying aquifers during the over 30,000 years of its existence, neither was a leakage caused during 20 years of intensive exploitation of aquifer A in the Hazeva 8 well).

More examples are discussed in the poster.

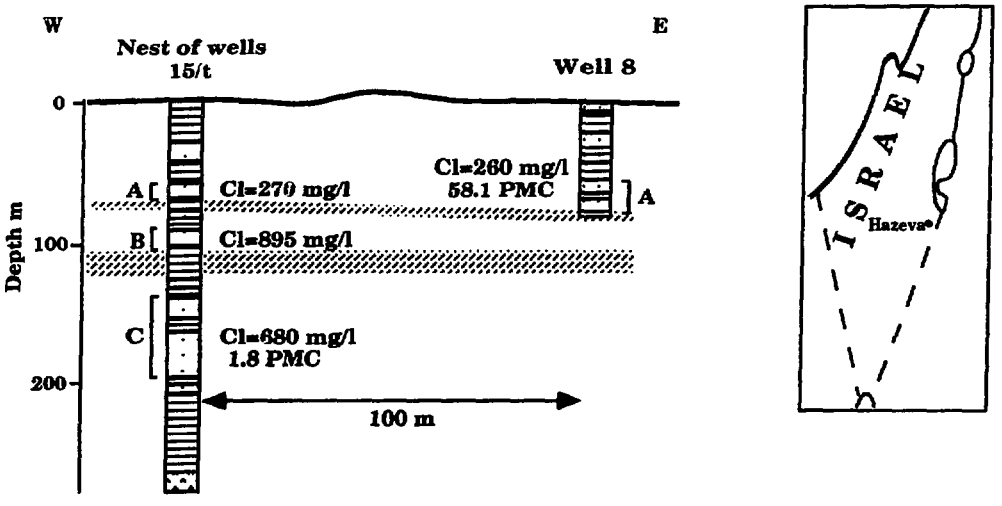

Fig.1. Sections of the discussed wells (▤- shale, ⬚- sands and sandstones, ▨ - hydraulic discontinuities).

Mapping of Seismic Units in the Plio-Pleistocene Sedimentary Fill of the Southern Dead Sea Basin

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About 90 multi-channel reflection lines were checked and interpreted at the Southern Dead Sea basin, from the Ein Gedi area in the north to the Hazeva area in the south. The purpose of this work was to map regional seismic horizons in the young sedimentery fill of the basin in order to delineate possible hydrocarbon traps and to study its tectonic development.

The young sedimentary fill of the basin appears in most of the sections as a series of continuous, straight and parallel reflectors. Eight seismic units were identified on DS-3621, the main strike line at the basin's center, separated by seven strong and continuous reflectors, PH1 to PH7. Successful loop-tying of these reflectors to the various dip lines confirmed the regional distribution of the units.

The series was found to overlay either the seismically amorphous salt beds of the Sedom Formation or the Hazeva Formation which has somewhat wavy and less continuous character.

Several conclusions can be drawn from the mapping of the seismic units:

- The deep central part of the basin is about 40 km long and extends from south of the Lynch straits, through the Boqeq and Sedom area to the northern Arava. In these areas, the entire seismic series is identified down to 3–3.5 seconds (5–6 km).
- At the shallow marginal parts of the basin: the Massada plain, the Lynch strait area and the Ami'az plain, only the younger seismic units appear (PH1 to PH5) down to 2–2.5 seconds (2–3 km). Hence, in these areas, the young subsidence commenced later than in the central parts.
- The strongest deformation of the young fill takes place on the Amazyahu fault system which is comprised of several Lystric faults extending from Neot Hakikar north west to Mount Sedom and southern Ami'az plain. The maximal northward lateral displacement of the fill units is about 8km. It is related to halokinesis and is taking place either on top of or within the salt beds of the Sedom Formation.
- Salt movement in the Ami'az plain eastward towards the Mount Sedom area may be inferred by the appearence of lystric faults and shallow synclines in the young fill.
- Negative flower structure which was identified on several lines in the Lynch strait area, is associated with the major western strike-slip fault of the basin.
- The continous and parallel nature of the mapped horizons, and the lack of prominent erosive unconformities indicate a similar and relatively stable depositional enviroment throughout the Plio-Pleistocene.

The Geological History of Israel — An Overview

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The known geologic history of Israel spans some 800 Ma. Three main stages, each with its specific tectonic setting, can be distinguished.

a) *The Pan African orogenic stage,* in which the basement was shaped by amalgamation of several magmatic arcs. The earliest rock complex originated as a local sedimentary basin that was invaded by several plutons. These rocks were pervasively deformed and metamorphosed in high greenschist to middle amphibolite facies (hi-T/low P regime). The crust was consolidated following a phase of extensive calc-alkaline granite plutonism (ca 600 Ma). This was followed by much erosion (≥10 km), limited magmatism (often alkaline) which included extensive diking, formation of molasse basins and faulting.

b) *The platformal (intra-plate) stage,* from the Early Cambrian to the mid-Cenozoic, during which Israel was a part of a generally stable platform. The transition to this regime was marked by regional peneplanation. Most of the time the area was affected only by long-wavelength vertical oscillations, but a few events of volcanism and rifting also took place. A platformal cover of mature sediments formed in the region in several depositional phases that were separated by periods of important erosion.

During most of the Paleozoic Israel was situated somewhat inland of the northern margin of Gondwanaland. Sedimentation was mostly clastic. Locally a few km thick sections were removed during mid-Paleozoic and (early?) Permian erosion phases. It was only following the latter phase that subsidence towards the Mediterranean continental margin became dominant. This margin and the adjacent Levant Basin were apparently shaped by rifting phases related to formation of Neo-Tethys in the Permian (?), mid to late-Triassic and Liassic, which were accompanied by igneous activity. It was since the Permian that most of the sedimentary cover of Israel formed, its thickness reaching more than 6 km at the continental margin. A characteristic facies zonation — from marine carbonates through marine mixed clastic-carbonatic beds to continental clastics — shifted back and forth in response to oscillations of the shoreline. This history was punctuated by an Early Cretaceous hot spot (magmatism, uplifting, ca. 1 km erosion) — a weak echo of the fragmentation of Gondwanaland, and by Late Cretaceous-Early Cenozoic compressional deformation (Syrian arc: folds, reverse and lateral faults) which echoed plate convergence in the adjacent Alpine Orogenic zone.

c) *Cenozoic continental breakup stage,* beginning in mid-Cenozoic times, during which Arabia broke away from Africa leaving the Sinai sub-plate in between. In Israel this produced a new plate boundary — the Dead sea transform — on which a left lateral slip of ca. 105 km took place since early or middle Miocene times. Slightly oblique opening produced along it deep rhomb-shaped depressions alternating with structural saddles. the transform shoulders were deformed to varying degrees. This was accompanied by regional uplifting and igneous activity. Locally magmatism was directly related to the transform. Concurrently the continental margin was affected by the Messinian event and by subsequent sedimentation.

$\delta^{34}S$ and High Ammonia Contents in the Rift Valley Springs — Indicators for Sulfate Reduction and Decomposition of Organic Matter

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$\delta^{34}S$ of sulfate and H_2S in the hydrothermal springs of the Dead Sea Rift was determined. Sulfate was found to be in the range of $\delta^{34}S_{CDM}$ = 9.6–38.2‰ while H_2S varies between –23‰ to +7.8‰. The isotopic fractionation, α =1.025–1.035, is similar to that expected from microbial sulfate reduction. High ammonia concentrations of up to several tens of ppm were measured in all springs, attesting to the reducing conditions at depth. It is proposed that the ammonia is liberated from organic matter during bacterial reduction of sulfate, following the reaction:

$$(CH_2O)_{106}(NH_3)_{16}(H_3PO_4) + 53SO_4^{2-} \Rightarrow 16NH_3 + 53H_2S + H_3PO_4 + 106HCO_3^-$$

The reaction might also represent thermochemical reduction of sulfate. However, this is less plausible since all laboratory experiments have yielded much lower sulfur isotopic fractionation than the measured values and field studies proposing such models found almost no fractionation.

$\delta^{34}S$ of sulfate in Chamei Ein-Gedi, Chamei Mazor and Ein Kedem are within the range of 19.3–19.5‰, close to marine composition. The composition in a shallow bore hole, close to Nachal Bokek, is significantly heavier (38.2‰), while in Chamei Zohar it is significantly lighter (9.6‰). It is proposed that except for Chamei-Zohar, the sulfate in the springs are remanents from sea water and/or are derived from dissolution of gypsum or anhydrite from the Sedom Formation. The heavy sulfur in the bore hole is due to a partially closed system where Rayleigh distillation occurs.

The low $\delta^{34}S$ in sulfate in Chamei Zohar may originate by: 1) Oxidation at depth, prior to reduction, of light H_2S liberated during maturation of organic matter under oxygen-deficient conditions. 2) Mixing of the hydrothermal solutions which have a marine $\delta^{34}S$ composition and groundwater with lower $\delta^{34}S$ values (<10‰). 3) Dissolution of gypsum or anhydrite with light sulfur from the Lisan Formation (–7.7 to –19.5‰).

The $\delta^{34}S$ of the sulfate in the Dead Sea is about 14‰, and is due to mixing between heavy sulfate in the hydrothermal springs and light sulfate in meteoric water around the lake.

New Elements in the Tectonic Configuration of the Judea Group from the Northern Negev to the Carmel (Yarkon-Taninim Aquifer)

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The mapping of the Top Judea Group and Top Telamim Formation (LC_3 marker) was carried out during 1991–1992 and was based on seismic and geological data (5,000 km of updated seismic lines, 1,000 oil, water and structural boreholes and surface mapping).

The maps depict structural configurations generated in a compressional regime, anticlines of high and low amplitudes accompanied by longitudinal and tranverse faulting and the accentuated truncation of the Judea Group along the Coastal Plain. The main new elements presented in this study are as follows:

1. In the area of Bik'at Arad-Be'er Sheva several narrow, elongated asymmetrical folds accompanied by reverse faults or flexures and an east-west oriented pattern similar to the aeromagnetic trend were discerned. The eastern faults of this setting are probably a continuation of the Qeren-Rogem reverse fault and the western faults a continuation of the Hebron flexure.

2. The Gat-Galon area displays a pattern of low relief structures bordered by subrectangular normal faults.

3. Along the Hebron flexure a reverse fault was deduced based on deep reflections.

4. The reverse fault east of the Helez anticlinal trend continues northward to Gan Yavne and Palmahim.

5. The normal fault east of Nirim-Revaha continues to Sha'ar Ha'gay.

6. In the Emek Ayyalon area, a pronounced elongated narrow graben was distinguished between the Hulda and Kefar Uriya strutures.

7. In the Tel Aviv area, two Neogene faults, N-S (Be'er Ya'aqov-Kefar Hayarok) and E-W (Bat Yam-Rishon Letzion) oriented, apparently border the embayment of Neogene volcanics.

8. The Caesarea and Carmel structures are separated by an E-W oriented Neogene graben, bordered by the Binyamina fault in the north. The vertical displacement of this fault is 500–700 m near the coast and decreases eastward.

9. The truncation of top Judea Group by the Saqiye Group and the LC3 marker by the Talme Yafe Formation were delineated.

The Computerized Geological Mapping Project — Maps at Final Preparation Stages

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The following maps were submitted for publication within the framework of the mapping program of the Geological Survey; they are presented in 17 posters. All maps were computer edited and processed by M. Rosensaft and A. Sneh with the technical assistance of A. Arazy, M. Weiss and R. Madmon.

1-Sneh, Bartov, Rosensaft - Geol. Map of Israel 1:200000

2-Sneh, Rosensaft - Geol. Map of the Coastal Plain 1:100000

3-Levitte - Zefat 1:50000

4-Michelson, Mor, D. - Gamla 1:50000

5-Sneh, Sass, Bein, Arad, Levitte, Rosensaft- Hadera 1:50000

6-Hatzor - Bet She'an 1:50000

7-Cook - Shekhem 1:50000

8-Hildenbrandt - Kefar Saba 1:50000

9-Shachnai - Ramalla 1:50000

10-Mor, U. - Mizpe Shalem 1:50000

11-Zilberman - Rehovot BaNegev - Holot Agur 1:500000

12-Roded - Dimona 1:500000

13-Hirsch - Makhtesh Qatan 1:500000

14-Yeheili, Elron, Sneh - Hazeva 1:500000

15-Avni - Har Loz 1:500000

16-Ginat - Yotveta 1:500000

17-Beyth, Segev, Bartov - Be'er Ora 1:500000

Gold Exploitation in Southern Israel — Early Islamic Period

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The "Wadi Tawahin" ("Millstone Wadi", in Arabic) archaeological site in the Nahal Roded area near Elat is characterized by the presence of some thirty millstones. They are unique for the region in their relatively large size (up to 80 cm diameter), shape and composition (quartz-diorite). The site was first noted by Frank in 1934, who suggested that the millstones were used for crushing *"schwerspar"* (=barite), and has recently been partially excavated.

A geochemical survey (ephemeral stream sediments) of the Precambrian terrain in southern Israel led to the discovery of a gold anomaly in the Nahal Roded area. The archaeological site occurs within the area of this anomaly. For the present study, sediments in and around the site were systematically sampled and analyzed.

The comminuted product of the millstones is a powdery material consisting mainly of quartz, and containing up to 20 ppm (g/t) gold. It appears that the gold was mined within proximity to the site, and that the ore contained microscopic gold. This is the first indication of gold operations in the ancient or modern Levant and it sheds new light on the importance of the Elat area during the Early Islamic period.

Pliocene Continental and Lake Deposits Along Nahal Zihor

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In the southern Negev, along the drainage basins of the streams Paran, Zihor and Hiyyon is a wide area covered by continental deposits — conglomerates, sandstones, clay and limestones.

In the area between Hiyyon plains and Halamish mountain, exist exposures of conglomerate that contain allochtones pebbles — magmatic pebbles, iron sand stones, quarzite pebbles, rounded chert pebbles (import chert) limestone and chert pebbles form Judea and Mount Scopus groups. The exposures are in a strip whose width is 3 km. and length is 10 km. The lithological composition of the pebbles, the clast-imbrication and the spreading out of the exposures evidence transport in a wide stream which brought pebbles form the east side of the Arava valley through the "Arava back" to the southern Negev.

The western exposures of this conglomerate exist along Zihor cliffs. Hundreds of meters to the west, in Nahal Zihor, are red and green clay with three layers of limestone exposed. These layers, each one meter thick, represent the center of a Pliocene lake.

Along the area between the cliffs and Nahal Zihor, the "margins facies" are exposed. The lake deposits exist in an area of 20 sq. km. — west to Ovil cliffs and north to Zhiha Valley. The maximal width of the lake deposits section that is exposed is 10 m. In the limestone, are ostracods and megafauna of brackish water, ("Bulimus Hawaderina" and "Planorbidae"). This kind of fauna live today in Lake Kinneret and are known from Pliocene exposures in Syria and Ubedia. The upper part of the clay layers are rich with salts; on the other hand, the lower part of the limestone deposits are very rich with lake fauna.

The spreading out of the lake deposits and their characters show evidence of a lake that existed in the Southern Negev. Water from the southeast part of the Negev and probably water from the east side of the Arava valley flowed into this lake.

The character of the section in the center of the lake represents changes in the water salinity which may have been caused by changes in the flow regime. The hollow, which contains the lake, was created by tectonic activity in the margins of Zenifim mountain. Inclination of the clay and conglomerates layers in the margins of the lake, and faults in the limestone layers represent young tectonic activity along the "Zihor-Barak" structural line after the deposition of Arava conglomerate.

Teaching Geology in High School

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Since 1991, pupils in Ma'ale Shaharoot high school have studied Geology. The program includes:

In the eleventh class: The rock cycle and earth materials (rocks, minerals and soils).

In the twelfth class: Plate tectonics and the geology of Israel.

The program is based on certain main principles:

1) Development of sceintific thinking.

2) Study with direct experience (including 12 days in the field).

3) Transition from perceptible (earth material) to concepts.

4) Transition from the surrounding environment (Elat area) to the outlying environment (the whole country).

5) Transition from the micro (formation environments) to the macro (plate tectonics).

6) Active study (Geotop,individual work on field problems).

7) Supplementary study in class, laboratory and field.

8) Usage of Mathematics, Physics and Chemistry basics.

9) Usage of varied various teaching methods in class: video films, slides, Geogames, etc.

The final examinations include: field exam, theoretical examination andfield camps reports.

During the past two years the students have studied very seriously. They enjoy learning, especially in the field. The feed back from their perents and from the school management teach about the high contribution of learning to the development of the scientific thinking, and the independent study ability of the pupils.

Jericho and En-Gedi Oases in Jewish Traditional and Ancient Literature

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The landscape, climate, and hydrology as well as the natural and cultivated vegetation of the plain of Jericho and Ein-Gedi are mentioned in the Bible (Genesis 13:10, 14:7; Deuteronomy, 34:3; Solomon's Song, 1:14; 2-Chronicles, 20:2) Mishnah (Menachot, 10:8; Tamid, 3:8) B. Talmud (Sabbath, 26a, Ta'anit, 27a) Tosephta (Tos. Berakhoth, 4:12; Tos. Sota, 13:3) and various Midrashim (Midrash Rabbah: Genesis, 99:4; Numbers, 15:2; Sifrei-Behalotcha). There are also references in ancient history books (Josephus Flavius - "The Wars of the Jews", 4:7:2; 4:8:3) ancient nature books (Strabo - "Book of Geography; Pliny - "History of Nature") and in travel books to the "Holy Land" (Burkhardt, 1283; The Priest Faber, 1484 and Joseph Swars, 1840).

The region known as "The Plain of Jordan" is described as "well watered everywhere ... even as the garden of the Lord: like the land of Egypt, as you come to Zoar" (Genesis, 13:10). Many springs are found in the Jericho area such as the Elisha Spring, known as a spring of health (2, Kings, 2:19–22) and in the En Gedi area such as: En Gedi, David and Nahal Arugot springs.

Abundant fresh water, hot summers and temperate winters provide favourable agricultural conditions for the growth of vegetables and fruits. Other plants were the source of herbs and incense such as Saffron, Cinnamon, as well as Persimmon and Balsam trees for incense. The extensive growth of these plants is known from Chalcolithic times at En Gedi and Neolithic times at Jericho; up to Modern times.

In ancient times Jericho - "The city of palm trees" and En Gedi - "Hazezon - Tamar" were a source "honey" from extensive date plantation. The name Jericho was originally thought to refer to "Jerach" which was the name given to people who in those times prayed to the moon. Later the name was changed to Jericho as is today, referring to the perfume of the Persimmon tree which was abundant in the area.

Jericho is located at a junction between the Judean Mountains in the west and Jordan River crossings to the east. Because of the clarity of the air around Jericho, people living there could hear the sounds of the High Priest and take in the odours of incense even though Jerusalem is about 25km away.

In Medieval times sugar was produced from cane grown in Jericho.

The Hasmonaim Kings built their winter palaces in Jericho. The most famous and beautiful of these was Harod's Palace. Evidence of abundant water was seen in the many swimming and ritual pools. Many of the Priests attending the Temple in Jerusalem lived in Jericho. During the time of the Mishna, Jericho was the home of many of the sages.

En Gedi, similar to Jericho, was famous for its dates, Persimmon and its spices and herbs. Archaeological finds in the area such as various containers for perfumes are evidence of an extensive perfume industry.

En Gedi was a food trading center between the east coast of the Dead Sea and Bar Kochab's camps in the west.

The future of the En Gedi area is given as prophesized by the prophet Ezekiel (47:10). Part of this prophesy can be seen in the extensive fields, orchards and fish ponds in the settlements of the area.

Gravity and Magnetic Fields in the Makhtesh Ramon Area

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The aim of this study was to compile a gelogical model from geophysical data on various scales (Ginzburg et al., 1957; Klang et al., 1983; Domzalski, 1967; Vulkan, 1988; Gvirtzman, 1991). Physical properties (density and magnetic susceptibility) of the rocks from outcrops and wells were measured .

A preliminary analysis of the geological and geophysical data showed that the various qualities, precision, scale, number of stations, density and regularity of the various sources could not be deduced. However, it is possible to make a preliminary interpretation using computer processing and interpretation methods using (SURFER, GRAFER, NCSS, STAT, PGD) to compile maps, graphs etc. Four geological cross-sections, perpendicular to the Ramon fault, along the geophysical profiles, together with petrodensity and petromagnetic measurements constitute the base for the quantitative analysis. The gravity and magnetic interpretation and modelling were carried out by using OST, ISMS, and RAZREZ systems.

This preliminary quantitative analysis in the Makhtesh Ramon showed a greater distribution, at depth, of quartz-syenite.

The results show that quartz-syenite have low magnetic suspectability and low gravity. It cropped out in the northern part of the Ramon fault, and the geophysical model suggests its presence to a depth of about 500 m below the surface south to the Ramon fault. Preliminary detailed gravimetric measurements and quantitative geophysical analysis showed also the exact appearance of a good correlation of relatively high gravity with the distribution of an ore vein in the Gavnunim Valley.

Problems of Water Resources in Israel

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The work is dedicated to studying new problems concerning the water resources in Israel. A series of steps for accumulation, recovery and utilization of water resources is proposed taking into consideration protection from pollutants and the exhaustion of resources.

One of the problems concerning this work is the drawing up the large-scale hydrogeological maps of Israel. This would allow the estimation of the ground water resources of the certain hydrogeological basins, and to work out the measures for the reconstruction of ground water output in regions where processes of pollution and exhaustion are observed.

Lake Kineret is an additional important source of water. In years when there is a high water level a sufficient amount is released to Dead Sea by way of the Jordan river. This project proposes to collect and store water in aquifers by means of installing small constructions on rivers (nahalim) flowing down the the Jordan river.

Another project considers the collection and accumulation of rain water in valleys and utilizing it for aquifers recharge.

The possibility of exporting water to neighboring countries situated along the Jordan river is also under consideration. For this, it is suggested to build special constructions on the rivers (nahalim) flowing down the Jordan.river.

The problems of increasing water resources in Coastal and Mountain aquifers, and also problems of ground water output from the Mediterranean shelf are under discussion.

In the work two aspects of the problem of protection of natural water resources are to be considered. The first aspect is the consideration of water storage (protection from exhaustion), and the second is protection from contamination. For each of these aspects several projects are to be devoted, one is connected with the development of the system of water saving by means of decreasing evaporation in basins and reservoirs and the others are connected with technologies and systems of rational water use in industry, progressive methods in irrigation etc.

This work also considers the project of protecting small river valleys from sewage dropping, enhancing of well construction, protection of aquifers from sea water intrusion.

Three projects are devoted to studying surface water as a cause for ecological changes, and three projects are devoted to studying ground water as a cause for ecological changes.

Permanent monitoring of environmental changes should be carried out in order to observe and estimate the character and depth of human interface and to fulfill the steps which have been proposed in this work.

Carrying out the projects proposed will increase the amount of utilization of water resources for 25–30% without quality damage.

Hydrogeology of Ormesa 1, 2, 1E, 1H, Geothermal Projects, East Mesa, California, U.S.A.

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Ormesa 1,2,1E,1H, Geothermal Power Plants were constructed by Ormat Energy System Inc., for production of electrical power of 30MW, 20MW, 10MW, 10MW, respectively. Each of the projects comprising few Ormat Energy Converter (OEC) modular units, each having a capacity of 1.2MW.

The depth of the geothermal reservoirs within those projects is ranging from about 4500 ft to few 9000 ft, and each of them contains few production wells and few injection wells. Also, the projects contain few shallow ground water wells penetrating to a depth of 750–1200 ft which serve as make-up water for cooling the OEC units.

All of the projects are located within Imperial Valley, East Mesa, which is a part of the Salton Trough. The Tertiary and Quaternary sediments that fill the Trough include predominatly unconsolidated sand, silt and clay, having an estimated thickness of 20,000 ft. The Golf of California and the Salton Trough developed in the late Cenozoic time by a combination of strike slip displacement and dip-slip movement, and the East Mesa geothermal field is the expression of a plate tectonic spreading center.

The capacity of the geothermal production water wells which are pumped into the power plants is ranging mainly from 700–2000 gpm (170–500 cu.m/h) per well, having water temperature of 280–340 °F (138–170 °C) and water salinity ranging mainly between 1700–6500 ppm Total Dissolved Solids.

Ar-Ar dating of Anorthite and Sanidine Fels from Hatrurim Fm. in Arad: Age Spectra and Their Interpretation

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Five whole rock samples and separated fractions from the Hatrurim Formation in Arad were dated by the Ar/Ar incremental heating technique. The dated rock samples are anorthite and sanidine fels, formed by high temperature-low pressure metamorphism. K containing minerals in the samples are from Feldspar and Zeolite groups.

Plateau ages are 2.3-4.0 my.

Isochron ages are 2.6-3.8 my.

Three extraction-step groups are observed in the age spectra. The first, extracted in the lowest temperatures, has ages similar to the plateau age but more "noisy". From the second group the plateau and isochron ages are calculated. The third, extracted in the highest temperatures, has ages older than the plateau age, around the age of 10-20 my, and is quiet "noisy".

At each extraction step the $^{39}Ar_k/^{37}Ar_{Ca}$ ratio is measured and K/Ca ratio is calculated from it. The first group of steps has medium K/Ca ratios. The second group has the highest ratios which forms a K/Ca ratio "plateau". The third group has the lowest K/Ca ratios.

Correlation between K/Ca ratios, calculated from the Ar extraction, and the K/Ca ratio as calculated from SEM analyses helped to identify the mineralogical control of the age spectra. The first group of steps is extracted from zeolites (philipsite, gismondite), the "plateau" — from sanidine and the last group of steps from anorthite.

Lower Cretaceous Stratigraphy in Israel: Updated Correlation

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The Lower Cretaceous (Berriasian to Albian) sequence of Israel and the adjacent countries can be divided into nine regional representative sections: 1. The sequence in the present coastal plain and continental shelf, in which the Gevar'am and Talme Yafe formations represent the sedimentary prism of the Early Cretaceous continental margin (see studies of Bein, Derin, Gerry, Z. Cohen, Martinotti and others). 2. The sequence of Helez, which represents the entire coastal plain and includes the Helez, Telamim, Yavne, Yakhini and Yagur formations (Grader, Reiss, Raab, Derin, Gerry, Z. Cohen, Shenhav, Brenner, Rosenfeld, and others). 3. Sequences in Gebel Maghara, Bir Lugama and Rissan Aneiza in northern Sinai (Douville, teams of the Anglo-Egyptian Oil Company from the beginning of the present century, Grader, Goldberg, Raab, Bartov, Arkin, Lewy, Kuss, and others). 4. Sequences in Lebanon, which include several maping and biostratigraphic units (Dubertret, Vautrin, Sant-Marc, and others). 5. A partly exposed section in the Galilee, which includes local formations (Eliezri, and others). 6. An exposed sequence in Samaria, which includes at the base the Tayassir Volcanics and local formations (Mimran, Lang). 7. A subsurface sequence in the Zohar-Arad region, which includes local formations (Aharoni, Bentor, Vroman, and others). 8. Exposed sequences of the Hatira Formation in the three Makhteshim of the Negev, which include several marine intercalations (Bentor, Vroman, Shilo, Price, Mazor, Nevo, Zak, Parnes, Lorch, Greenberg, Weinberger, and others). 9. An exposed sequence in the Elat region, which includes the Amir, Avrona and Samar formations (Weissbrod).

The great differences in lithology and in the time that each of these sequences represents have permitted only partial correlations, such as: Helez-Galilee (Reiss), Helez-Continental Shelf (Gvirtzman, Klang, Derin, Bein, Weiler), Helez-Negev (Arad, A. Cohen, Brenner), Lebanon-Galilee (Eliezri), Lebanon- Galilee- Samaria (Mimran), Zohar-Makhteshim (Bentor, Vroman, Aharoni), Zohar-Makhteshim-Elat-Egypt (Weissbrod, Gvirtzman, Lewy). Some of the main lithological boundaries were correlated with global falls of sea-level (Flexer, Reyment, Braun, Hirsch, Sass, Bein).

It appears that three problems prevented overall regional synthesis: A.Difficulties in correlating platform carbonates in the northwest with siliciclastic sequences in the southeast. For this same reason there are still disagreements concerning the lateral and vertical boundaries between the Judea and Kurnub groups; proposals of new revised nomenclatures are still beeing suggested (Shilo and Wolf). B.From the present biostratigraphic correlations, both the mutual relationships between each of the different disciplines (benthic and planktic foraminifera, ammonites and macrofauna, ostracods, palynomorphs, etc.), and the relations between local and global distribution charts, a

stratigraphic breakthrough cannot yet be made. C. There are still big differences concerning the Early Cretaceous time span: from 48.6 Ma (Harland et al., 1990) to 39 Ma (Odin and Odin, 1990).

Significantly improving the correlations in Israel, Lebanon and Sinai are: 1. K-Ar ages of basalts from Tayassir, the Hermon and Ramon and especially more reliable Ar-Ar ages of the Ramon Basalt (Lang, Steinitz, and others). 2. The better understanding of the regional event of Early Cretaceous heating of the lithosphere around Israel (Garfunkel, Eyal, Kohn, Feinstein). 3. Determination of the marine origin of the upper part of the Amir Formation and the finding of a volcanic event within the Elat sequence (Weissbrod, and others). 4. Revision of the number and of the distribution in space and time of the marine intercalations in the Hatira Formation in the Negev and the correlation of the lowest intercalation with a marine ingression via Elat to Egypt (Weissbrod, Gvirtzman, Lewy). 5. Magnetic reversal, from R below to N above, within the Ramon Basalt (Ron and Baer). 6. The diachronous relationship and age differences, based on palynology, between the bases of the Helez and the Zuweira formations (Brenner). 7. The subdivision of the Gevar'am and Talme Yafe formations into standard cosmopolitian planktic foraminiferal zones (Martinotti). 8. Precise time determination, in terms of planktic zones, of some of the hiatuses within the Cretaceous sequence of the coastal plain and offshre (Martinotti, Lipson-Benitah, Derin).

Consequently, new revised regional correlation of Israel, Lebanon and Sinai was made. The ages of the volcanic events and the magnetic reversal were correlated to global scales. Some of the main lithological boundaries and some electric-log markers were interpreted as regional, nearly synchronous, datum-levels and thus, were correlated to global charts in terms of biostratigraphy, chronostratigraphy and age. Some of these datum-levels were correlated with the global falls of sea-levels. The new model clarifies the stratigraphic relationships of that part of the sequence which does exist in Israel as well as the great part of the Lower Cretaceous sequence that is missing. The entire transition from the continental Gondwanaland to the oceanic Tethyan margin during the Early Cretaceous times is compressed within the area of Israel.

Salination Mechanism in Deep Aquifers Between the Mediterranean Sea and the Rift Valley, Israel

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It is claimed that the main salination mechanism of major underground hydrological systems in Israel are due to the hydraulic gradient that exists between the Mediterranean Sea and the Rift Valley, which slowly but effectively causes a large scale groundwater flow from the east into deep aquifer system, including seawater inclusion. This theory is tested by using a mathematical-physical model of groundwater flow develops by Zeitoun and Gvirtzman (this conference). In the first step, the model is implemented using a Finite Element code on a vertical cross section between Ashdod and the Dead Sea to a depth of –2000 m below sea level. The numerical code computes the two-dimensional hydraulic head distribution and the flow field.

From an hydrogeological point of view, the Dead Sea represents a deep basin into which groundwater are drained from all directions. Despite the existence of a water divide in the Judean aquifer separating between the flow towards the rift valley and towards the Mediterranean Sea; it appears that in deep layers (–1000 m to –1500 m), groundwater flows only to the east.

The main obstacles for such a flow are the thick and impermeable geological formations encountered along the flow path, specifically the Saqiye and Talme Yafe formations. In any case, a completely impermeable formation cannot be found in nature; therefore, the time-span needed for passing through these layers should be calculated given their hydraulic conductivities and hydraulic gradient. On the other hand, in several places these obstacles are very thin or absent. For example: in the Caesarea-Binyamina area, the Mt. Carmel, and Rosh Haniqra, outcrops of the Judea Group can be found at the sea bottom; therefore, significant sea water intrusions are possible. In this research, these possibilities are tested using a solute transport model which computes the time-span by particle tracking.

Interpretation of Ramon Basalt Magnetic Anomalies (Southern Israel): Magnetic Modeling and Paleomagnetic Study

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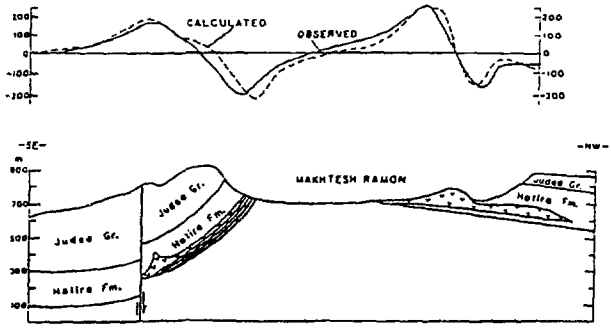
Two magnetic anomalies were interpreted in the present study: one is located 0.5 km south of Makhtesh Ramon (1240/9935 local grid), and the other (1205/9963) is related to one of the basaltic hills (Early Cretaceous volcanism within the Hatira Formation). Determination of the magnetization vector in the suggested model (Fig. 1) is based on susceptibility measurements and paleomagnetic study. The magnetization is a vector sum of the induced magnetization and the Natural Remanent Magnetization (NRM). In this way remanent magnetization was not neglected in the interpretation.

The interpreted anomalies are much stronger than other anomalies which are related to Ramon basalt, and their shape (location of the "high" in relation to the "low") indicate a W/NW magnetization. The interpretation suggests that the southern body is composed of 3 basaltic flows, as seen in the exposed edge of the body, which was sampled. All 3 flows have strong remanent magnetization (10^{-2}–10^{-3} emu/cm^3), but the upper flow is the dominant one and is responsible for the main part of the total anomaly. Its NRM is 20 times stronger than the induced magnetization and it points to the W/NW. The true susceptibility which was measured in the upper flow is $4150 \cdot 10^{-6}$, while the effective susceptibility, taking into account the NRM, is $75520 \cdot 10^{-6}$ (cgs). The result is an effective vector 18 times stronger than the induced vector and with declination of 290° as expected from the shape of the anomaly.

The interpretation shows the complexity of determining a magnetization vector for a magmatic body. In this case the remanent magnetization can not be neglected and homogeneous magnetization for a body can not be assumed.



Magnetization vectors

	NW body	SE body		
		Upper flow	Middle flow	Lower flow
K*10e+6	25000	75520	18897	25272
Declination	305	289	253	19
Inclination	20	32	18	22

Fig. 1. The interpreted profile.

Geological Importance of a Digital Terrain Model (DTM)

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The Geological Survey of Israel, in conjunction with the Israel Mapping Centre and Historical Productions, Inc., has completed a digital terrain model (DTM) for the 67,200 km^2 area in the Israel Mapping Centre's standard 1:250,000 scale North and South sheets of Israel. This DTM, consisting of more than 107 million height points to decimeter precision, covers the area with a 25 m grid. The DTM is primarily based on the 10 m contours of the existing 1:50,000 scale topographic sheets. This DTM is among the most detailed for any country in the world.

This talk will discuss the importance of this DTM to many aspects of the geological sciences. Examples will be given from the literature as well as for studies either planned or underway. A brief outline of various uses of DTMs is given below:

I. Gravitational processes

Engineering geology: slope maps, risk assessment
Hydrology
watershed and drainage pattern definition
mass wasting and erosion potential
snowpack volume related to elevation
surface flow dynamics
Climate, chemical weathering

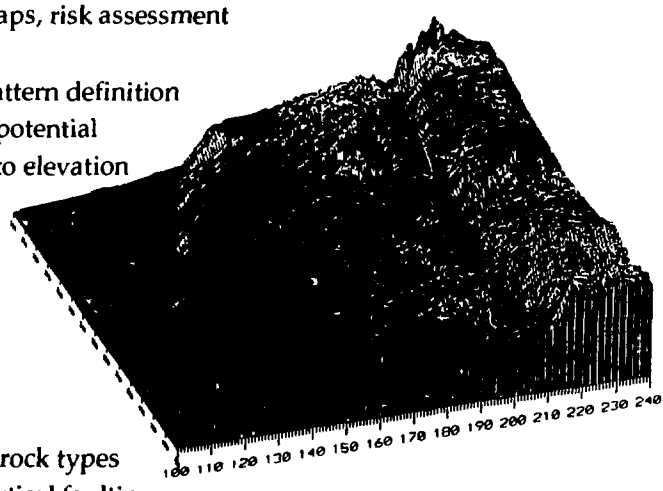

Fig. 1: Northern Israel

II. Geometrical studies

Hypsometry
Volume estimations
3-D rendering possibilities
Quantitative geomorphology, rock types
Tectonics - blocks, grabens, vertical faulting
Topographic corrections to gravity measurements
Definition of deformation and its time sequence
Geological mapping
resolution of structural relationships and blunder detection
definition of structural contours by heights at surface contacts
Topographic corrections to gravity measurements

III. Aspect related studies

Insolation - solar (thermal) stress
mechanical weathering
vegetation cover
Rainfall, topographic shadowing effects
Remote Sensing
correction of albedo for sun angles
correction of radar reflection for look angle
Tectonics - lineament and fracture detection

IV. Visualization

Continuity of land and marine morphology
Relation of geological parameters to topography
Shaded hypsometric presentations
Merger with other data sets, including generation of stereo pairs
Draping of any imagery over its corresponding topography
Rectification of oblique photos - extraction of locations of points - orthophotos

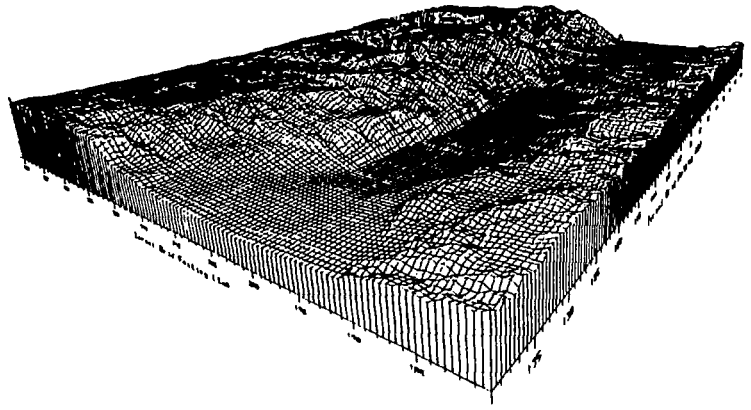

Fig. 2: The Dead Sea

Distinguishing Between Tectonic and Non-Tectonic Colluviation on Scarps

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An essential part of determining the seismic hazard of an area is to identify the paleoseismisity of existing faults. One of the main techniques used is to identify different faulting events by the deposition of colluvial wedges on the fault scarp. The common assumption in paleoseismic studies is that individual stratigraphic packages in the colluvium, are formed through erosion of the scarp formed by surface rupture related to large seismic events. Dating of the stratigraphic units then leads to an estimate of the timing of surface rupture events. Some of the limitations of this approach are the difficulty of locating datable material and the possibility that some of the stratigraphic units in the colluvium may result from slope processes other than tectonic related activity. The degree of soil development on the wedges has been used to identify periods of stability on the scarp slope to constrain the lapse time between depositional events. In a previous study, a large fault scarp in the southern Arava was trenched and a number of different colluvial wedges, separated by buried soils were identified. To determine if all these colluvial wedges are the result of tectonic activity, a terrace riser was trenched in two places. One trench is in close proximity to the fault scarp and the other is approximately 500 m away from the fault. The colluvial stratigraphy on the terrace risers has been described and compared to that found on the fault scarp. A much larger number of colluvial wedges and associated buried soils were found on the fault scarp than on the terrace riser which indicates that many of the wedges are the result of tectonic activity.

New Developments in Underground Excavation Design in Blocky Rock Masses

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It is common practice in rock engineering to predict ground response to excavation on the basis of empirical rock mass classification systems. The most commonly used methods (the Q and RMR systems) take as input the strength of the intact rock, density and quantity of joint systems, condition and strength of discontinuity planes, and the environmental conditions underground. As an output the methods predict support pressures and stand-up time, on empirical grounds.

Conventional classification methods however ignore a common failure mechanism underground, the release of removable blocks into the excavation space. The removability of a block depends only on the geometry of the block with respect to the free face. The mechanical properties of the rock mass, as well as the environmental conditions underground, do not effect the kinematical solution. Therefore identical removable blocks can form in rock masses of varying "quality", as long as the free face and the rock structure do not change.

Block Theory provides a rigorous solution for the removability of a block, bounded by k joints of different orientations ($k \geq 3$), and a known free face. Application of the theory becomes less straight forward as the number of joint sets (n) in the rock mass increases. The number of distinct joint combinations (N_{jc}) is: $N_{jc} = n!/\{k!(n-k)!\}$. Each joint combination produces 2^k half-space combinations (Joint Pyramids), $(k^2 - 3k + 2)/2$ of which are removable from a given free face. The failure likelihood of each removable block can be evaluated if we consider the joint combination probability, and the mechanical stability of the removable block. A failure likelihood histogram can be generated for all joint combinations, from which the most likely blocks can be selected. These blocks should provide the basis for design, in the relevant rock masses.

$^{40}Ar/^{39}Ar$ Dating of Prehistoric Basalts in Southwest Syria

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Alkali basalts of Upper Pleistocene to Holocene age are exposed in the Leja area in southwestern Syria. These flows, which originated at Tel Hader, flowed generally southward, except for one flow, the El Wara Basalt, which is exposed a few hundred meters east of the present international border in the Golan Heights.

Samples of this unit were dated by the $^{40}Ar/^{39}Ar$ incremental-heating method (Ohio State University.) This method has certain limitations when measuring very young samples especially those with low K contents such as basalt. In order to overcome some of these obstacles, relatively large samples (~2 gr) were measured, using only a few increments (3–4). The middle steps yielded a relatively high percentage of radiogenic argon which significantly improved the precision.

Six samples yielded ages of (in Ka): 73 ± 11, 66 ± 5, 63 ± 15, 60 ± 17, 57 ± 9, 56 ± 10, with an average of 62.5 ± 6.3 (1σ). Although the error of an individual measurement is higher, the similarity of ages from different samples taken from the same unit confirms the reliability of the results. However, since the method of error attribution does not appear to be adequate for young samples, we suggest a realistic uncertainty of ±20,000 years.

The El-Wara prehistoric basalt is the youngest basalt exposed in the region, and young enough to enable the use of the ^{230}Th–^{238}U disequilibrium method to calculate the Th/U ratio of the mantle source of the basaltic magma. The determination of this ratio has a special importance in characterizing the geochemistry of alkali-basalt sources and the relation between mantle processes, tectonics, and recent continental volcanism of the plate boundary of the Dead Sea Transform and the East African Rift.

Locating Reservoirs Suitable for Deep-Well Injection of Industrial Wastewater in Israel

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The disposal of industrial wastewater is a major environmental problem. Because industrial wastewater contains trace metals and other toxic compounds, its disposal may endanger soil and water resources. On the other hand, its heterogeneity results in very expensive reclamation processes. Over the last 30 years, subsurface disposal of liquid industrial waste by deep-well injection has become acceptable in the United States. The estimated annual volume of industrial waste in Israel exceeds 50 million m^3. In 1991, for the first time, a permit for injecting industrial wastewater into the abandoned oil well Kohav-1 was granted to the oil refineries in Haifa. The "Lapidot" company currently injects 200 to 250 barrels/day of caustic soda into the well. Following this precedent, the need to evaluate the suitability of Israel's subsurface for this activity is clear, to minimize the above-mentioned risks.

In our study, subsurface rock units were classified as either confining or reservoir units according to the following guidelines: (1) rock units containing formation water with salinity < 10,000 ppm were rejected; (2) rock units containing brines were classified as either confining or reservoir units according to their lithology; (3) in regions where detailed structural information was available, unfaulted areas with simple geological structure were selected; (4) areas with a high density of wells were rejected; and (5) areas where the depth of the reservoir top is lower than 2500 m below land surface were rejected.

Areas that were suitable according to these criteria were described in detail as a group of preferable reservoirs for deep-well injection of industrial wastewater.

The Isotopic Composition of Sulphur in Rainwater from the Negev Desert

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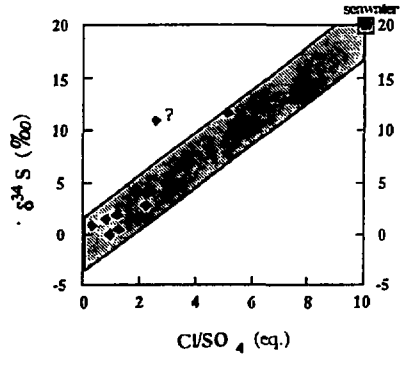
During three hydrological years (1982/83, 1983/84, 1988/89) we collected 8 rainwater samples from 5 stations. The locations are Sede Boqer (4 samples), Revivim, Mizpe Ramon, Hazeva and Neot Hakikar (one sample from each). The $\delta^{34}S$ versus Cl/SO_4 ratios in the rainwater samples are presented in Fig. 1. Except for one sample (from Mizpe Ramon) which is probably contaminated with local gypsum, the samples fall in the range (marked) found for rainwater in Israel by Wakshal and Nielsen (1982) and Herut et al. (in prep.). The $\delta^{34}S$ - Cl/SO_4 relationship is explained as a result of a mixing process between seaspray-laden air with uniform $\delta^{34}S$ (~20 ‰) and a non-seaspray source with an almost constant $\delta^{34}S$ composition (~0 ‰). Most of the Negev samples fall in the lower range (<3 ‰). An exception is one sample from Sede Boqer that shows a higher $\delta^{34}S$ value (11.8 ‰). This sample was collected during a rain event in which much seaspray was injected into the atmosphere (by high winds) and later scavenged by the rain. As a result, enrichment of the $\delta^{34}S$ and Cl/SO_4 ratios is detected.

Two main sources for non-seaspray SO_4 are known: (a) anthropogenic and (b) biogenic.

The two sources can be local or remote. We assume that the Negev is a relatively 'clean' desert that cannot serve as an anthropogenic or biogenic source of sulphur because of its sparse population, industry and vegetation. It seems that SO_4 is mainly derived from a remote source. Most of the rainfall events over Israel are associated with westerly winds in which air masses come from industrialized zones of Europe, cross the Mediterranean Sea and may deliver substantial amounts of anthropogenic sulphate and/or natural sulphate derived from the oxidation in the atmosphere of volatile sulphur compounds produced by biological activity in the Mediterranean Sea. The question arising is whether this remote source is mainly anthropogenic or natural. We cannot answer this question at the present stage of our study.



Bedload Storage and Discharge in a Quasi Bedrock Steep Stream, Upper Meshushim River, Golan Heights

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The bedload of a stream consists of those particles moving along or near the stream by rolling, sliding or saltation. Bedload discharge is a small portion of the total sediment transport but in mountain rivers it increases. The importance of bedload lies in that it determines the morphology of the channel and therefore influences the water and sediment regime. In this study the major topics are: The total volume of bedload storage, its physical characteristics and the relationship between bedload transport and storage with the hydraulic regime.

Accurate and detailed data of the total bedload storage is necessary for testing theories of bedload transport and residence time of bedload in channels. A lot of field work must be invested to obtain accurate data; the Upper Meshushim River, a low order mountain stream with a single active bedload channel, enables one to obtain a reliable measurement of the total storage. Bedload storage volumes measured in the channel were about 300–400 kg/ m of channel reach, and values were consistent from several reaches along the channel. The total mass of active bedload computed for the 8 km channel reach is 3000 ton.

Bedload transport in the Upper Meshushim stream, a 3% steep chanel incised in basaltic bedrock, takes place during high magnitude and low frequency flood events. During the drought years 1988–1991, flood peaks were low and there was little movement of coarse bedload particles. During the rainy 1992 winter, during a high peak flood with a 1:6 years recurrence interval, coarse bedload discharge was about 1000 kg or 0.3 per thousand of the total channel storage. Most of size particles are active during floods and during climatic average years aggradation processes are dominant. During very low frequency flood events, 1% to 4% of total bedload is transported and for a total period of 100 years, the computed bedload discharge is about 10% of the total channel storage. Average residence time is therefore about 1000 years for the coarse material.

In the studied channel, available bedload storage is much larger than maximum sediment yield values for catastrophic floods; hydraulic transport factors are therefore dominant in the bedload discharge process.

The Preliminary Results of Micromagnetometry as Applied to Archaeology in Israel

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Israel Antiqueties Authority

Magnetometry has been used in archaeology since 1950-s, more frequently than other geophysical methods because of their cheapness and rapidity. It has extensive possibilities for prospecting many kinds of archaeological objects such as ancient fortifications, buried stone foundations, walls, columns and fired structures - kilns and furnaces.

The first experience of using the method in Israel was at the sites of Bet-Shean (a well-known State Archaeological Park of the Roman Period) and Kissufim Road (a Chalcolitic cemetery in the western Negev).

In these two cases we are concerned with two different kinds of building material (from the point of view of their magnetic properties). At the site of Bet-Shean it is basalt (high or middle magnetic susceptibility) so we expected and obtained intensive anomalies which identified the objects of research: parts of ancient buildings and kiln. At the site of the Kissufim Road the material is unbaked bricks (low magnetic susceptibility),but here we also obtain some contrast anomalies reflecting the position of another charnel-house at the flank of the excavation area.

All data offer extensive information and after preliminary interpretation are used for reasonable planning of excavation and producing safeguard zones of the sites.

The Stratigraphy and Paleogeography of the Hazeva Formation Near Arad

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Sediments of the Miocene Hazeva Fm. are preserved along the regional water divide in the Arad area, in ancient valleys oriented perpendicular to the Rosh Zohar ridge. The sequence consists of fluvial-lacustrine sediments up to 90 m thick, which represents only part of the original sequence. Residual sediments of the Hazeva Fm. are scattered on the summits of the Rosh Zohar anticline. Thus during the Miocene this anticline was buried under fluvial sediments.

The Hazeva Fm. comprises three units, also known from other parts of the Negev. The lower two units are a basal conglomerate, consisting at the base of clasts of local origin (the Base conglomerate), overlain by marl unit probably lacustrine, possibly correlative with the middle member of the Hazeva Fm. (Gidron Mbr.). The base of this sequence is located at elevation of 600 m.a.s.l. and its top at 625 m.a.s.l.

The base of the upper most member of the Hazeva Fm. is located at elevation of 560 m.a.s.l., filling a valley which is incised at least 65 m in to the top of the previous fluviatile members. Its lower part is composed of densely packed, well rounded chert pebbles ("Allochthonous chert"), forming mega-cross bedded structure (1–3 m in thickness). This conglomerate is overlain by sand with cut and fill structures changing upward to a bedded sequence with well developed paleosols. The upward reduction in size of clasts reflects a gradual decrease in stream energy, partly related to the filling of the primary relief, and accompanied by development of extensive floodplains.

The incision of the valley, later filled by the upper member, indicates Miocene uplift of the Rosh Zohar anticline. The amount of the uplift was at least 65 m (measured from the top of the marl). The incision and the deposition were made by westward flowing streams, which drained areas far to the east or southeast, indicating that there was no intracontinental drainage basin east of Arad in this period.

A Young Conglomerate in Nahal Amud — An Indicator of a Paleodrainage System

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In the framework of the study of paleo-drainage systems in the Galilee, a young conglomerate which contains Eocene, Judea Group and basalt pebbles was studied in Nahal Amud just north of Ami'ad-Farod Road.

Radiometric dating of three basalt pebbles, using the K-Ar method, yielded an age of 2.7–2.3 Ma (±0.5 Ma). Three basalt flow exposures, located only a few hundred meters to the south, were also dated and their age was found to be 2.5–2.2 Ma (±0.2 Ma).

The basalt flows are topographically higher than the conglomerate; the basaltic pebbles were found only north of the flows exposure and their relative amount in the conglomerate is decreasing northward.

The dating and the described configuration indicates a paleo- (younger than 2 Ma) NW flow direction, generally towards the Mediterranean. This flow direction is along the old Amud River which predated the formation of the Sea of Galilee base level in the southeast.

K-Ar Age of Authigenic Feldspar from the Cenomanian Hazera Formation

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Pure K-feldspar was isolated from a calcitic dolostone sample from the Hevyon Member of the Hazera Formation (91–96 m.a.). The high content of the K-feldspar in the rock and especially its abundance relative to detrital quartz grains indicates an authigenic origin for it. SEM observations show the K-feldspar crystals to be idiomorphic, most of them in the size range of 4–15 micron, confirming its authigenic origin.

The K-Ar age of the K-feldspar was found to be 92.3 ± 1.9 m.a. (K = 12.12%, $^{40}Ar_{rad}$ = 0.446 × 10^{-4} cc/gr).

The K-Ar age of associated clay minerals in the <0.2 micron fraction was found to be 96.1 ± 2.1 m.a. (K = 4.25%, $^{40}Ar_{rad}$ = 0.163 × 10^{-4} cc/gr). This fraction, assumed to be authigenic, contains only a highly illitic I/S phase. If the latter age corresponds with the stratigraphic (depositional) age then the K-feldspar age reflects its diagenetic formation time.

Automatic Extraction and Mapping of Geological Lineaments from Remote Sensing Data

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Regional study of linear features, such as faults, joints, folds, dikes, crustal fracturing and lithological contacts, using aerial photographs and particular satellite images has made important advances in geological research during the last few decades. Recognition of lineaments has been used for investigating active fault patterns in areas of difficult accessibility, water resources investigations, mineral deposit exploration, and in the study of structural or tectonic history of a region.

The Hough transform is an established tool for discovering linear features in images. The present investigation presents a new and specific algorithm for detecting geological lineaments in satellite images and scanned aerial photographs which incorporates the Hough transform, a new kind of a "directional detector", and a special counting mechanism for detecting peaks in the Hough plane.

Three test sites representing different geological environments and remote sensing altitudes were selected. The first site represents sedimentary conditions of chalk beds on cherry picker photography. The second represents plutonic conditions of granite rocks on an aerial photograph. The third, a tectonic fractures of carbonates, chalks and cherts on digital satellite data. In all cases automatic extraction and mapping of lineaments conformed well to interpretation of lineaments by human performance.

Ophiolitic Upper Tectonic Unit in the Cycladic Orogen, Island of Tinos, Greece

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A unique metamorphosed dismembered ophiolitic section that outcrops at the island of Tinos sheds new light on the tectono-metamorphic evolution of shallower levels of the alpine orogen in the Cyclades. This ophiolite, as well as a number of unmetamorphosed sedimentary sequences in the Cyclades are termed "Upper Units". They are considered to be remnants of the overburden removed from above the subducted sequences (Lower Unit) during exhumation by low angle normal faults. The Upper ophiolitic Unit outcrops in six different localities on Tinos, exhibiting variable "stratigraphy" and degree of exposure, but similar inner structure. The ophiolite is tectonically dissected (as evident by phyllonitic ductile shear zones) to three different lithological slices (thrust sheets): Streaky mafic phyllites whose texture and mineralogy suggest a basaltic protolith underlay massive serpentinized dunites containing variable amounts of carbonate, and meta-gabbros exhibiting well preserved magmatic textures are interspersed with serpentinites at the top. The presence of antigorite-forsterite-magnesite and antigorite-chlorite-tremolite-talc assemblages in the ultramafic rocks and chlorite-epidote-actinolite-albite in the phyllites suggest metamorphism at greenschist to amphibolite facies. Pseudomorphs of Ca-poor amphiboles after clinopyroxene that are replaced by Ca-rich amphiboles in meta-gabbros and phyllonites, suggest a poly-metamorphic history in which an earlier high temperature stage was largely erased by a later greenschist facies overprint. A possible scenario might be non deformational sea floor event followed by regional metamorphic stage during orogeny.

A thin layer of amphibolite exposed at the base of the intermediate serpentinite slice suggests a rapidly decreasing metamorphic grade in the basic volcanics underneath it. This feature, observed in several orogenic belts, is interpreted as a "metamorphic sole" caused by contact aureole at the base of hot ophiolites.

An oxygen isotopic profile of the Mt. Chiknias section demonstrates a break in $\delta^{18}O$ values at the transition from the greenschists below the ophiolite (12–15‰) to the ophiolite itself (7–10‰). These results suggest that the ocean floor isotopic signature is the dominant factor in establishing these values. Whereas the protolith of greenschists originated in volcanosedimentary environment where low-temperature reactions with water were common, gabbros and peridotites solidified at high temperature conditions.

Rocks Anisothropy Effect on the Well Crooking

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While drilling oil, gas and water holes much importance is attained to maintaining of the given direction. Therefore, at holes' design and testing, the factors inducing borehole deviation should be taken into consideration. Geological factors among all the rest are of utmost importance, and primarily the drilling anisothropy of rocks.

There are many research works dedicated to the anisothropy effect on holes deviation in the vertical plane (Woods, Lubinsky). On the other hand, the influence of this factor on space crooking has been studied insufficiently.

We have derived analytical expression describing the trajectory of the drill bit, in assumption that the only factors affecting the crooking are: rocks anisotropy and the axial effort applied. We have obtained expressions for components of lateral force which is responsible for crooking and is induced by anisothropy. The dependence of lateral force on bed positions, drilling direction, anisothropy index and drill bit characteristics has been analysed.

The Tectonic Pattern East of Cyprus

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By integrating seismic reflection profiles from three surveys between Cyprus and the northern Levant coast, we reconstruct the main structural features of this area. These comprise four sub-parallel morpho-structural units. From north to south these are the Kyrenia-Misis Range, the Famagusta-Hatay belt, the Larnaka-Baer-Bassit belt and the Hecataeus-Latakia belt. The very conspicuous West Tartus Ridge extends along the southern boundary of the southernmost unit, coinciding with the northern boundary of the Levant Basin. Younger features, including the Latakia Trough, the Cyprus Depression and the Gelendzhik Rise, are superimposed on the main structure.

The deep structure of the major morpho-structural units is controlled by previously recognized thrusts, probably related to collision between these units and to ophiolites emplacement, whilst most of the Mesozoic and Cenozoic Neo-Tethys crust consumption took place farther north. The step-like shape of the present plate boundary, between the Cypriot Arc south of Cyprus and the southern boundary of the Anatolia plate north of the Gulf of Iskenderun, accounts for recent transtension between Cyprus and the northern Levant coast. A late change to strike-slip motions and some extension between the main morpho-structural units is suggested here.

The morpho-structural units and the superimposed features form a zone of deformation that occupies the entire area between Cyprus and the northern Levant coast. Not all the structural elements in this area are presently active. However, the relationships between presently active and dormant elements produce a unique pattern that accounts for the main features here. This pattern exemplifies a significant change from compression to transtension in an incipient collision zone.

Integrated Interpretation of Geophysical Data Using Logical-Informational Algorithms

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The intricacy of the state-of-the art geological problem and the ambiguity of the interpretation of geophysical observations call for the integration of geophysical methods between themselves and also with other forms of investigation.

Various researchers have developed numerous approaches for an integrated interpretation of geophysical data. According to our experience it is most convenient to use information parameter. The amount of information (I) at each stake (point) due to the application of the i-th method is

$$I_i = -\log P_j \tag{1}$$

or

$$I_j \approx \log|U_i / \Delta U_i|, \tag{2}$$

where P_j is frequency rate of the j-th interval of the i-th indication (field) on the histogram (for more precise calculation the Bayes' evaluation of the probability that the results will end up in the $_j$-th interval can be applied) and U_i and ΔU_i are amplitude and determination error of this indication, respectively.

After summing up all the information elements which enable one to conclude a priori that the object of the desired class is present, random noises and components which are caused by heterogeneous geological features are suppressed.

In order to avoid singling out fictitious objects by the plot of $1/n \sum_{i=1}^{n} I_i$, which is possible when a great amount of information contained in the data of one or two methods only an additional integration criterion, which depends on the number of significant indications, can be calculated with levelling out their relative influence

$$I_{integr} = \sum_{k=1}^{n(n-1)/2} (I_p)_k / (I_p)_{max} \tag{3}$$

where I_p is determined from the formula

$$I_p = (I_1 + I_2)\, I_1/I_2, \quad I_1 \le I_2, \tag{4}$$

by using pairwise combinations of n methods employed.

To avoid the missing of deeply embedded objects, in some cases it is expedient to use frequency rates of average values or average field estimates on a sliding interval of averaging instead of P_j and U_i values, respectively. Along with a simplified version

based on the summing up of the information elements obtained from formula (2) the method has been realized as an "Integration" program for calculation of the sums of information elements by formula (1) and the corresponding I_{integr} index. Unlike other methods under consideration, this factor is capable to revealing of the objects characterized by the maximum number of indications of different intensities. The comparison of I_{integr} with the sum of information elements enables one not to miss an object which, by these or other reasons, did not manifest itself by some indicators.

Application of above procedures by surface and air surveys at the Caucasus and in the Middle Asia have allowed to increase the geophysical prospecting effectiveness.

First Results of Magnetization Study for Southern Sinai

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(a) Available data analysis shows that the known methods of systematic calculations of effective magnetization (I_e) on the basis of observed magnetic field were not suitable here. Therefore a new modification of Khesin's and Alexejev's (1984) invention was elaborated. It is based on the correlation between observed magnetic field and land relief. This procedure allows to calculate the direction and value of magnetization vector in the case of ΔT-measurements over conjunctive slopes that are formed by the rocks of the same composition.

(b) Seven méridional geological-geophysical profiles were constructed for magnetization calculation of aeromagnetic data in southern, south-eastern and central parts of South Sinai. Here the low magnitude of magnetic anomalies, magnetic minimums over faults and the common low magnetization of Precambrian crystalline rocks were noted. The method developed was applied for Ie calculation on 30 intervals of the studied profiles where the correlation between ΔT-field and relief was observed. On these intervals it was found that: 1) Most of calc-alkaline granitoids had the magnetization of n x 100 mA/m (n ≈ 2 - 6). These granitoids occupy about 50% of Sinai sector of Arabian-Nubian Massif territory. 2) Similar range of magnetization was calculated for the most of alkaline granitoids that occupy 10-20% of South Sinai's territory. 3) Magnetization over 1A/m was noted only for metavolcanites, gneisses and seldom on some of the granitoid plots. As the metamorphic rocks of basement are distributed on only 12% of the area it is difficult to assume their essential contribution to the formation of magnetic anomalies in the districts of deep-buried Precambrian basement.

(c) Magnetization has also an uneven character for the same type of rocks. Therefore only in two cases it was possible to calculate the I_e inclination for calc-alkaline granitoids that had similar I_e values on conjunctive slopes. These angles are 12° and 16°, i.e. they are different from inclination angle of modern acting magnetic field (42°). Further study of space differentiation of magnetic properties will allow to define more precisely the geological structure of South Sinai and the study of magnetization inclination will define more precisely its geodynamics.

(d) Magnetic susceptibility measurements of 67 samples by æ-meter MS2 of Bartington Instrument confirms mentioned above integral characteristics of magnetization: 1) Faint magnetic rocks (æ = 0-200, un.10^{-5} SI): in several occasions granite-gneisses, Feirani and Katharina volcanics, granites and hydrothermally altered rocks. 2) Most of rocks have moderate magnetic (300 - 1300, un. 10^{-5} SI). Amongst them granite-gneisses; Feirani and Katharina volcanics; gabbro-hornblende; diorites; Umm-Malaq, Girgar, Ghashi and Lathi calc-alkaline granites; Sharm and Sahara alkaline granites; Yahmid quartz-monzonite. 3) Essential magnetic rocks (1600 - 4600 un. 10^{-5} SI) : diorite-gneisses and andalusite schist of Kid Massif; some Feirani volcanics, border diorites, Yachmid quartz-monzonite, Sharm granites, diabase dike.

A New Technique of Hydrocarbon Recovery from Porous and Crack-Cavernous Reservoirs

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A problem of receiving reliable information and influxes while well testing is connected with providing hydrodinamic communication of formation with a well.

The main cause of hydraulic communication breach between formation and well is colmatage of filtration channels during drilling, drilling-in and killing on the stage of well completion. This colmatage even can't be overcome with the use of stimulation methods.

In porous reservoirs a colmatage zone is no more than several millimetres, but as a rule, to overcome it by the perforation methods is impossible, because of arising secondary colmatage in perforated channels, contents of suspended particles in perforation fluid should be no more than 10 mg/l. To reach arrive such a clearence is impossible in standard methods, because on the way to the bottom hole the perforation fluid is being polluted to 2,500–15,000 mg/l of suspended particles.

The new technique permits operations of secondary drilling-in in the medium of special fluid from which solid phase is removed that rules out colmatage in perforation channels.

According to technique, 2 to 3m^3 of self-cleaning special fluids is injected to the bottom hole which fluid does not interact with overlaying mud at all stages of perforation.

Solids which get into the fluid as the latter is treated and injected into the well are precipitated with a floculant. Time needed to clean a batch of the special fluid concides with that necessary to make preparation for perforation, i.e. 5 to 10 hours. During this period the content of suspended particles lowers down to 10 mg/l and less.

The technique is operable at reservoir pressure gradient up to 0.018 MPa/m and at bottom-hole temperatures up to 160 °C.

The entire work package is performed using a drilling rig and cementing unit.

The new technique has passed full-scale testing and is simple and highly reliable.

Mass Transport of Shallow Water Carbonates into Deep Water Facies, Middle Eocene, Central Arava Valley

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The Matred Formation, belonging to the Avedat Group, is usually composed in the Arava region of two limestone cliffs, rich in larger benthic foraminifera, interbedded with chalk of a deeper water facies. Biostratigraphy and microfacies of these units, their field geometry and their sedimentary structures support an allochthonous origin for the limestone units, transported towards the SSE and emplaced within an authochthonous chalk facies. The biostratigraphy indicates that deposition and emplacement took place in the Middle Eocene from Zone P11 to Zone P14. Benjamini (1980) demonstrated sedimentary hiatuses at this time in the western Negev, underlain by exposed surfaces lacking indications of subaerial exposure (caliche, paleosols). Submarine mass transport origination in the central and western Negev explains both the hiatuses and their associated features, and tho observed cliff units in the Arava region.

The initiation of mass transport is attributed to sea level fall during this time (Haq et al., 1988), and subsequent development of a carbonate ramp environment around the western and central Negev high. Relatively rapid sedimentation and steepened paleotopography were the initial conditions necessary for mass transport. the allochthonous units came to rest on a region characterized by thin, condensed pelagic sediments. In the Arava region, total thickness per unit time was therefore substantially increased by this transport process.

The ramp history may be reconstructed form the preserved limestones. The earliest allochthonous units are composed of packstones origination in a deeper, outer ramp environment. Towards the end of the Middle Eocene grainstones of inner ramp origin predominate, indication a shallowing trend over this period.

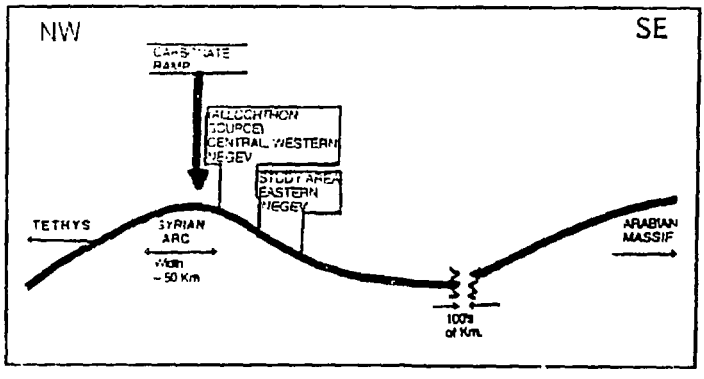

Fig. 1. Paleogeographic setting of eastern Negev study area with respect to Syrian Arc fold belt, open Tethys and Arabian platform.

Pelagic Condensed Sections from the Eocene of the Arava: Global Sea Level Change and Late Eocene Emergence

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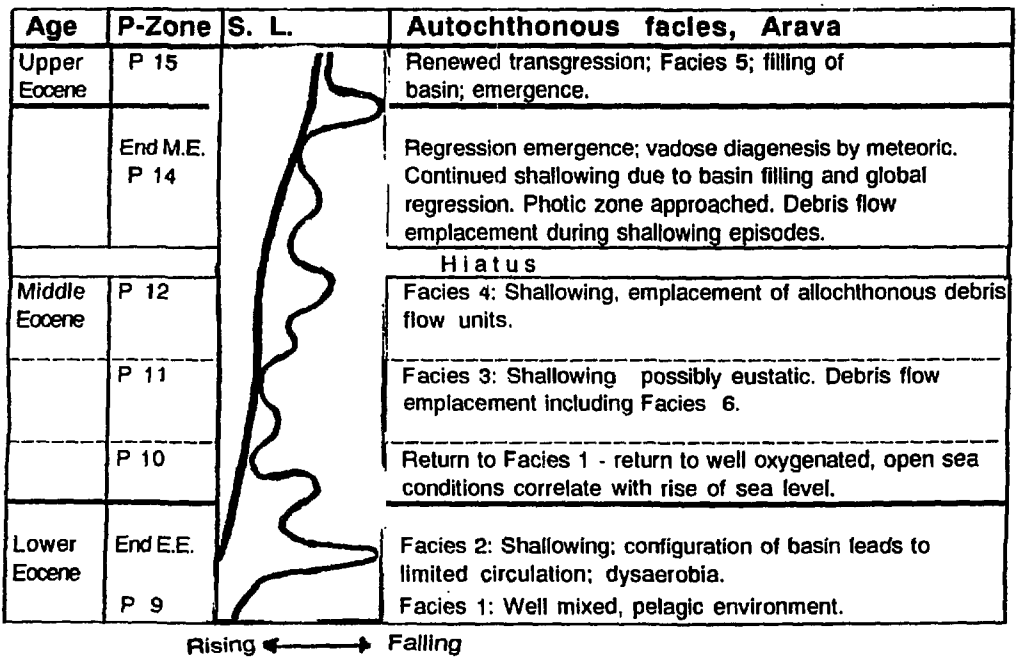
The Middle and Upper Eocene of the central Arava is composed of allochthonous limestones with interbedded, mostly autochthonous chalks. Deletion of the limestones leaves a thin chalk section with all the attributes of a condensed sequence in the sense of Loutit et al., 1988, namely, low sedimentation rate, presence of glauconite, phosphorite and barite, bioturbation and hardground features, with a pelagic background fauna. Microfacies may be interpreted as indication a shallowing trend superimposed on global eustatic changes. Two regressive events, at the end of the Middle Eocene and in the lower part of the Upper Eocene, both led to emergence.



Facies 1: Packstone to wackestone, low diversity, dominance of *A. bullbrooki, A. aspensis*. Benthic foraminifera rare to absent. Glauconite filling tests and dispersed, Phosphate; winnowing. Open sea environment, nutrient-rich, mixing, oxygenation. Facies 2: Mudstone, small, round planktic foraminiferal species, benthics dominated by buliminids. Glauconite, phosphate. Bottom waters poorly oxygenated, stratified. Facies 3: Wackestone, planktic foraminiferal fauna dominated by large *Acarinina*, diverse benthic foraminiferal population, glauconite, phosphate. Open sea, well mixed, slight shallowing from acies 1 & 2. Facies 4: Similar to 3 but planktic fauna more diverse, intraclasts indicative of storm disturbances. Facies 5: wackestone with planktic foraminifera as 3 & 4, benthic foraminifera extremely diverse, small gastropods common. Fine clastics present. Further shallowing indicated. Facies 6: Conglomerate. Planktic foraminiferans in both matrix and clasts. Glauconite. Debris flow at margin of slope; pelagic environment.

Obtaining Additional Water Resources by Means of Rational Utilization of River Runoff After Heavy Rainfalls

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Most small rivers (nahalim) in Israel have irregular flow characteristics. Analysis has shown that 79–90% of the annual amount of runoff flowing into rivers occurs during a period of 2–3 months. With such a regime the water stream has a high rate and is not used practically. This water passes to the sea. According to the 1986–88 data some $180-210\times10^6$ m^3 is discharged into the Mediterranean Sea and $120-130\times10^6$ m^3 — into the Dead Sea and Jordan annually.

Utilization of the runoff to replenish groundwater and hence, to increase the groundwater output is proposed by the authors.

The main objective of this proposal is to reduce the rate of runoff in rivers and increase the percolation rate into aquifers throught permeable deposits in order to replenish groundwater. Such a reduction in runoff is to be carried out by means of constructing a cascade system by building temporary of permanent artificial rapids at a height of 1–3 meters placed on the small rivers and their tributaries having little discharge.

The construction of rapids would change the flow characteristics, increase the time of flow and create better conditions for additional recharge into the aquifer. Additional recharge of groundwater would allow the output to increase, also it would change the flow characteristics decreasing the heavy flooding of the rivers, avoiding the yearly destruction that takes place in valleys of rivers.

The forecasting of the behavior for the engineering construction, hydrological and hydrogeological systems and technical result, including the estimation of the stability of the rapids, modeling of the river and the pond routing, infiltration influence to the aquifers and finding out the optimal groundwater output regime. Construction of rapids decrease or stop catastrophical floods into rivers (nahalim) and stop demolition of cities, villages, engineering constructions.

Yarkon-Taninim Conventional Hydrologic Wisdom: Fact or Fantasy

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The Yarkon-Taninim aquifer (Judea Group) is a very important source of fresh groundwater. Today it is widely assumed that hydraulic interconnection exists from Beersheva to the Carmel foothills. This is the conceptual underpinning from which the water budget is calculated. Isotopic analyses including radiocarbon, tritium and the stable isotopes of C, O, H and chemical analyses have been made on spring and well waters from this supposed single aquiferial system. The results do not support this concept.

Younger, sweeter groundwater flows from the Rosh Ha'ayen spring and surroundings (Yarkon system). Recharge from the Hebron Hills flowing via the Beersheva region is clearly not discharging at the Rosh Ha'ayen spring. The Yarkon system is a separate aquifer from that of the Beersheva aquifer.

A study of the age relationship of the water indicates that (1) there is a vertical stratification in the Yarkon system, (2) the storage capacity of the Beersheva system is larger than previously considered, (3) the flow in the Beersheva system is considerably slower than that of the Yarkon system.

Sensitivity of Seismic Hazard at a Site as a Function of Uncertainty in the Specific Tectonic Setting Characteristics

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Seismic hazard which stems of an active fault is determined by the combination of geometerical parameters (the extent of the fault zone) and mechanical parameters (e.g. stress concentration, elastic-plastic features, the sense and nature of motion) that are typical of the discussed fault.

One of the more significant parameters required for the hazard analysis is the fault segments lengths, on which motion may be expected. It appears, that the relationship between the single segment length to the earthquake magnitude may differ between various tectonic settings. One such example was introduced by Nuttli (1985) who emphasized the difference between mid-plate and interplate eartquakes due to the faulting characteristics.

The present work makes use of the classical approach of cornell (1968) and Mcguire (1976) to hazard analysis. We used the multi-parameter sensitivity method to assess the significance of the uncertainty in the input parameters for the conclusions of the seismic hazard analysis. In the multi-parameter scheme, many parameters are varied simultaneously. This makes it possible to study the dependence of the hazard on each individual input parameter and also to determine if the effect of a parameter depends on the default value chosen for other parameters in the study.

Specific attention was paid to the influence of the lack of knowledge regarding the specific tectonic setting, on seismic hazard at selected sites.

For that test we used a constracted example to analyse the effects of parameters on log annual exceedance probability, at a near (25 Km) and a far (70 Km) site, for exceedance thresholds of 10% g and 20% g.

We found that the tectonic setting may he a crucial parameter at the far site, but only negligible at the near one.

The use of the current methodology enables us to enlighten the most significant parameters which pose the major contribution to seismic hazard.

The outcome of the study is that effort should be devoted to the exploration of segment length-magnitude relationship in order to reduce uncertainty in seismic hazard assessment at a far site.

A New Version of Geoelectrochemical Exploration Technology

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The technology discussed here is based on the CHIM-technique for geoelectrochemical exploration of deep-laying ore deposits and oil accumulations. The CHIM-technique (abbreviation of Russian term "partial extraction of metals") was developed in the former USSR. Its current "halo"- version detects, by surface measurements, displaced halos of the mineralization's indicative elements in electromobile forms (ions). The ions are extracted with an electric current into the specially designed element-collectors (ECs). The ECs are grounded in measurement points along an explored profile and are connected to a direct current source as mono-pole cathods or anods, while the common complimentary electrode is placed in "infinity". Anomalous values of the extracted elements are considered as a direct response of the exploration target.

The halo-version is widely used in former USSR in exploration for gold, copper, copper-nickel, tungsten-molibdenum and base metal deposits. The technique also has been successfully applied in oil provinces and kimberlita fields. The depth of the explored ore body may exceed 600 m (including 100-200 m of overburden), and the depth for an oil pool is 2-3 Km. A prominent limitation of the current technique is that no quantitative assessment of the exploration target can be made based on the field results.

Recently, the dipole CHIM-version, which would presumably allow quantitative interpretation, has been proposed by the author. This version is based on simultaneous extraction of cations and anions from the surface formations. According to this technique, both cathod and anod electrodes, represented by the ECs, are grounded in each measurement point. This allows a quantitative conversion from the extracted mass of specific element to it's concentration in a processed volume of the surface environment.

Stable-Isotopic Signatures and Tectonic Correlation: A New Statistical Approach and Application to the Cyclades

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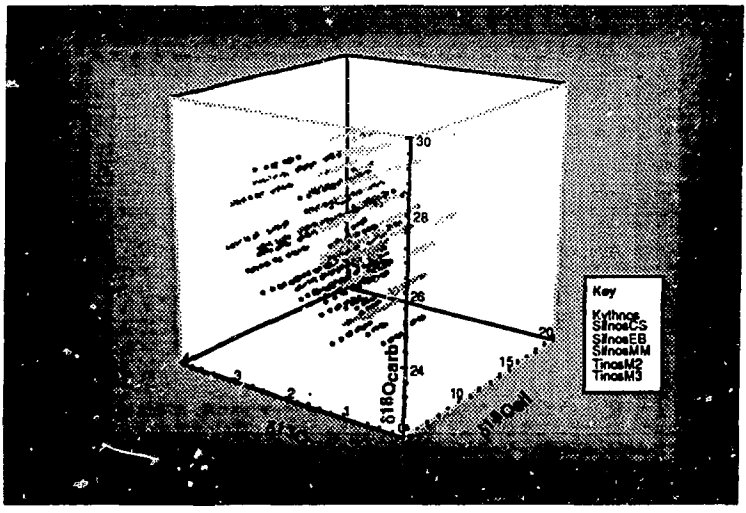
Correlation between tectono-metamorphic units separated by areas lacking outcrop is an old problem: this is particularly severe in the islands of the Cyclades orogen. Whole-rock geochemical procedures such as $\delta^{18}O$ and $\delta^{13}C$ compositions are one means of addressing the problem. Recent advances in understanding the behaviour of stable isotopes during the metamorphism (diffusional exchange at contacts; channelized fluid flow; devolatilization) have made it possible to distinguish original sedimentary or protolith isotopic values from those due to metamorphic effects. Broad sampling of of marbles and interlayered metabasites from the Cycladic islands of Sifnos, Tinos and Kythnos has yielded a substantial dataset of stable isotopic compositions representing pre-metamorphic values. At most two independent parameters are available for study in any one sample, which insufficiently characterizes the sampled units. In this study, we consider the compositions of marbles and metabasite samples from the same unit as separate parameters, yielding three independent variables for statistical correlation ($\delta^{18}O_{marb}$; $\delta^{13}C_{marb}$; $\delta^{18}O_{basite}$). Because no one marble- metabasite pair is "correct" (i.e., do not come from the same rock sample), all possible pairs from samples form each unit are used to define the maximum range from of the three parameters for a given unit. 3-D point plots, such as that illustrated below and discriminant analyses show that this "per unit" approach separates units significantly better than the "per sample" approach.

Results confirm geological evidence that rocks from Kythnos correlate well with those from the Greenschist unit of central Sifnos. Other units, particularly the Tinos M2 area, occupy distinct parameter volumes and imply that units on Tinos and Sifnos may not be directly statigraphically correlatable despite overall similarities in their metamorphic evolution. In contrast on a regional scale all units seem to overlap near the point {$\delta^{18}O_{marb}$ = 25‰, $\delta^{13}C_{marb}$ = 2.3‰, $\delta^{18}O_{bas}$ = 11‰} These values represent the locus of low temperature sea floor alteration of parent basalts and the marine sedimentary signatures of the parent limestones of the marble-metabasic bearing lithologies.



The Tectono-Sedimentary Units of the Cyclades (Greece)

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Sedimentary series overlie the crystalline rocks of the Cycladic Massif (central Aegean). Outcrops exist on the islands of Paros, Naxos and Mykonos. They are a part of the so called "Tectono-sedimentary Unit of the Cyclades" which contains sedimentary facies related to orogenic uplift of mountain chains : turbidites (flysch) and molasse on Naxos, molasse with iron and barite mineralization on Mykonos, and molasse and turbidites on Paros. According to previous works the age of these series is Oligocene-Miocene.

Normal faults separate the sedimentary series from the underlying rocks of the Cycladic Massif, bringing the surface sediments over rocks created at depth, and omitting a many kilometers thick crustal sequence in Late Miocene time. Structural relationships within the sedimentary series and between them and the tectonic contact, suggest a regime of tilted blocks overlying a low angle normal fault (detachment). Therefore, an extension regime has to be asumed for the Aegean Region during the late Tertiary, being related to collapse of the Aegean part of the Hellenic Orogen.

The sedimentary units do not contain clastic components of rock types which are widespread in the crystalline Cycladic Massif. Components of submarine volcanic series were found as well as pebbles of chert and marine carbonate with Eocene fauna. Fauna of this age was also found within fine grained sediments (marls and sandstones). These assemblages suggest the existence of an Eocene basin in the Aegean and the subsequent erosion of its floor. Therefore, Eocene tectonics must be assumed. The sediments contain also a variety of metamorphic pebbles : meta-igneous rocks of low pressure, calc-schists, mica-schists, meta-quartzites, meta-pelites. The remains of this basin were later overlain by Miocene sediments and affected by Miocene and later tectonics. The clast assemblages found in the studied sediments, which represent their source rocks, allow to reconstruct the types of geologic units that were exposed in the Aegean region during the time of deposition, and also to constrain the direction of movement along the tectonic contact underlying the sedimentary units.

Petroleum Zonation of Israel

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Israel is situated on the boundary of northwestern Arabian Plate and the east part of the Mediterranean Megazone of the marginal troughs (East Mediterranean and Mesopotamian troughs). It is possible to outline inside of Arabian Plate some of the greatest structure: anticlines North, - Central, and South Arabian) and synclines (Iraq and Rub-al-Khali). The great part of Israel belongs to the west marginal very strong dislocated part of North Arabian anticline — to the Levant uplift (structure of 1st. rank). This uplift is cut by the Jordan-Dead Sea rift system on the west and east part. There are in the west part of the Levant uplift many smaller structures of 2 and 3 ranks: swells, depressions, domes etc. (Arkin et al., 1984; Bartov, 1990; Bein, Gvirtzman, 1977; Cohen et al., 1990 et al.). According to tectonic zonation it is possible to outline in Israel-marginal parts of two Petroleum Provinces and some subprovinces, regions and districts (from west to east).

1. Mediterranean province (East Mediterranean marginal trough) — offshore and partly onshore.

2. North Arabian province (North Arabian anteclise) — onshore.

2.1 Levant subprovince (Levant uplift)

2.1.1 Israel region (west part of Levant uplift) is divided by the Yisreel Valley and Beer-Sheva tectonic zones (Neev et al., 1985, Bartov, 1990) on

2.1.1.1. Galilee district

2.1.1.2. Judea-Samaria district

2.1.1.3. Negev district

2.1.2. Jordan-Dead Sea rift valley region.

In most prospects for Israel Mediterranean province, it is possible to find oil and gas field, as known in North Iraq (Mesopotamian marginal trough).

In the Levant subprovince, it is possible to find oil and gas fields such as are known in Palmyride aulacogen and in north part of Rutba uplift in Syria, including oil/gas fields under young volcanics (Beydoun, 1988, 1991). In Samaria, Judea and Northern Negev, most prospects are connected with burried Triassic and may be Palaeozoic anticlines, which are not marked Jurassic and more young cover (Druckman, 1979; Garfunkel, Derin 1984; Cohen et al., 1990). But it is possible to discover oil/gas fields in Jurassic and more young traps.

Finally, in Jordan-Dead Sea rift grabens, there are chances to discover hydrocarbon field as known in the Suez rift zone (Gilboa, Cohen, 1979).

Are Millions of Years Necessary for Petroleum Formation?

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Real-time studies in laboratory and natural settings described in the literature clearly show that petroleum may be formed in a period of a few years or less.

Laboratory studies demonstrate that organic matter can be extensively converted to hydrocarbons at temperatures below 300 °C under non-catalytic conditions and with a minimum of water present. Heating times of a few years or less are sufficient to generate oil and gas from suitable precursors such as oil shale or brown coal. Further, it would be more realistic to consider that source rocks in their natural environment may contain clay minerals which act as catalysts for maturation reactions. In addition, dry system experiments are unrealistic to natural systems - pyrolysis work incorporating more realistic factors of temperature, pressure and the presence of water may reduce the time factor orders of magnitude.

Natural seafloor hydrothermal systems (such as in the modern day Gulf of California) provide evidence for a continuous single-step mechanism for efficient petroleum generation, expulsion and migration. Diagenesis and catagenesis is similarly rapid. In some sedimentary basins in geologically active areas a hydrothermal mechanism has been described for the maturation of sediments. This involves heat transport away from deep faults or volcanic centres by laterally flowing aquifers.

Thermal conduction is said to be a major parameter in quantitative maturation studies. However, particularly for the early stages of a basin's history, it would be more realistic to take into account high permeability sediments. These provide excellent pathways for convective heat transfer by flowing fluids and enable preferential heating of regions at rates much higher than that provided by conduction alone.

Another assumption that is commonly made in regard to palaeoheat flux is that the dominant source of heat was the basement. However, episodic tectonic processes may be associated both with higher temperatures and with the formation of structural traps. These processes include rifting, drifting, overthrusting and diapirism. Higher temperatures may also be associated with rapid burial and overpressuring.

Temperature rather than time is the most sensitive parameter in petroleum formation - laboratory studies show that rates of chemical reactions increase exponentially with increase in temperature. Since no measurable parameter can be directly converted to palaeotemperature there are considerable uncertainties in modelling palaeotemperature.

Conveying the Messages of the Geological Research to the Public

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Objectives

Contribution to the scientific thinking of school students
Environmental education to all
Preservation and income source: science and art based tourism

Reserves and Monuments

National Geological Reserves (e.g. Ramon and Timn'a parks)
Monuments (missed: Patish, Beit Zait, Beer Sheva quarry, Carmel)
Geological benchmarks in urban areas and along road sides
Geological trails (e.g. Eilat, Timn'a, from Sea to Sea)

Exhibitions

In geological institutes (e.g. Dept. of Geol., Hebrew University)
Active Geological Museum
Scientific Research Exhibition (proposed at the Ramon Science Center)

Production of geological educational materials

Games, films, computerized learning sets (encouraging beginnings)
Touristic geological map
Touristic geological guide

School teaching materials

High school program (operates, till 5 points)
Geotope and other mini-research programs (existing and planed)
Teaching units for geography lessons
Inter- disciplinary units (geochemistry, geophysics, geo-biology)

The academic frame

Geology teaching certificate (in operation in Jerusalem)
College for field guides
Teaching program for teacher's colleges
Teaching licensed tourist guides
Annual meeting and regional excursions for layman

Teaching Geology Contents in Elementary School: The "Mabat" Program

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The "Mabat" (Science in Technological Society) program is a new program for science teaching in elementary school and serves as an alternative — both in terms of its approach and in its contents — to previous programs.

The guiding principle of the new program is its aim to provide scientific and technological literacy for all. Contents and presentation methods were selected in the light of this objective:

* Focus on science teaching — understanding natural phenomena and processes through the acquisition of basic scientific concepts. The program's contents aim to form the groundworks for both a scientific understanding of the environment and continued studies on higher levels of education.

* The scientific contents are mostly presented in their technological context, in order to give the pupil a first understanding of the ways in which scientific principles are applied to solve practical problems and for the improvement of human existence at large. Often, when it is more relevant to the learner, the point of departure is the technological aspect.

* The "Mabat" program stresses the impact of science and technology on our physical and social environment with the purpose of developing involvement with and a critical attitude toward day-to-day problems of a scientific - technological - social nature.

The description of the program's structure and its target population should make it clear that this is not a conventional disciplinary program for Geology instruction or indeed for teaching any other science. Geology contents are central in some of the study units, especially in those that go under the collective heading of "Natural resources". Contents are presented in a way that allows pupils to acquire the conceptual skills that are germane to the discipline. This is done by means of activities such as observation, identification and classification, conducting experiments, drawing conclusions (from experiments and from observation), etc. These activities take place both in the classroom (this includes laboratory work), and outside (field excursions, visits to museums and research institutes).

Specific contents are selected according to the child's cognitive development. The program has no intention to make pupils into "little Geologists" or "young scientists" but only aims to provide a pleasant and sympathetic way of transferring knowledge in a subject that has been neglected in this level of education for many years.

Application of Artificial Intelligence to the Determination of Seismic Sources in the Galilee Area

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Artificial Intelligence (AI) techniques are increasingly incorporated in the management and control of industrialized processes. In this work we introduce a technique which integrates between pattern recognition (PR) and fuzzy logic to the determination of seismic sources. The essence of this approach is the imitation of the seismologist's perception and reasoning to the tion of various seismic event types. In the first stage, events are transformed and stored in the form of images. Every new recorded event is imaged and correlated to those already stored. In the second stage the seismologist integrates a number of images into a representation of the same event category.

The PR method may be viewed as the conscious part of perception. At this stage each new recorded signal at each seismographic station is transformed into a sonogram (3D image of signal energy in time and frequency) and compared to those already stored in the computer memory. After the process of comparison, each at each station is classified to one of the predetermined sources and assigned with one of the following levels of adaptation: Definite, Probable, Possible and No Detection.

The next stage involves the integration of all single determinations (SE) into a network event classification (NE). This integration is carried out by applying a rule based system (COASSIAN) in order to decrease the uncertainty introduced in the seismic source identification.

We adapted the current AI technique to the Israeli seismographic network. The data included 29 local seismic events from the Galilee area in the time : 5/88 - 7/88. The determination of success or failure regarding the events was with comparison to the IPRG seismological catalogue and with an expert's opinion (in the case of dispute). From the analysis of the results we received 5% of failure, 85% of success and 10% of no solution.

The degree of success in earthquakes identification was - 93% and - 0% of failure. In contrast, the determination of quarry explosion yielded 67% of success and 16% of failure. The reason behind this large discrepancy inbetween this two categories lies in the fact that signals' quality of quarry sources is drastically lower than those from earthquake sources.

It may be concluded that in future, the current AI method may be incorporated (in an effective and reliable way) in assisting the seismologist. However, the condition for such a successful application requires upgrading of the Israeli seismographic network in such a way that the signal quality will be drastically improved with respect to resolution, dynamic range, and S/N ratio.

3D Velocity Field and Relocation of Earthquake Hypocenters in the Galilee Area by Seismological Tomography

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By seismological tomography we try to map the velocity field of seismic waves in an active region. The applied method makes use of the observed arrival times of local events, as received by a net of seismographs located in a specific region. In general, the method which traces the wave propagation paths from the source to the receiver, estimates the calculated arrival times, compared to the observed ones.

A difficulty stems from the fact that the knowlege of the wave paths and the earthquake hypocenters depend on the same features which we try to estimate, the velocity field. The difficulty may be solved by using the inversion method. By this technique we change simultaneously the velocity field (by series of iterations) and the hypocenters locations, in order to minimize the time difference between the calculated and observed arrival times.

Thurber suggested an algorithm for the seismological tomography, based on local seismic records. In this algorithm we subdivide the 3D medium into voxels in each of which we try to estimate the velocity of the P and S waves, along with the hypocenter determination, according to the improved model.

In the first stage we applied Thurber's method to the Dead Sea vicinity. The results indicated that the method is very sensitive to the limited distribution of seismographs in this very region.

In the second stage we applied this method in the Galilee area were the of seismographs is much better. The velocity field, as obtained in the current work will be compared to the geophysical maps received by other means. In addition, we shall compare the relocated hypocenters to those listed in the seismological bulletin.

Integrated Method of Hydrocarbon Phase Forecast

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The study of petroleum perspectiveness of the Galilee (the Northern Israel) is offered on the base of the phase forecast universal method which was developed by the author for the Pricaspian Basin (Russia-Kazakhstan). The Galilee is the important region for petroleum exploration in Israel. The method contains a study of thermal and pressure conditions in depths (reservoir temperatures and pressures, bubble-point pressure) and a map constructions of these parameters with divide of primary oil, gas, oil-gas and gas-condensate accumulation zones.

The drilling in the Galilee didn't discover oil and gas fields. The region is investigated insufficiently, processes of oil and gas distribution on area and in rock section are not elucidated finally. So, for exploration efficiency increasing systematical study of factors, which influence on generation and accumulation of oil and gas in depths, is needed.

Scientific hydrocarbon phase forecast permit to divide exploration regions according to the types of the main product (oil, gas, oil-gas, gas-condensate) and, consequently, to substantiate quantity and depth of wells, to provide the works by special equipment, to choose optimal technology. Different investigations showed that most informative parameter is the "bubble-point parameter" (F_p),

$$F_p = P_{bf}/P_s,$$

where P_{bf} — background (regional) bubble-point pressure, MPa,

P_s — reservoir pressure in pay bed, MPa.

The time of influence of increasing temperatures to organic matter cathagenesis, depth interval and some others factors are important too.

Comparison Analysis of the Geological Structure of the Northern Israel (The Galilee) and the Southern Syria

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On the base of geological structure study of the Galilee (on Israel sources) and the Southern Syria (on Soviet, American and French investigations) we can draw the conclusion about the similarity of some features of geological structure in the regions. In the Galilee 19 wells are drilled, including 7 on the depth down to 2 km, 9 - from 2 to 3 km, 3 - more 3 km (Atlit-1 - 6556 m, Devora-2A - 5650 m, Rosh Pinna-1 - 3864 m). Another well - Zemah-1 (T.D. 4249 m) is in the Jordan Valley rift zone. From these 19 wells only 2 discovered the Triassic sediments, 12 wells discovered the Jurassic rocks and another 3 - the Upper Cretaceous. The using of the data on neighbouring regions, particularly - on the Southern Syria, allows to construct a more complete picture of the Galilee geological structure and its evolution history. Active geological investigations in Syria were began in 1920 years by French scientists. In the 1950–1960 years Soviet scientists did great works here. In the last years the American firm "Marathon Oil" studied the region in common with Syrian investigators. In Syria 3 refraction profiles were carried out, its common length is about 500 km, and about 5000 km of reflection profiles; gravity, geological and magnetic maps were constructed; several wells were drilled in which gas was found. In the Southern Syria (the Rutbah Heights) is TF-1 well, T.D. 3365 m, it discovered the Lower Ordovician layers, CH-2 well is in the Palmyrides, T.D. 3122 m, it discovered the Triassic dolomites. On seismic sections four sediment layers and the basement are defined according velocity. The sedimentary cover are broken to blocks. Its main part consists by the Mesozoic rocks on thickness of about 6 km. The remaining part is the Paleozoic and the Precambrian deposits on thickness 3.5–5 km.

In the Precambrian the territories of Syria and Israel formed the one structural-tectonic zone. In appointed periods the Northern Israel and the Southern Syria were the one basin, for example, during the Triassic-Jurassic primarily limestones and dolomites are formed here, and the Cretaceous and the Tertiary rocks are similar.

The evolution of the Palmyridean through is depend from the Levantine boundary farther to west. In the Early Mesozoic aulacogen evolved here. In the Late Cretaceous the inversion began, especially intensively in the Neogene and the Quaternery.

The similarity of the evolution history of the regions during large geological time predetermines the probable existence of oil and gas fields in the Galilee.

Volcanic Park in the Golan Heights

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The unique volcanic landscape of the Golan Heights includes various features not found in other locations of Israel. Furthermore, the Golan Heights presents part of the huge volcanic region which extends to the neighboring countries which we cannot visit.

The Golan Regional Council, the Golan Research Institute, the Nature Reserve Authority and the Settlement Department of the Jewish Agency, have developed a plan for a volcanic park in the Golan Heights in cooperation with the Society for the Protection of Nature in Israel, and the Jewish National Fund.

The park's program includes the establishment of a visitor's center and several developed sites, each including a guide station. In each group of sites, paths will be constructed, signs placed, and the "tour it yourself" guide system made available (organized tours will also be possible). Other "non-volcanic" points of interest located along the paths will be also included as part of the tour.

The following group of sites are planned for development (from south to north): (a) southern Golan sites; (b) Gamla sites; (c) Avital-Bental sites; (d) Birket Ram — Banias sites. Other volcanic exposures will also be developed for visits. The first group of sites to developed are those in the Avital-Bental area, which are now under detailed design.

Possible Active Role of Bacteria in Phosphorite Genesis

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Petrographic evidence, including electron microscope studies, have confirmed the presence of bacterial structures, including microbial mats, in phosphorites. Laboratory studies have shown that apatite can be synthesized through bacterial mediation both by replacement (of carbonate) and by direct precipitation. In spite of the above the general opinion prevailing today is that the role of bacteria in phosphorite genesis is mainly passive.

Recent work on bacterial populations in the Benguela upwelling system showed that two different populations occur, one the upwelling population is dominated by fermentative isolates (*Vibrio, Enterobacteriaceae*); the second population which occurs during non-upwelling periods has a greater biomass but has a lower diversity. It is dominated by oxidative isolates (*Pseudomonas, Acinotebacter*). This finding is particularly significant when we consider that these two bacterial genera effect phosphorus removal in biological activated sludge systems.

The biological excess phosphorous removal (BEPR) process requires anaerobic/aerobic sequencing of microorganisms. The bacteria (mainly *Acinotebacter*) sequester phosphate as poly-phosphate in the aerobic environment and release it as orthophosphate in the anaerobic environment. We found evidence for the presence of such phosphate-sequestering bacteria in the water column (50 m depth) off Swakopmund, Namibia 22° 25' S, 14° 16' E. This is the area where Recent phosphate concretions are found. We therefore propose a natural bacterial mechanism which mediates phosphate concentration in the anaerobic interstitial waters leading to phosphate precipitation.

The Stagnation of Deep Subsurface Brine in the Oak Ridge Reservation

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The deep hydrogeologic system underlying the Oak Ridge Reservation contains, in places, contaminants such as radionuclides, heavy metals, nitrates and organic compounds. Groundwater at that depth is saline and has been considered in previous studies to be stagnant. On the basis of existing and newly collected data, the nature of the saline groundwater's flow and its potential discharge into shallow, freshwater systems was assessed. Data included (1) spatial and temporal pressures and hydraulic heads measured in the deep system, (2) hydraulic parameters of the formations in question, (3) spatial temperature variations, and (4) spatial and temporal chemical and isotopic composition of the saline groundwater. In addition, chemical analyses of brine in adjacent areas (Tennessee, Kentucky, Ohio; Pennsylvania and West Virginia) were compared with the deep water underlying the reservation to help assess the origin of the brine. Preliminary conclusions suggest that the saline water contained at depth is old, but not isolated (in terms of recharge and discharge) from the overlying active, fresh water-bearing units. The confined water (and dissolved solutes) move along open fractures (or manfimade shortcuts) at relatively high velocity into adjacent, more permeable units. Groundwater volumes involved in this flow are likely to be small.

Evidence of the 1927 Jericho Earthquake and Accompanying Dead Sea Tsunami from Slumped Sediments in the Jordan River Delta

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The largest earthquake to strike the Holy Land in the 20th Century was the July 11, 1927 Jericho earthquake which caused severe damage and destruction. The magnitude 6.2 Jericho earthquake was generated by left-lateral, strike-slip motion of the Jordan (Jericho) fault along the Dead Sea rift (Ben-Menahem et al., 1976). The aftershock pattern suggests that fault rupture extended into the Dead Sea, and we have mapped this fault from analyses of high resolution seismic reflection data. Adjacent to the location of the southernmost aftershock of the earthquake, we discovered the headwall scarp of a very large submarine slump in the bottomset region of the Jordan river delta in 250 m water depth. A sudden displacement of bottom mass created a tsunami that accompanied the 1927 Jericho earthquake and piled water 1 m high along the north shore of the Dead Sea (Blanckenhorn, 1927; Brawer, 1928; Shalem, 1956). The uniqueness, recency, and location of the slide, suggest that seismic triggering of the slump during the 1927 Jericho earthquake is the most probable mechanism for its formation. The seismic triggering of the slump may be related to the change in fault geometry at this location. Interpretation of sparker profiles across the same area reveals that beneath the 1927 slump is a series of buried slumps that indicate that this area has been repeatedly affected by seismic events and a record of earlier Jericho earthquakes can be found in the sedimentary record.

The Educational Contributions of the "Geotop" Project

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A geological investigation project named "Geotop" (the top of the geology learning) was developed as a compulsory part of the geology curriculum. "Geotop" is defined as a mini-research project, which takes place in the field or laboratory or both. In parallel to the development of the project for geology majors, a similar version was modified for high school geography students. The "Geotop" project was introduced into the geography curriculum as a vehicle to enhance and strengthen the geology teaching within the geography curriculum, as well as to give those students, many of whom had suffered failure and frustration in their former science studies, another (and maybe last) opportunity to experience science in more positive light.

The "Geotop" system for the non-science students consist of four components: the programme organizers' team, the geography students, geography teachers and the field investigation project leaders (mainly postgraduate geology students).

The evaluation research which have followed of the project since 1987 included assessment of the students' achievements and attitudes towards the project. In 1992 an attitude questionnaire was posted to the home addresses of students who participated in the programme during five years of implementation (1988-1992).

All the different sources of the evaluation (students, teachers, field leaders), the different methods of evaluation (quantitative and qualitative), the different outcomes (attitudes and achievements) and the time perspective (short-term and long-term) consistently support each other, combining together to give a very encouraging picture of the "Geotop" programme. These findings indicate that the students hold high positive attitudes in the affective and cognitive domains of the programme. They strongly agreed that their learning performance had improved and were very interested and enjoyed it, especially in relation to their other studies in high school. This enjoyable learning experience was implanted in their minds and they still carry it with them. Most of the students use the geological knowledge and the thinking tools they acquired in their daily life, thus enhancing their understanding of their natural environment. For some of them this experience influenced their current and future choices of academic subjects.

It is suggested that the novelty and interdisciplinary characteristics of the earth-sciences and the "Geotop" model could be used to develop investigation projects in relation to other science-student populations concerned with chemistry, physics and biology. Such ventures would enable those students to apply some of their theoretical background knowledge to solving real geology problems.

Geology in the Israeli Curriculum — Overview

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Geology education in Israel is in a process of revival. At the present, geology as an independent discipline exists at the high school level. In the lower levels, e.g, junior high school, elementary and kindergarten, earth sciences subjects are included within other disciplines such as biology, chemistry, physics and geography. Although the curriculum of those disciplines includes earth-sciences subjects, the teaching of those subjects is very limited for two main reasons: a) the teachers have a very limited earth-sciences background b) there is a lack of learning and teaching materials.

The success in introducing geology to the high school level, as an independent discipline, positively effected the lower levels as well. Teachers and principals are more open now to encourage the geology teaching. Since 1990 curriculum materials have been developed for all ages, from the kindergarten through the elementary and junior-high to the high school. In addition, in-service training for teachers who deal with earth science topics have been conducted.

The efforts to introduce the geology into the educational system have been anticipating by intensive activity in the informal educational systems. Successful cooperation with public associations and bodies created a supportive public opinion for geology at all levels and a need to extend the teaching of this discipline in the formal educational system.

Although our success, so far, the process of introducing the earth sciences within the Israeli educational system is only in its first stages. However, it seems that the comprehensive approach of working simultaneously in the whole spectrum of the educational system, as presented above, is an efficient way which might produce more meaningful educational achievements in the near future.

The key for our ability to continue in introducing geology into the educational system is the quality of the people who will be involved in this process. The geology community should encourage and support those members who would choose to answer the educational challenge.

Criteria for Distinguishing Between Ash-flow Cooling Units in the Ramat Yotam Caldera

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The Ramat Yotam Caldera (RYC) represents a Late Precambrian (548Ma) ash-flow caldera in the northern part of the Arabian Nubian Shield. It occupies the southern part of the Ramat Yotam graben, about 2km west of Elat.

The intracaldera area comprises the remnants of a silicic ash-flow sheet with an exposed thickness about 250 m. From oldest to youngest, there are the Shelomo Tuff Member (STM), the Mahzevot Tuff Member (MTM), and the Yotam Tuff Member (YTM), the main constituent (about 200m) of the RYC Formation. The present work refers only to the YTM.

The correlation of ash-flow tuff sequences of different parts of the intracaldera is problematic in terms of collapse tectonics. However, a corellation is necessary in order to provide keys to the paleovolcanological and petrological framework.

The cooling-unit concept was adopted to divide and correlate the different sequences of the YTM. The following criteria were used for distinguishing between cooling-units: (a) degree of welding; (b) flowage structure; (c) degree of crystallization.

Two simple cooling units and two compound cooling units constitute the intracaldera ash-flow sheet. Each cooling unit exhibits a vertical zonation from a zone of moderate welding and low crystallization at the base, to a zone of dense welding and high crystallization at the top. Subzones of rheomorphism and of granophyric devitrification are also present.

Neogene Pyroclastics with Associated Peperites in the Zalmon Valley, Central Galilee

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Post Cover Basalt volcaniclastics were recently found in the Zalmon Valley, central Galilee. This volcanic complex overlies conglomerates of the Hordos Formation, and is overlain by a young conglomerate.

The sequence, about 15m thick, consists of lapilli tuffs, lapilli tephra, tuffaceous sandstones and microconglomerates, and in particular, peperites.

The juvenile lithoclasts are only glassy basalts, whereas the cognate lithoclasts are mainly carbonate rocks.

The volcaniclastics are indicative of rhythmic phreatomagmatic activity associated with subaqueous and subaerial volcanoes.

The peperites were formed by mixing of basaltic material and wet sediments of the Hordos Formation. The tuffs indicating a proximal facies, were generated by the co-deposition of hydroclastic material in a lake, together with unconsolidated carbonate mud.

Highly fumarolized vent breccias were found close to the discussed sequence and are also indicative of a proximal eruption center.

Risk Factors Along the Sharon Escarpment, and the Effect of the Nof Yam Event, August 1992

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The Sharon Escarpment between Giv'at Olga and Tel Aviv terminates the westernmost eolianite ridge strikewise, parallel to the ridge crest. It is up to 40 m high and has 75-90° slopes. The escarpment moves evenly eastward by continuous collapse on the seaward side. Rockfalls of slabs about 2 m thick and several meters long separate from the face of the cliff, slide downward and come to rest as a 40-50° talus of loose sand, which is removed in seasonal stages by wavewash. No rockfalls occur as long as talus stabilizes the cliff's foot. The frequency of rockfalls is uniform, independent of cliff height or composition.

Talus-clear sections, where the next event will be a vertical rockfall, were defined Risk A sections. Sandslides from wave-cut talus aprons involve mostly horizontal mass movement (including riding blocks of calcarenite), and these were defined as Risk B. Non-truncated talus was defined as Risk C.

A slide cycle starts from the Risk A situation. After the rockfall a Risk C situation is obtained, which through a sequence of B-C-B-C situations returns to Risk A. According to unproven estimates, Risk C lasts 1 to 2 years. Risk B several years, and Risk A up to 10 years and possibly more. The rate of retreat for the total escarpment is controlled by bulk strength of the cliff and by the wave climate (i.e. the frequency of beach clearance of all talus). The rate is not perturbed by cliff composition, by cliff height, by cliff angle or by clifftop activity, as claimed by some authors, but one-time events may have a temporary or local effect on the rate of retreat.

The Nof Yam event of August 1992 (a high-magnitude subsurface explosion, several hundred meters east of the cliff) caused rockfalls at the nearby Risk A sections. About 64% of a 250 m stretch of escarpment underwent change: total length of the Risk A sections diminished from 68% to 35%, and the combined Risk B and C sections increased from 32% to 65%. The reduction of the Risk A situation represents shortened lifetimes for these sections, proportional to their decrease in frequency, while for Risk B situations the event increased their frequency without lengthening their lifetime (the event increased the amount of removable material, but not the rate of removal). Accordingly, the cycle was temporarily sped up by the amount of time lost by the shortened lifetime of the Risk A sections, i.e. by the 33% of the overall average rate of retreat. The effect of the event will be lost in less than 10 years, when all the event-induced talus aprons will be cleared away.

Geomorphological Mapping of Makhtesh Ramon (Preliminary Results)

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The geomorphological map of 1:50,000 scale has been carried out in the western part of Makhtesh Ramon.

The legend of the map has been based on the historical-genetical method. The types, forms and elements of relief are given by various symbols, patterns and colors. Genetic types of relief are expressed by color. The age is shown by the color nuance. Morphology along with the neotectonic features are given as contours and nonscale symbols.

The following types of relief have been identified in the western Makhtesh Ramon: 1. fluviative; 2. denudational; 3. complex relief created by fluviative-slope processes; 4. eolian; 5. anthropogenic.

Two subdivisions have been identified among the fluviative and denudational types of the relief. First group includes set of different surfaces, the second corresponds to forms and elements. Fluviative surfaces are related to recent stream forms and terraces. Denudational surfaces consist of debris slopes, structural terraces and flat structural surfaces on the rocky basement etc. Complex relief includes pediment surfaces of different age and height.

Preliminary results of the mapping are:

1. Recent relief of the western part of Makhtesh Ramon was mainly formed before the development of highest terrace and pediment surface.

2. The distribution of the terrace and pediment levels reveals close paragenetic connection. Each pediment surface corresponds to the terrace of the same level.

3. Rock-defended terraces are prevailed in the Ramon valley, whereas the low accumulative terraces are presented only in its upper stream. It seems, that the western part of the Makhtesh was unlike its central part during the terrace accumulation.

4. The legend designed for the geopmorophological map of the western Makhtesh Ramon can be applied for the mapping of the High Negev.

Consistency Limits as an Indicator for Chalk Properties

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Measurement consistency limits (liquid and plastic limits) are a traditional means of investigating soil and soft rock, including chalk. By means of the consistency limits, the rock type can be identified, and the following rock properties can be evaluated:

a. rock plasticity
b. free swelling
c. clay content
d. strength

Hundreds of measurements of consistency limits and other geomechanical properties were executed on chalk samples from the Eocene age, collected from Eocene rock outcrops from all over Israel. Quantitative analysis of the measurements reveal the following:

a. There is no connection between strength (unconfined compressive strength) and the consistency limits.
b. There is no correlation between carbonate content (an indirect expression of clay content) and the consistency limits.
c. There is no connection between free swelling calculated on the basis of consistency limits, and the measured results for free swelling.

To measure consistency limits in chalk, one is obliged to crush and winnow in advance. Crushing the chalk rock to grains less than 20 microns in diameter changes the basic properties of the rock. Actually, under such conditions, what measured are the properties of unconsolidated grains. Therefore, the factors that influence the consistency limits are the sliding friction of the chalk grains and the chalk density.

The connection between chalk density and the consistency limits was examined. The results were as follows: as the density rose, the consistency limits decreased.

This indicated that the consistency limits were influenced by the chalk density and not by the clay content or other factors that can be obtained from (that exist in) natural chalk. The consistency limits, therfore, are not among the properties of chalk, and should not be considered among the geomechanic properties that define this rock.

Age Determination of Pedogenic Carbonate Nodules Using Electron Spin Resonance

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Carbonate nodules are formed in calcareous soils under semi-arid climatic conditions. Rain-water dissolves calcite in the parent material near the surface and redeposits it deeper in the section, at the wetting depth, where calcite is recrystallized and the nodules are formed. Today nodules form in areas which receive 200–300 mm annual rain fall, and their presence in paleosols is a reliable paleoclimatic indicator. Determining the age of such nodules may give the timing of the climatic event, as well as an upper limit to the time of deposition of the parent material. Dating nodules has proved difficult by any of the methods attempted so far. Detrital components, organic contribution and exchange of material with the surrounding soil and ground-water hampered analytical precision in both ^{14}C and U-series methods.

Well developed carbonate nodules (stage III) grow over a long period of time, typically in the range of 8–15 ka. Moreover, there may be several episodes of growth, controlled by changes in supply of moisture to the soil. Therefore, in order that the dates obtained by any dating method will have any geological significance, the samples must be studied carefully and sampled accordingly.

ESR dating measures the accumulated dose due to natural radiation, recorded in a mineral since it was formed. By knowing the annual dose rate emitted by the sample and the surrounding soil, the age of the sample may be calculated from the ratio between the accumulated dose and the annual dose rate. ESR dating has been used successfully to date carbonate materials such as corals, speleothems and travertines, however ESR dating of nodules was never thoroughly explored.

In this study carbonate nodules from a sandy loess section near Shivta were studied. The samples were collected along a trench, at various depths. Thin-sections and SEM were used to examine the internal structure and growth stages of the nodules, and an age estimate was obtained using the ESR method.

The nodules were separated from the sediment by washing. Thin sections and SEM samples were made from whole nodules. The remaining nodules were crushed and most of the detrital components were removed by hand picking and magnetic separation. Aliquots from the powdered samples were step-wise irradiated by a ^{60}Co γ source and the ESR signal was measured using a Varian E-12 spectrometer. The accumulated dose was estimated using the "additive dose" method. The environmental dose was calculated from the concentrations of U, Th, and K in the sample and sediments, measured by NAA.

Thin sections show that the nodules are made of homogeneous microcrystalline calcite embedding detrital silty quartz. No growth rings are observed. Fragments of land-snails and limestone are rare and it seems that most of the calcite had recrystallized when the nodules formed. The SEM shows that the nodules are composed of uniform, rhombohedral, low-Mg calcite crystals, their size ranging between 5–10μm. There is no evidence for dissolution or multiple-stage growth. These observations demonstrate that the nodules grew in during a single episode and were not subject to further interaction with their environment.

Within the analytical error, the samples show uniform ages. Preliminary age calculations for the nodules are in the range of 60–70 ka. Ages and paleoclimatic interpretations will be presented and discussed.

Composition of Fresco Pigments from King Herod's Palace in Jericho

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Natural materials were used by man for painting since the dawn of civilization. Earliest indications in Israel for using "earth pigments" (ochre) are found in the Upper Paleolithic (40,000–20,000 years ago) sites, and evidence for extensive use of ochre was found in the Natufian layers of El Wad cave in Mt. Carmel (Weinstein-Evron & Ilani, 1991). The use of natural mineral pigments has developed over time, and pigments were collected from man's near and far environment. They were used as body paint or applied to a variety of materials, such as wood, pottery, stone and plaster.

A set of pottery bowls containing powdered pigments were found at Herod's palace in Jerico (1st c. B.C.), near walls painted with frescoes. This find is so far unique in Israel, and uncommon in other parts of the Roman Empire.

Ten powdered samples of different colors were sampled from the bowls and 8 small fragments of paint were removed from the frescoes (courtesy of E. Netzer and S. Rosenberg, the Hebrew University). The mineralogy of the samples was determined by XRD and the chemical composition was estimated using a SEM equipped with an EDS. The raw materials used for producing the pigments were defined and their sources identified. This information revealed the technology used for pigment production and routes of trade.

The composition of the powdered pigments is as follows: Black - charred vegetal material; white - dolomitic chalk; pink - heated kaolinite; red - cinnabar; brick-red - hematite; orange - minium; mustard-yellow - goethite; green - celadonite; pale-blue - synthetic cuprorivaite ("Egyptian Blue"); purple - a mixture of pale-blue and pink. Most pigments were also identified in the fresco fragments, except for minium. Perhaps the samples are not sufficiently representative of all colors, or some of the pigments did not survive the millennia on the plaster.

The pigments in the bowls are all finely ground (1–5μm). There is some contamination from the soil in which the bowls were buried and small amounts of inter-contamination between materials. Otherwise, most of the pigments are pure, usually comprising one mineral each. On the other hand, the paints on the fresco are a mixture of several pigments, occasionally diluted with limestone. Since cinnabar, minium and celadonite are not found in Israel, it is obvious that some of the pigments were brought from outside the country. The source of these materials is from different localities in the Roman Empire. Other pigments could have been found and produced locally. Whether the pigments were imported or of local origin, the artist was highly skilled at preparing the pigments for painting and applying them on the walls.

Physical and Geological Aspects of Fracture Bifurcation

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Two topics are complementarily treated. Firstly, finding the correct geometrical features of embrionic secondary cracks (ESC) in the vicinity of the tip of a moving primary crack before and at bifurcation. Our results indicate that at low velocities of the primary crack, the ESC initiates ahead of the tip, parallel to the primary crack, whereas at high velocities ($V > 0.2C_L$ where C_L is the longitudinal acoustic velocity) the ESC appear behind the tip at angles that deviate from parallelism to the primary crack, and rotate as a function of crack velocity. Furthermore, we correlate the size of the original flaw, Co, the final ESC length, l, and the minimal radius from the tip, r, for ESC initiation. These results enable us to determine the mechanical and geometrical ESC parameters and map them prior to bifurcation and at the bifurcation zone. Secondly, by applying this technique to geological small, large and regional faults, particularly to bifurcation fault systems associated with specific earthquakes and/or eruptions (e.g. in Fig. 1) a new method for characterization of fault zones could become possible.

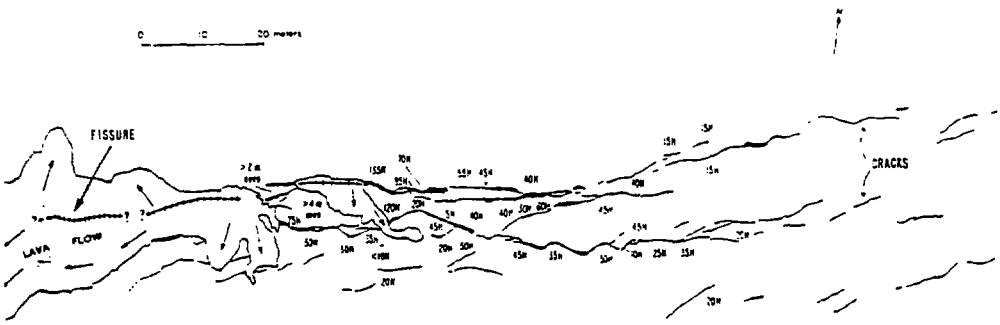

Fig. 1. Map of primary fissure and subsequent cracks prior and at bifurcation from the Hawaii 31.12.74 eruption, after Pollard et al. 1983, Tectonophysics 94: 541–584.

Application of the Integrated NMR-TDEM Methods in Groundwater Exploration in Israel

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The Nuclear Magnetic Resonance (NMR) method is the only physical tool currently available which is able to detect directly the presence of groundwater, its depth, volume, aquifer texture and transmissivity. The Time Domain Electromagnetic (TDEM) method has been proven highly efficient in detecting saline groundwater on the basis of resistivity. The combined application of these two methods is the most promising way to delineate accurately groundwater depth, volume and salinity. This hypothesis was tested during a feasibility study conducted over the whole of Israel during the summer of 1992.

The Russian Hydroscope and the Geonics Protem-IV instruments were used for the NMR and TDEM measurements respectively. Thirty six NMR stations were established, mostly close to existing water wells; among these, 19 showed a reasonable signal. Fourteen TDEM measurements were taken in combination with NMR measurements and a reasonable correlation between resistivity values and water salinity was obtained using the TDEM method. At most NMR stations the presence and relative water content were accurately detected, while the depth, transmissivity and aquifer texture were less reliably detected. The low noise protection of the NMR equipment is at present the weakest part of the system. Another limitation is the maximum penetration depth of only 74–138 meters.

The TDEM anomalies were obviously caused by low resistivity lithologies, while some of the false NMR anomalies could be explained by low signal-to-noise ratio. With regard to the freshwater-seawater interface, it was in all cases accurately determined by the TDEM method alone. It is interesting to note that, at the same depth, NMR measurements indicated a sharply increasing anomaly followed by the absence of water at greater depths. The latter phenomenon can most likely be explained by the very low resistivity of the Dead Sea water, which was not taken into account by the existing NMR interpretation.

Gravity Over the Kinneret Region — New Maps and Preliminary Results of the Interpretation

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New marine gravity data were collected during 1988 in Lake Kinneret from a small utility vessel using the BGM-3 Sea Gravity System. Before that, in 1986–1987, a detailed bathymetric survey was conducted in the Lake. Additional data from the Institute of Petroleum Research and Geophysics helped to expand the gravity coverage to the land area around the Lake.

A free air map of Lake Kinneret and its vicinity was compiled. A Bouguer anomaly map was prepared using the new bathymetric data. Some transformations of Bouguer gravity map were accomplished. They include estimation of the regional and residual anomalies, computation of the first derivative and up-ward continuation maps. Analysis of the gravity data and 2-D modeling of the Kinneret basin reveal complex deep crustal structure of the region.

The Bouguer gravity map of the Kinneret region shows several distinct features. The Korazim block, a structural high covered by basalts, is clearly distinguish. A steep gravity gradient on the southwestern side of the basin indicates that it is associated with a fault. The location of the lowest value in the gravity low in the lake is shifted about 6 km south relative to the location of the deepest portion of the bathymetric depression. This probably indicate a propagation of the basin to the north.

Gravity Flow Fracture-Voids at the Water Table Region — A New Insight to the Interpretation of this Test

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In many fissured systems fracture-voids are present in the vicinity of the well. During pumping, the water level in the well drops and fracture-voids are drained. The volume of the fracture-voids which are filled with water during well recovery, will retard water level rise and this influence on well recovery will be reflected as a discontinuity in the derivative of the recovery curve (hereafter referred to as interference segment).

Laboratory simulations showed that increasing the volume of the fracture-void increases the interference period (time over which the interference segment is observed) and decreases the slope of the interference segment.

Interference segments detected in a recovery test conducted in a research well at Ramat Hovav, (forced gradient conditions) demonstrated the existence of such fracture-voids in the field. Moreover, the existence of interference segments detected in hydrographs obtained in three other research wells completed in the same aquifer further demonstrates the consistency of this phenomenon.

The ability to detect fracture-voids is directly proportional to the volume of the fracture-voids and inversely proportional to the recovery rate, i.e. the hydraulic gradient around the well and the hydraulic conductivity of the tested interval.

A New Look at the Hebron Magnetic Anomaly

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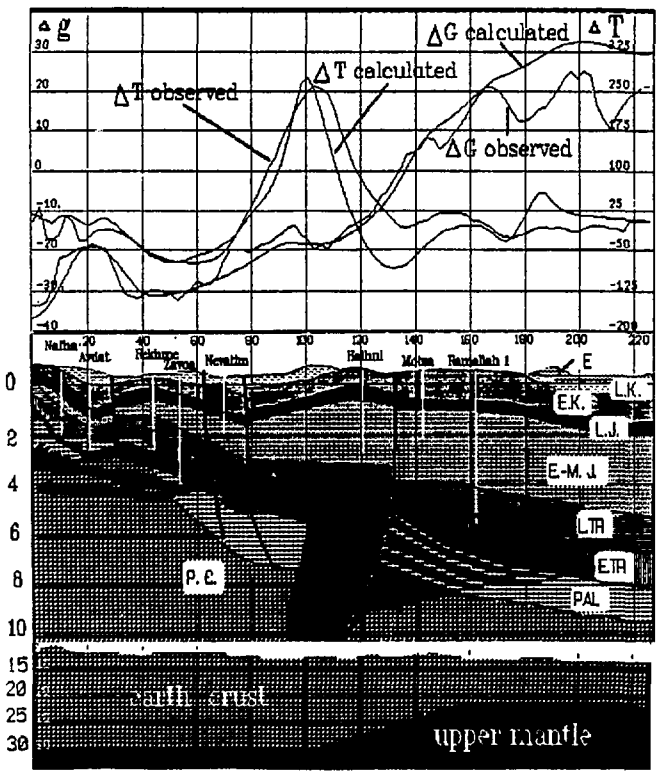
The gravity and magnetic data along a 200 km profile from the Ramon-1 well to the Ramallah-1 area was interpreted. The model used data from the existing wells in the region for geological control of the sedimentary sequences and from deep seismic reflection profiles for delineation of the basement-sedimentary unconformity. The observations from the model are as follows:

1. A large, distinct volcanic body appears to penetrate the sediments in the Hebron area. It has a sharp southern boundary and narrows gradually northward. This body is separated from the volcanic bodies which are known from the Negev and northern Israel.
2. The sedimentary section increases from about 5 km in the northern Negev to about 12 km in central Israel.
3. The crustal thickness in central Israel is reduced by about 10 km with respect to the northern Negev. In central Israel the basement is only about 10 km thick, somewhat resembling oceanic crust in thickness.



Residual Gravity Map of Israel and Adjacent Areas

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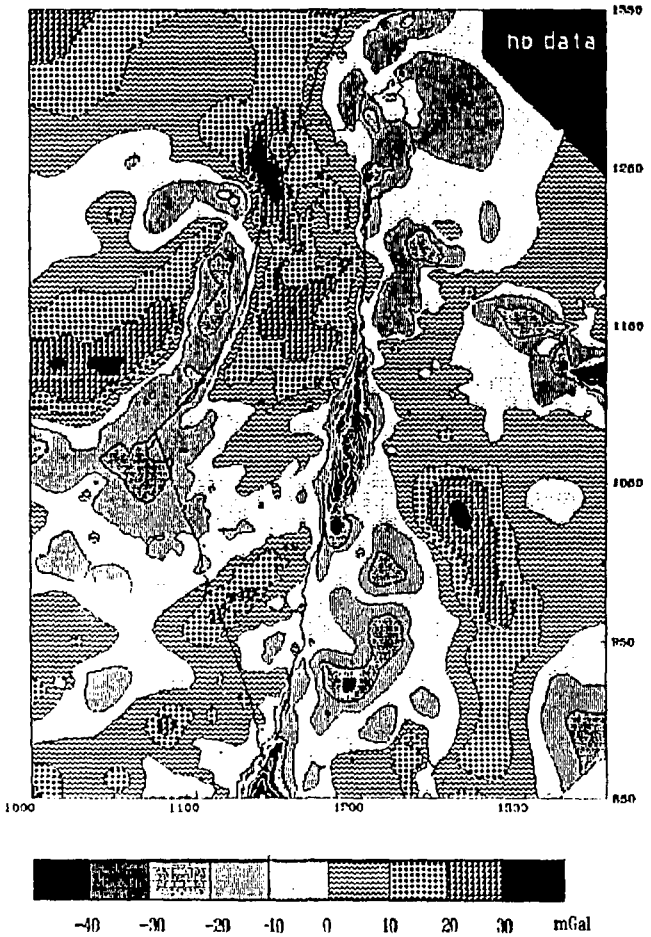
The Bouguer anomaly map of Israel and adjacent areas, including the eastern Mediterranean and Jordan, show a prominent gradient of some 200 mgl in a NW-SE direction. The main reason for this regional trend is the change from the sediment covered oceanic crust of the eastern Mediterranean to the high continental crust of the Sinai block and the Arabian plate. In this work, we removed a regional gravity field described by a 3rd degree polynomial from the Bouguer gravity map. The resulting residual map shows the gravity features related to local geology more clearly. The large negative anomaly associated with the Dead Sea basin is noted in the center of the map. This anomaly can only be modeled if a 10 km thick sequence of very low density rocks is present, suggesting that salt is a major component of the section.



Tectonic Characteristics of Earthquake Mechanisms in the Sinai Subplate

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Characteristics of the present tectonics of the Sinai subplate are defined on the basis of about 60 fault plane solutions of $M_L \geq 4$ earthquakes that occurred during the last 50 years. These solutions are determined from the polarity of first P wave arrivals as published in the ISS, ISC and picked from ISSN seismograms.

Strikes of the fault planes are found to be subparallel to the subplate borders. The distribution of maximum P and T in the mechanisms is bimodal. The solutions of the first mode, which include most of the Dead Sea transform events as well as the main Suez rift seismic activity, show a NW-SE compression. This agrees with the principal stress axes suggested by Garfunkel, 1981, based on macrostructures. The other mode, which is normal to the first one, includes the solutions in the Cyprean arc.

Directions of motion on the fault planes (rake) record the main styles of deformation: sinistral shear and normal faulting in the transform zone, thrusting in the Cyprean arc and extension in the Suez rift. Although sometimes the auxiliary planes had to be considered because the real fault planes are not always known, the overall tectonic patterns are clear.

The style of deformation near plate borders is determined by the relationship between the azimuth of the plate motion and the strike of the fault planes. Along a transform zone, a 'simple' relationship is defined when a lateral motion occurs on a fault which is parallel to the direction of plate motion. When the fault strike deviates from the azimuth of the plate motion an additional dip slip component is expected. A 'complex' relationship occurs when different mechanisms appear. Analysis of fault plane solutions in the Dead Sea - Lebanon region shows that some events are 'simple' and therefore record the transform motion. On the other hand, 'complex' solutions are relatively common north of the Carmel-Fare'a structure and reflect the complicated structural relationship in this region.

The 'Black Heart' Dike

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The 'Black Heart' dike is one of the dikes at Nahal Ardon, Makhtesh Ramon. The dike differs from others in its remarkable zoning; dark in its center, crossed by joints which form blocks with an average length of 20–40 cm and average width of 15–20 cm. The flanks of the dike are light in color. The dike is in three segments as ascending a cliff of 15 m height. The segments are inclined to the west, thus each has an upper and a lower flank. The upper segment is almost vertical, while the middle and the lower one are inclined at about 40°.

There are, in principle, two possible ways for explaining the zoning: a) the dike is a composite dike of multiple intrusions b) the dike has suffered alteration of different intensities in its center and its flanks. 70 petrographic thin sections were made across the 1.5 m wide lower segment, being taken almost successively while the maximal distance separating the sections was 1 cm. Petrographic analysis was carried on all thin sections and modal analysis was performed on 48 of them. Olivine, the most susceptible mineral to alteration within the minerals in the rock, was the primary mineral used to indicate the level of alteration qualitatively and quantitavely. Pyroxene played a secondary role in determining the alteration levels, while plagioclase, which underwent minimal alteration, was less useful. Three samples were selected, according to the petrographic analysis results, representing the different zones of the cross section for the performance of chemical analysis, and some samples were selected for x-ray analysis of the alteration minerals.

The petrographic analysis show the dike to be composed of a single uniform rock, olivine basalt, with diminution of crystal size toward the margins, and which underwent alteration in different intensities. Modal analysis shows assymetry in alteration. The alteration of the lower flank was strong, and the altered zone is 43 cm wide. In the upper flank alteration was less severe and the zone is 23 cm wide, while the dike's center is only slightly altered. The blocks formed by the joints in the center have thin altered margins, and the remainder of the block is fresh.

A similar pattern, of alteration in the outer part of the dike and fresh rock in the center, is shown by chemical analysis. With Al, Ca and water content increase, and Si, Mg and Fe content decrease in the strong alteration zone compared with the fresh center of the dike.

We conclude that the dike has suffered alteration by hydrothermal solutions which advanced along the dike margins and altered it specially in its flanks but also in its center. The differing intensity and width of the altered zone, in the upper and lower flanks is explained by escape of the solutions ascending along the upper flank into the country rock, while the solutions ascending along the lower flank could only pass into the dike

Testing the Applicability of a Seismic Antenna in Israel

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The concept of a seismic antenna, or more specifically a small aperture regional array, has been developed by NORSAR of Norway and, for the last decade, has been tested and implemented in Norway (NORESS and ARCESS), Finland (FINESS) and Germany (GERESS). These arrays required heavy investments in sophisticated equipment and advanced processing techniques, including multiple narrow band frequency filters, beam-forming, frequency wave number analysis, polarity of broad band registration, etc.

An attempt has been made to apply this technology in Israel. As a first step, we installed a six station array with an aperture of a few hundred meters on Mt. Turr'an. A preliminary analysis of the data acquired by this seismic antenna since July 1992 reveals that there is a good chance the seismic antenna will be applicable in Israel and will require a much lower technical and financial investment as compared to those operating in Europe. Upgrading of the current instrumentation is required in order to continue testing and better assess the potential of the seismic antenna in Israel.

Application of the New SvE Method for Earthquake Hazard Assessments in Israel

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The SvE method (after Shapira and van Eck who proposed it in 1990) incorporates: (a) Monte Carlo simulations of local and regional seismicity; (b) stochastic simulations to generate S-wave accelerations; (c) analyticaldetermination of the non-linear seismic response of a specified site; (d) statistical analysis of the calculated response spectra of the simulatedfree surface ground accelerations.

The SvE method provides the equi-risk site-specific response spectrum whichis the a-seismic design function.

Data from earthquakes monitored by the Israel seismic networks were used byShapira and Hofstetter (1992) to obtain estimates of the kinematic parametersassociated with earthquakes in Israel. These data were applied to the SvE,demonstrating the applicability of the method to earthquake hazard assessment inIsrael.

Evidence for Late Archean (ca. 2600 Ma) Crust in Sinai

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The Pan-African continental crust of NE Africa and Arabia formed during the end of the Precambrian roughly between 900 and 550 Ma ago from the growth of and collision of numerous island arcs, marginal basins and accreted terranes. One of the most fundamental problems remaining in the shield is the presence (or absence) and character of pre-Pan-African continental crust in this region. Although 2.3 to 1.1 Ma old clasts in a late Precambrian conglomerate in the Eastern Desert of Egypt point to the existence of older crust, it has been repeatedly argued that there is no evidence for either a pre-Pan-African foreland or reworked Pan-African basement in northern Afro-Arabia. Archean basement is known to occur only at Uweinat, about 1000 km west of Pan-African rocks and in the Sudan.

The U-Pb isotopic age of zircons from a tonalitic gneiss in SW Sinai was determined. The gneiss occurs in narrow concordant sheets within high grade metasediments of the Feiran Group. The zircons define a mixed population but most are very fine idiomorphic, clear, zoned and contain numerous microlite inclusions. Collectively these characteristics appear to define magmatic zircons. Other zircons are oval to barrel-shaped, corroded or metamict and also fractured or broken. These could be metasomatized and/or detrital zircons. Combinations showing a corroded (detrital ?) core with a clear and zoned (metamorphic or magmatic ?) rim are also frequently present.

Five different grain fractions (>80μm-<30μm) were analyzed and the results plotted on a U-Pb concordia diagram. The five points define a discordant array (MSWD = 0.17) with an upper intercept at 2580 ± 50 Ma and a lower intercept at 624 ± 6 Ma. The older age points to the presence of a Late Archean to Early Proterozoic zircon component in rocks (Feiran Gneisses) which are intrusive into metasediments with continental margin characteristics (Solaf Formation). The mean $^{207}Pb/^{206}Pb$ age of ca. 1200 Ma is probably a mixed age representative of the complex polycyclic nature of the zircons. The younger age is compatible with numerous others which clearly record the age of Pan-African tectogenesis. Tentatively the present data provide the first evidence of Archean elements partaking in the generation of NE Pan-African crust.

Possibility of Detecting Seismomagnetic Effects on Magnetic Structures Along the Dead Sea-Jordan Fault

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The greatest seismomagnetic effect is obtained on magnetic dikes or other magnetic structures which are located either inside or close to a fault. In order to estimate this effect, calculations of rock magnetization changes caused by stress accumulation within a strike slip fault were made. Stress field calculations were based on the dislocation theory developed by Steketee, assuming a rectangular vertical dislocation surface within a semi-infinite, isotropic elastic medium. A computational model was developed in order to compute the geomagnetic field changes in the case of non- uniform magnetized rocks. These computations were applied to real structures situated close to the Dead Sea-Jordan strike-slip fault. Considering the relationship between earthquake magnitude and fault dislocation, we discuss the possibility of detecting geomagnetic changes as precursors to strong earthquakes.

Copper Mineralization in the Cambrian Timna Formation

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Copper mineralization occures in the Cambrian Timna, Timna vally. This study focuses on the genesis of the copper mineralization assembleges and their relation to the host sediment. Three mineralogocal assembleges can be defined:

1) *Copper sulfides* — These are located within the massive dolomitic litofacies (Sasgon Member) as spheriods ranging in size from < 0.5 to 5.0 mm. The main copper minerals within the spheriods are: chalcocite (Cu_2S), copper-silver chloride, copper carbonates and copper silicates. Relicts of gypsum, quartz, calcite and native-sulphur are found within the sulfides spheriods. The calcite is interpreted to be a relict of the pre-dolomitization stage of the carbonate sedimentary and diagenesis.

2) *Copper silicates and Copper-rich clays* — These are found within the sandy lithofacies and at the soft horizons at the base of dolomites, of Sasgon Member. The copper silicates occur as veins, cement to the quartz and feldspar grains and as spheroids. The copper-rich clays occur aside to the copper silicates within the sandy and the dolomitic facies of Sasgon Member. It is most probable that the clay-rich horizons acted as traps for percolating solutions. The main copper silicate mineral is chrysocolla ($Cu_{2-x}SiO_5(OH)_3 \cdot XH_2O$) appears in turquoise, green and blue forms. The color change is due to the varios Cu/Si ratio and to differnt water contents. The chrysocolla occurs as spheriods that replace quartz and feldspars grains. This implies that chrysocolla was formed by reaction between copper and dissolved silica.

3) *Copper chloride and Copper carbonates* — These minerals occuring in the sandy lithofacies as crusts, veins and cracks secondary to chrysocolla. The main minerals are: paratacamite ($Cu_2(OH)_3Cl$), malachite ($Cu_2CO_3(OH)_2$) a side to gypsum and halite. Location, field appearence, mineralogical and petrological content of the ores indicate that the host rock exert a strong control of the type of mineralization. The observed mineralization types indicate three different phases of copper deposition: 1) a primary sulfide stage, 2) remobilization of copper and its concentration in clay and silicate horizons, 3) a further remobilization in the presence of chloride-bearing solutions. Thermodynamic conditions associated with these phases will be discussed.

A Method for Estimation of the Firing Temperature of Ancient Pottery by Infrared Spectroscopy

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A method for estimation of the firing temperature of ancient pottery by infrared spectroscopy is suggested. During firing of raw materials to pottery, processes of dehydroxylation of clay minerals, as well as formation of X-ray amorphous matter, usually occurs. At increased temperatures, new high- temperature minerals are crystallized in the fired matter. The common method used for estimation of the firing temperature is X-ray diffraction, based on determination of the mineral assemblage in the fired matter due to the destruction of original minerals and crystallization of new minerals which are a function of the firing temperature. However, this method is limited to examination of crystallized materials. On the other hand, IR spectroscopy enables to identify the changes in the amorphous matter as a function of the firing temperature. The latter method has specific advantage for pottery fired at a relatively low temperature where only amorphous matter is formed, but not high-temperature minerals.

According to the proposed IR spectroscopy method the firing temperature is elucidated by comparing the IR spectra of the pottery to those of the raw materials fired at known temperatures. The method takes in consideration the main type of clay mineral and presence of lime material (calcite) in the raw material. Therefore, the IR properties in the spectra of the pottery is compared with those formed by the firing of calcareous and noncalcareous kaolinitic and montmorillonitic raw materials. Those raw materials were fired between 600–1000 °C for a long time, which is reasonable for pottery firing and completion of the most of the thermal reactions. Like the processes which occur in the pottery after firing, those fired raw materials were rehydrated and recarbonated for a long time.

The comparison between IR spectra of the pottery and those of fired raw materials takes in consideration the presence and strength of OH bands and the locations and width of SiO bands which are a function of the destruction of clay minerals and crystallization of new minerals. In pottery made from calcareous raw material, the location and width of CO_3 bands in connection with original or recarbonated calcite depends on the firing temperature.

A New Quantitative Method for Estimation of the Proportions Between Kaolinite and Montmorillonite-Illite in Sediments and Soils by Infrared Spectroscopy

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A new method for quantitative measuring of the relative amounts of ordinary kaolinite and montmorillonite-illite in sedimentary rocks, sediments and soils, and also in pottery raw materials, by infrared spectroscopy is suggested. Those clays and mixed-layer illite-smectite are usually the most abundant clays in many sediments and soils and could appear together in different amounts. The common method used for identification and semi-quantitative estimation of the type and amounts of clay minerals is X-ray diffraction. However, many factors may affect the intensity of diffraction peaks of the clay minerals and percentage estimates may be misleading. Therefore, an additional quantitative estimation method is needed, for which the proposed method is designed.

The proposed IR spectroscopy method is based on measuring the relative intensities of the OH stretching bands of those clays in the IR spectra. In the spectra of the kaolinite and montmorillonite mixtures the sharp OH stretching band of kaolinite at 3620 cm^{-1} overlay the wide OH stretching bands of montmorillonite, while the sharp OH stretching band of kaolinite at 3696 cm^{-1} is almost free. With increasing amounts of kaolinite, the 3696 cm^{-1} band becomes progressively stronger, while at 3620 cm^{-1} the band is combines with the wide band of montmorillonite. Similar results were found for kaolinite and illite mixtures.

The relative ratio between the kaolinite band at 3696 cm^{-1} and the combined band at 3620 cm^{-1} gives the relative amount of kaolinite and montmorillonite- illite in the sample. Calibration curves were prepared for this determination. The method is very sensitive for samples containing small amounts of kaolinite. It is particularly suitable for samples containing unordered mixed-layer illite-smectite. The method is rapid, and the sample is measured as is, without the prior preparation and orientation needed for the X-ray diffraction method. Instead of separating and measuring clay fractions after decantation, the whole clay sample is examined. Calibration curves can be also prepared for quantitative measurement of any clay, mica or other minerals.

The Components of the OH Stretching Band in the Infrared Spectra of Smectites Containing Iron and Magnesium, Elucidated by Curve Derivatives

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The components of the OH stretching band in the infrared spectra of smectites containing iron and magnesium were elucidated by curve derivatives. This method allowed better resolution of IR spectra of clay minerals. The spectra were recorded on a Nicolet FT-IR spectrometer. The derivatives of the curve were obtained using its "DERIVE.FTN" program. The first derivative curve enhances the shoulder height and makes it possible to obtain a quantitative measurement, while the second derivative makes it possible to determine the shoulder is exact position. In principle this method can be used for any clay, mica or other minerals.

In the original spectra the OH stretching band of smectites exhibits only one broad maximum and a number of practically invisible shoulders. The results show that the second derivative makes it possible to distinguish and identify the individual OH-stretching components linked to Al(OH)Al, Fe(OH)Al and Mg(OH)Al vibrations and, in addition, the Fe(OH)Fe, Fe(OH)Mg and Mg(OH)Mg vibrations in iron and magnesium rich smectites, respectively. According to these results the locations of OH stretching components are at about: Fe(OH)Fe at 3575–3580, Fe(OH)Al at 3600–3605, Al(OH)Al at 3625–3630, Mg(OH)Al at 3645–3650, Fe(OH)Mg at 3670–3675 and Mg(OH)Mg at 3685–3690 cm^{-1}.

The proposed method could also be used to estimate trioctahedral positions in the main dioctahedral structure of the smectites and to ascertain if the Al substitution by Mg and Fe in the octahedral sheet is random or located. Magnesium-rich smectites containing iron (like some types of Wyoming Bentonite) show in the second derivative relatively strong components of Fe(OH)Mg and Mg(OH)Mg vibrations but only a shoulder of Fe(OH)Al vibration. This behavior appears to be connected with presence of some trioctahedral positions with located Mg and Fe in the main dioctahedral structure of these magnesium-rich smectites. The trioctahedral positions give priority for the two components of Fe(OH)Mg and Mg(OH)Mg vibrations but not for the component of Fe(OH)Al vibration.

The Origin of Iron Age Kraters with Grooved Neck, Excavated at Tel Hadar, Sea of Galilee Shore, Determined by Petrographic and Mineralogical Analysis

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The origin of an Iron Age group of kraters decorated with horizontal grooves on their necks, excavated at Tel Hadar on the eastern shore of the Sea of Galilee, was determined by petrographic and mineralogical analyses. No identical vessels were found in Iron Age Israelite sites and their origin is therefore of great interest. Most of the kraters were found in stratum I of this site, estimated to be from the 9th century B.C.E. (Several similar kraters were found in stratum II, from the 11th century B.C.E.).

Most of the grooved-neck kraters examined show similar petrographic features and contain various types of unsorted and rounded grains and little pebbles of basalt, chalk, limestone, chert and quartz in a calcareous clay matrix, indicating that the raw material had been prepared from a calcareous clay alluvium containing those particles. Basalt grains together with carbonate grains in the pottery and the micrographic textures of the basalt are similar to those of the Yarmouk river alluvium, indicating that the Yarmouk basin may have been the source of the raw material and the krater's place of origin. The petrography of most of the basalt grains in the kraters is similar to that of the Raqad basalt flow in the Raqad-Yarmouk basin. In addition, Some basalt bowls excavated together with the kraters have the same petrographic features characteristic of the Raqad basalt flow. It seems that both the kraters and the bowls were imported to Tel Hadar from this area.

One grooved-neck krater has different petrographic features and contains only unsorted chalk fragments with fossils of Eocene foraminifera in a calcareous clay matrix. The micrographic texture indicates that the raw material of this krater was prepared from rendzina soil. This soil develops on chalk and it abundant in the vicinity of the excavated site on the Eocene chalk of the Northern Gilead area. Consequently, it seems that this area is the krater's place of origin.

Those observations are supported by the excavation report from Irbed, where similar kraters have been found. It appears that Tel Hadar had trade relations with the Yarmouk-Raqad and Gilead areas during this period.

The Ceramic Technology of Iron Age Cooking Pots, Tel-Hadar

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The ancient ceramic technology of Iron Age cooking pots excavated at Tel-Hadar, on the eastern shore of the Sea of Galilee, was determined by petrographic and mineralogical analyses. The results showed that most of those cooking pots are composed of a noncalcareous or slightly calcareous clay matrix and usually contain only one type of unsorted rock fragments, basalt or limestone. As known, many cooking pots contain crushed monocrystalline calcite from an additional source that were added as tempers to the raw material.

The research interprets those observations:

- Use of noncalcareous clay matrix indicates that for the preparation of cooking pots, the potters preferred a clay raw material that is impermeable and stable under repeated heating and cooling and in direct contact with fire.
- Presence of only one type of unsorted rock fragments and micrographic texture indicates that the potters used as raw material noncalcareous clay soil containing those fragments.
- The basalt or limestone fragments indicate that basaltic soil or terra rossa soil, respectively, were used as raw materials. Basaltic soil is developed east of the excavated area, on the Golan basalt plateau. terra rossa soil is developed on limestone and appears in other places. It is possible that those areas are the sources of raw materials and the vessel's place of origin.
- For noncalcareous clay matrix potters could also use clay sediment, but they preferred using soil, probably because it is available near the sites while noncalcareous clay sediments are rare in the region. There is no need to bring raw material from far away nor to dig for it. In addition, the clay in the soil is relatively poorly crystallized and contains iron oxide which serves as a flux material, both of which may bring about earlier firing and sintering.
- Use of noncalcareous clay necessitated the addition of an efficient flux such as lime to reduce the firing temperature and it appears that monocrystalline calcite were added as temper for this purpose. The use of limestone tempers for this purpose is inappropriate, since it is causes defects in the pots. This seems to explain why the potters went to great efforts to obtain this rarely found calcite before crushing and adding it to the raw material.

The knowledge of raw materials enabling suitable ones to be selected for their advantages for cooking pots indicates high ancient technological development.

The Ceramic Technology of Iron Age Storage Vessels, Tel-Hadar

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The ancient ceramic technology of Iron Age storage vessels, jars and pithos, excavated at Tel Hadar on the eastern shore of the Sea of Galilee, was determined by a petrographic and mineralogical analyses. The results showed that most of these vessels are composed of a calcareous clay matrix and usually contain various types of unsorted and rounded grains and pebbles of basalt, chalk, limestone, chert, quartz sand and silt.

The research interprets those observations:

- Use of calcareous clay matrix indicates that for the preparation of storage vessels, the potters preferred a clay raw material that is fired at a lower temperature. As known, lime is a flux material and vessels made from this clay are sintered earlier. The lime content also gives a lighter color to vessels.

- Presence of various types of unsorted and rounded grains, pebbles and micrographic texture indicates that the potters used calcareous clay alluvium containing those particles as raw material.

- Calcareous clay alluvium containing both basalt and carbonate grains is present in the vicinity of the excavated site only in the drainage system of the Golan slopes toward the shore of the Sea of Galilee, and it seems that this area is the source of the raw material and the vessel's place of origin.

- For calcareous clay matrix potters could also use marl rock, but they preferred using alluvium, probably because it is available near the sites which are usually located closed to water sources like rivers. In addition, poorly crystallized clay in the alluvium may have fired and sintered earlier.

- The presence of grains in the clay matrix indicates that the dominant clay in the raw material was montmorillonite. It seems that the potters kept the original grains of the raw material as tempers to reduce the high plasticity, collapsing and shrinking of this clay during the preparation of the vessels.

- The presence of different sizes and various types of grains and pebbles in the pottery indicates that the potters made no effort to sort the raw material. The production of storage vessels requires large amounts of raw material. It appears that for production of big vessels designed for storage of dry foods, a coarse local raw material was sufficient.

The knowledge of raw materials enabling suitable ones to be selected for their advantages for storage vessels indicates high ancient technological development.

The Ancient Technology of Cement for Plaster and Building Materials, Tel Michal

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The ancient technology of cement for plaster and building materials is determined by petrographic and mineralogical analyses. The samples were collected at Tel Michal (Makmish), on the Mediterranean coast north of Tel Aviv, especially from a built Hellenistic wine press found at this site. The results show that those samples are composed of calcareous cement material of microcrystalline calcite (micrite), surrounding particles, like pebbles, Glycymeris shells and quartz grains.

The research interprets those observations:

- The micrographic texture of the calcareous cement material indicates that recrystallization of microcrystalline calcite between the particles caused the cementation and solidification.
- A natural cementation process by recrystallization of calcite is very slow and therefore a forced artificial process was needed.
- It seems that incinerate calcareous raw material was used to obtain the cementation process. This material probably contained decarbonated calcite and the cementation occurred in the recarbonation process of the calcite.
- The cement material texture of the samples is similar to those formed in recarbonated calcite. In both cases it is characterized by a low degree of crystallinity and a microcrystalline calcite.
- The location and width of CO_3 bands in the IR spectra of the cement material indicate that the calcite is recarbonated after heating.
- Ancient digging places of calcareous raw materials, like chalk and and lime incineration devices are abundant in our area.

It may be concluded that the calcareous raw material was incinerated to the calcite decarbonation temperature (at about 700 °C), CO_2 was released and CaO was formed. The decarbonated raw material reacted with some water and $Ca(OH)_2$ was formed. It seems that at this stage the particles were added and the material was used for plaster or building. The cementation process occurred by the reaction of the $Ca(OH)_2$ with atmospheric CO_2, followed by recrystallization of calcite in the recarbonation process.

The Use of Natural Radioactivity for Tracing Sediments from the Jordan River to Lake Kinneret

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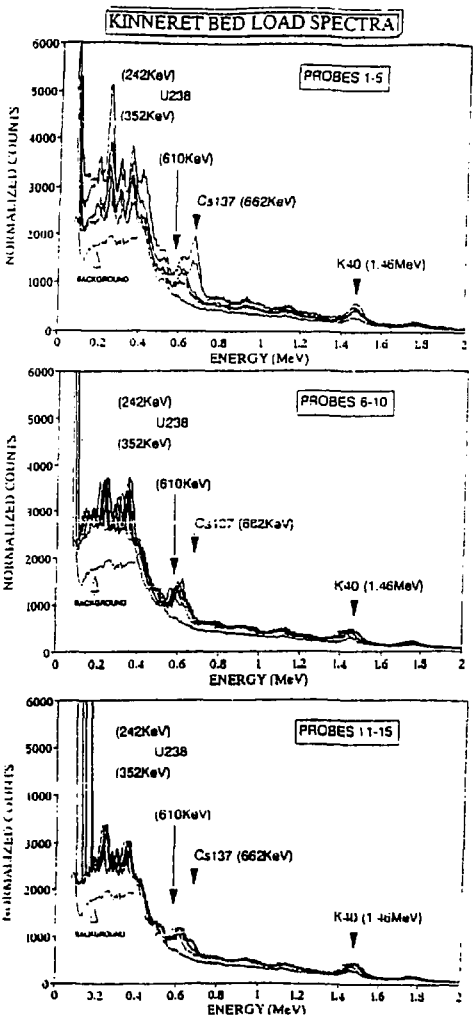
The aim of this paper is to present the method of using natural radioactivity of sediments for their follow up through the river-lake system. Sediments of different origin differ by their isotopic composition and may be classified by specific gamma spectra signature. The suggested method of passive gamma radiation is being used now, among other methods, in the study of sediment transport from River Jordan into Lake Kinneret.

The samples of bottom ground were taken along the suggested sediment routes. Granulometric and gamma spectrum analysis of the samples were performed. Gamma spectra of the samples were obtained using 3 × 3" NaI detector and measuring system, developed in the Van De-Graaff Accelerator Laboratory at Department of Physics of Technion. Typical spectrum of the probes shows three spectral ranges suitable for tracing purposes: 1.46 Mev line of K^{40}, 0.662 Mev line of Cs^{137} and lower energy range of the U-Th family.

The very preliminary results in the Jordan River Mouth show three distinct regions of different gamma activity of the bed load of Lake Kinneret: highest gamma activity observed in the native Kinneret bed load, lowest gamma activity recorded in the coarse river-drawn sediments (sized larger than 0.05 mm), and the in-between values obtained from the bed load area of mixed Jordan river/ Achziv rivers/ native Kinneret sediments.



Bedload Discharge Determination by Fluorescent Tracers at the Jordan River Mouth

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Experiments with fluorescent tracers in the Jordan River mouth to Lake Kinneret enables to get qualitative and quantitative assessments of the direction and velocity of bedload transport. The fluorescent tracers are ecologically pure, unlike the artificial radioactive tracers which are forbidden in the Kinneret watershed, and their detection is characterized by extremely high sensitivity and selectivity, especially under excitation by laser sources which detect both spectral and kinetic parameters of luminescence.

The aims of the study are: 1. To prove the reliability of the fluorescent tracer method by comparing it to traditional sediment transport methods: 2. To determine the relationship between parameters of bedload discharge and hydraulic characteristics of the flow.

The results confirm the reliability of the fluorescent tracer method for measuring bedload discharge at the mouth of the Jordan river. During floods bedload discharge achieved large values comparatively to suspended load discharge, which usually accounts for 95% or more of the total river sediment discharge. Bedload discharge increases rapidly with water discharge increase, with a proportion coefficient of approximately 10^4. The average real velocities of bedload movement are approximately 1 cm/hour and the active layer depth is about 6 cm. The bed relief during floods is characterized by large active sandy structures which migrate from the Jordan river into lake Kinneret, forming a large sandy mouth bar in the contact zone.

$^{230}Th/^{232}Th$ and Pb Isotopes in Prehistoric and Quaternary Basalts from SW-Syria and Northern Israel — Inferences for the Th/U Ratio of the Plume Beneath the Northern Arabian Plate

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The Th/U **source ratio** of Quaternary basalts from Israel and Syria was calculated in two ways: (1) from the slope of the correlation line in the coordinate system: $^{208}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$; and (2) from $(^{230}Th/^{232}Th)$ activity ratios in prehistoric basalts from the Leja area, SW-Syria (whose $^{40}Ar/^{39}Ar$ ages are 60 ± 20 ky, Heimann et al., this volume). While the slope of the Pb-Pb correlation line corresponds to Th/U **source ratio** of 2.5 ± 0.1, the $(^{230}Th/^{232}Th)$ activity ratios yielded higher **source ratio** of 2.9 ± 0.1. Both values are significantly lower than the **measured ratios** of the basalts (ranging between 3.5 to 3.9).

These results suggest that : (a) The Pb-Pb correlation is probably a mixing line between two end-components; this implies that the **sources** of the Israeli-Syrian Quaternary basalts are not uniform with respect to Th/U ratio (and the abundances of other incompatible trace elements); and (b) U and Th are strongly fractionated during basalts genesis. Yet, because both elements are highly incompatible, partial melting for itself cannot cause this fractionation. In the same time it cannot be explained by crystallization of olivine, clino-, or orthopyroxene.

The Th/U ~ 3 that is inferred for the **sources** of the Syrian prehistorical basalts is significantly higher than **N-MORB** values (Th/U = 2.5) and it is rather similar to plume-type sources such as Hawaii and Iceland. This confirms the plume-type geochemical characteristic of the Israeli-Arabian basalts **sources**. Moreover, on the coordinate system $^{87}Sr/^{86}Sr$ ratios versus $(^{230}Th/^{232}Th)$ activity ratios the **sources** of the Syrian basalts lie close to the **HIMU** mantle component. Yet, the Pb-Pb mixing line suggests that a low Th/U component should be also present in the Quaternary basalts **sources.** We speculate that this component is more similar to **N-MORB**, and that it was incorporated within the rising plume while it intruded the uppermost mantle beneath the Arabian plate.

Direct Dating of the Sedimentary Sequence in Israel Using the K-Ar Method — Interim Report

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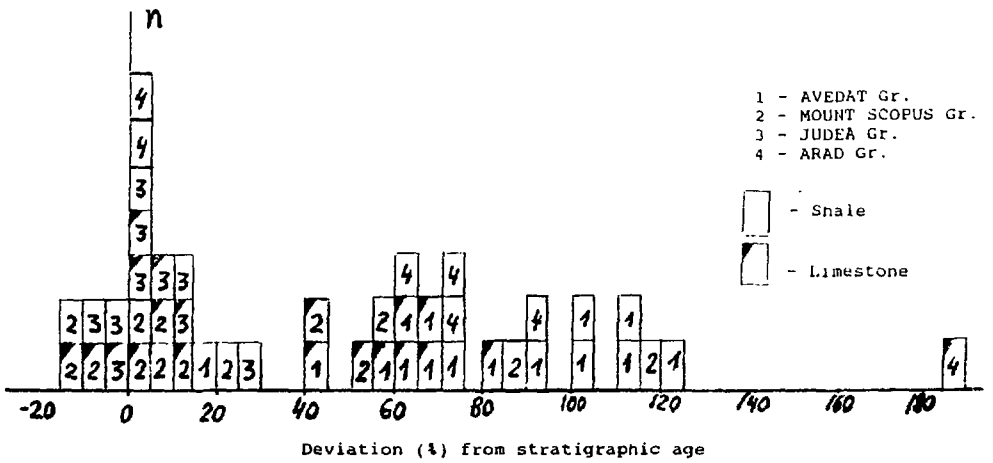
Some 50 K-Ar age determinations have been performed on silicate fractions (clay minerals, some feldpar) separated to size fractions from some 20 shale and carbonate samples from Jurassic to Paleocene formations in Israel. The results (Fig.) show that:

1. In some cases the K-Ar ages are significantly higher than the stratigraphic age, reflecting the age of mica and feldspar which accompanies the kaolinite. The latter is the major clay mineral in this group. The silicates in these samples are all or to a large extent of a detrital origin.

2. In some cases the K-Ar age of the separated fraction is equal or close to the stratigraphic age. The samples contain different clay mineral assemblages. All contain smectite or phases of I/S. In some authigenic feldspar is also present. The fractions dated represent therefore mixtures (size/mineralogy) of components which are: a) detrital; b) reset (K-Ar clock) and/or authigenic.

3. Ages which are significantly younger than the stratigraphic age have not been encountered, even in the finest (<0.2 micron) fractions. It is concluded that these clay minerals did not lose radiogenic argon since their inclusion in the host rock.

Concluding, the overall pattern of results indicates the potential in the dating of such clay fractions in terms of geochronologic-stratigraphic aspects, paleogeographic aspects, as well as the petrology of clay minerals in these depositional environments.



Temporal Variation (During 1992) in the Radon Flux at the Enot Zuqim (Dead Sea) Anomaly

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Anomalous radon emanation sites were found, during 1989–91, in unconsolidated sediments along major faults belonging to the Rift system in the Dead Sea area. Monitoring the anomaly of Enot Zuqim, extending over a area of 2–3 sq. km., was undertaken during 1992. Five monitoring stations were set up. Three stations were located around the strongest anomaly traced in the previous year, covering the area between the fault scarp and the Dead Sea. Two additional stations were placed 3 km to the north, one next to the fault scarp and one 0.5 km to the east. The time variation in the radon flux, already indicated in the previous year was observed in all five stations. The duration of an anomaly is 7–10 days (circa two half lives of ^{222}Rn). The intensity of the anomaly (10,000 pCi/l and more) is up to 100 times the background values (circa 100 pCi/l). A correlation of the peak events is indicated between the sites, which are spread over an area of 2–3 sq. km. No correlation is found between the radon flux versus the barometric pressure and the atmospheric temperature. The various water seepages at Enot Zuqim show different levels of radon content, some of which reach the levels measured in the gravels. Still the Rn concentrations are roughly constant over the monitored time interval and do not show the variation observed in the sediments. As far as known a radon flux of such magnitude and such spatial distribution is not known from other places, especially from a tectonically active zone. Monitoring radon, especially in water wells, has often been suggested as a possible earthquake precurser.

Mineralogy of Clay and Marl Beds Within the Judea Group in Jerusalem Area

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The mineralogy of clay and marl beds within the carbonatic section of the Judean Group in Jerusalem area was examined. Two aspects were studied: Space and time changes in the mineralogical assemblage, and the relationships between clay minerals and carbonates due to their coprecipitation.

Changes in mineral assemblage are mainly connected with the concentrations of quartz and kaolinite. Increased amounts of those detritic minerals indicate a continental component either from a close continent or due to changes of stream directions.

Small amounts of quartz and kaolinite in soft Lower Cretaceous and Lower Cenomanian layers indicate small continental influence. Since kaolinite and quartz are found in the north, the streams with those detritic minerals probably arrived from this direction. Increased amounts of quartz and kaolinite are observed in the Upper Cenomanian, mainly in Moza and Kfar-Shaul Formations, indicating significant continental influence. Their amounts decrease westward.

"Superlattice" structure of mixed layers smectite-illite with 3:1 and 1:1 ratio is present. It seems that those clays were transported to the area and their structure does not represent any deep in situ burial changes.

The smectite, illite and mixed layers clays in the samples tend to coat the other minerals, cover their surfaces and fill in pores. Those phenomena create tiny closed local systems which may effect recrystallization processes. Therefore, reaction between Mg-calcite crystals which have precipitated from sea water and interstitial water was prevented, thus preserving unstable phase. Dolomite crystals which precipitated within a clay surrounding tend to become calcitic, phenomena found mainly in Moza marl.

The ability of clays to form unaerobic microscopic environments caused precipitation of pyrite in Moza marl.

Oil Shows in Mt. Sdom and Their Implications to the Age of the Potential Source Rock

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A variety of hydrocarbon shows are known in the Dead Sea area. They are classified as: 1) gas - in the Zohar field, 2) light oils - in Triassic beds, 3) heavy oil - in many drillholes in the western margins of the graben, 4) asphalts - as seepages, and 5) immature asphalts - as floating blocks on the Dead Sea and in drillholes in the Amiaz Plain.

Several studies, carried out in the last 15 years, have shown that all the oils and asphalts in the area belong to one geochemical family, and have been derived from the Senonian bituminous rocks.

During recent drilling by the Dead Sea Works company in Mt. Sdom, different type of oil shows were encountered. This oil is characterized by: high sulfur content, saturated hydrocarbon envelop of light-heavy oil, predominance of even straight chain hydrocarbons in the C15+ range, predominance of phytane over pristane, high content of gammacerane, and low content of diasteranes. These biomarkers and the high sulfur content indicate that this oil was derived from a source rock which belongs to a carbonate/evaporite sequence deposited in hypersaline environment with an anoxic bottom.

Some of the Mt. Sdom oil properties could indicate fair geochemical correlation with other oils in the area. However, more detailed study revealed significant discrepancies in the correlations of biomarkers. In addition, no correlation is found using stable carbon isotope ratios: del ^{13}C of the Mt. Sdom oil is –21.7 permil, whereas the range for the Senonian oils and asphalts is –29.0 – –27.5 permil.

The correlation of this oil with some organic-rich marls of the Sdom Formation is fair, but maturation indicators show significant differences. The oil is in the initial stages of catagenesis while the marls are definitely in the diagenetic stage.

We suggest that the Mt. Sdom oil was originated in the deep graben from similar organic-rich marls. It should be mentioned, based on the heavy isotopic signature (–21.7 permill) of the oil, that the source rock age may be Miocene (Sdom Formation?). Similar isotopic signature (and biomarkers) is known in several oils in the Mediterranean region. These oils were originated from Miocene carbonate/evaporite source rocks.

Alteration of a Basaltic Dike, Makhtesh Ramon, Israel

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Triassic and Jurassic sedimentary rocks are intruded in Makhtesh Ramon by Lower Cretaceous (125–140 Ma) basaltic and trachytic dikes. The purpose of this study is to determine the paragenesis of the alteration processes, to learn what fluids participated and to determine at what temperatures and when the processes occurred.

The present study is based mainly on samples of a basaltic dike ("BH") which is relatively fresh in the center and significantly altered towards its margins. The dike is exposed in Wadi Ardon intruded into carbonates and clays of the Ardon Formation. Whole rock and separated minerals were examined using petrography, mineralogy, geochemistry, stable isotopes, paleomagnetism and $^{40}Ar/^{39}Ar$ dating methods.

The fresh basaltic rock is composed of plagioclase (labradorite), pyroxene (augite), olivine and ore minerals (ilmenite and Ti-magnetite). Its geochemical composition is similar to average Ramon basaltic rocks.

The alteration processes were divided into stages. At first, the olivine and pyroxene were destroyed and authigenic calcite, micro-quartz and smectite were deposited. As a result, Mg and Fe were released and Ca content increased. At a later stage the plagioclase decomposed bringing about the growth of authigenic alkali-feldspars, kaolinite and another generation of calcite. This is evidenced by decrease in Na and Ca amounts and an increase in K content. The rocks in contact with the country rock are the most altered. The final stages of alteration include precipitation of micro-quartz, smectite and calcites (in small veins). Al and Ti stayed immobile through all alteration processes.

Whole rock $\delta^{18}O$ values vary from +8‰ in the fresh rock to +19.7‰ in the most altered rock. This is due to the decomposition of the low $\delta^{18}O$ magmatic phases and the formation of authigenic minerals having higher $\delta^{18}O$ values. $\delta^{13}C$ results indicate that the alteration processes occurred mainly in the presence of meteoric derived water bearing soil CO_2 that had some degree of interaction with sedimentary rocks. The oxygen-isotopic composition of the water is interpreted to be brackish to meteoric.

The magnetic field direction and the magnetic properties of the fresh rocks are distinguishbly different from those of all the altered rocks. The paleomagnetic and mineralogy data of the ore minerals combined with their petrographic relation to the other authigenic phases, particularly the alkali feldspars, made the alteration's age determination possible. The fresh rock was dated to 135±3 Ma and the alkali-feldspar to 80±3 Ma using the $^{40}Ar/^{39}Ar$ method.

The suggested explanation is that all alteration processes took place at low temperatures (<70 °C) in the presence of meteoric water, in an open water-rock system under continental conditions. A predominant part of the alteration, which includes the precipitation of authigenic alkali-feldspars, kaolinite, calcite and Ti-rich ore minerals occurred in the Upper Cretaceous, well after the dike had cooled.

The Regional Effect of the Nile Delta Load on the Southern Levant Continental Margin and Coastal Plain — Preliminary Results

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The results of the quantitative basin analysis of the late Tertiary Levant continental margin indicate that, in general, the path of the tectonic subsidence along the Levant continental margin follows the expected thermal subsidence for old margins. Tectonic subsidence is defined as the remaining subsidence after removing the one that is caused by the combined effects of the sedimentary load, the paleo-water depths and the eustatic seafilevel changes.

During the Pliocene a phase of increased tectonic subsidence occurred in the coastal plain and shelf area of the southern Levant. This anomaly decreases eastward and northward. In the eastern direction it decreases from about 450 m in the shelf area to 250 m in the inner coastal plain.

This anomaly in the tectonic subsidence is probably caused by the flexure of the plate from the load of the Nile Delta sediments that were deposited since the Pliocene.

Preliminary results of two-dimensional elastic and visco-elastic models indicate that the flexure of the plate caused by this load are sufficient to explain the anomaly in the tectonic subsidence and part of the uplift of the Judean mountains.

Paleopedology of Two Quaternary Sections on Carmel Coastal Plain

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In the Carmel Coastal Plain paleosols were distinguished in colluvial, fluviatile and aeolian (kurkar) environments. They are tentatively correlated as Middle Paleolithic based on archaelogical evidence.

The alluvial fan of Nahal Ezov is exposed about 15 m above sea level. Here a dark-coloured clayey layer 1.5 m thick, interpreted as paleonazaz (aquic Chromoxerert) on the basis of microfabric analysis, is found between two alluvial gravels. The top of this paleosol is incised by numerous erosional channels. The Upper gravel contains Middle Paleolithic implements. The sequence of gravels and intercalated nazaz indicates in our opinion sea level fluctuations.

A paleocatena of red sandy soil (hamra) in the kurkar ridge was studied along the Tel Aviv-Haifa high-way near Tel Qara. A pedosediment of paleo-hamra (with several Middle Paleolithic flint artefacts) occupies a depression in a kurkar layer 8–12 m above sea level, laterally grading to a beachrock. This complex is covered by a reddish compact lense 0.2 to 0.8 m thick with abundant gastropod shells and ooids bound by micritic cement and mixed with brown-coloured aggregates from eroded hamra soil. Thus a subaerial erosion episode was accompanied or followed by a local mixing of marine and pedogenic deposits, containing also a few lithic artefacts.

We suggest that the same pulse of sea level within isotope stage 5 is possibly indicated in both localities described above.

Three-Dimensional Thinking in Structural Geology — A Computer-Based Learning Unit for High-School Students

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Learning and understanding structural geology, involve the ability of multidimensional thinking — investigation of three dimensional structures that change with respect to the dimension of time. The ability to think in three dimensions is related to a specific field in cognitive science known as "spatial ability", or "spatial abilities".

Spatial abilities or skills are required in many important fields like natural sciences, geometry, engineering and architecture. In spite of that, a large part of the population display considerable difficulties while dealing with spatial tasks and problems. This feature is also very common in structural geology learning, where students of high-schools and university as well, have difficulties in solving problems which require spatial abilities.

In order to facilitate high-school students in learning concepts and acquiring spatial skills in structural geology, a computer-based learning unit is being developed.

The development process includes:

a) A pre-development research studying students' thinking processes and difficulties in solving problems in structural geology.

b) Development of the software according to the results of the pre-development research.

c) Evaluation.

The structure of the software:
Part A — Basic concepts and principles in structural geology:
Concepts such as dip, strike, thickness of layers, topographic and geologic maps, and principles such as superposition, original horizontality and lateral continuation of layers will be covered in this part..

Part B — Investigation of geologic structures:
This part will be focused on describing, characterizing, and understanding the development of brittle and ductile deformation structures.

Part C — Solving applicable problems:
In this part students will be able to aplicate the knowledge and skills they have acquired in parts A and B for solving problems in structural geology. An example is deciding where to place an oil drill based upon information about the geologic structure of a certain area.

Underground Shale Oil Recovery from Israel's Oil Shale Deposits

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Oil shale deposits occur throughout the world and may, in fact, represent the most abundant form of hydrocarbon on earth. As coal oil shale can be burned directly as a fuel, this practice is in the principal use both in some countries and in Israel. But it is more rational to reprocess oil shale to get synthetic fuel and raw material for petrochemical. Now in the world there are 19 commercial and 11 research & development oil shale reprocessing projects.

Presently, the main method of oil shale reprocessing is it's retorting in above ground plants.In this techniques approximately 80% of the mine material must be disposed as the inert inorganic portion of oil shale. Disposal presents serious enviromental problems adding considerably to the cost of oil produced. Besides, more than one half of all shale oil reserves are contained in low grade oil shale, like Israel's deposits. Only through "in-situ" (underground) processing can oil from these deposits be economically recovered (see Table).

Economic analysis of oil shale's retorting process

ITEM	In-situ process			Above ground process	
	VBMF	HBMF	GBMF	Paraho	HYTORT
Capital Cost ($MM)	1279.0	1415.2	824.4	1748.8	2303.0
Operating Cost ($MM)	213.3	218.4	148.8	170.4	232.3
Total ($MM)	1492.3	1633.6	973.2	1919.2	2535.3
Oil Selling Price ($/bbl)	27.5	29.5	21.2	39.7	58.0

The overal reserves of oil shale in Israel are estimated to be over 10 billion tons but relatively low quality; yielding 56–64 liters per ton. The oil shale beds are thin (30–40m) and overburden is also relatively thin - about 20–50m. These conditions are most of all appropriate for the Geocinetics variant of underground oil shale reprocessing (GBMF). Horizontal burning moving front (GBMF) technique design specially for the oil shale beds having a total depth, including the overburden, less than 100m. The main problem that occur in the realization of GBMF technology - achievment of the desired degree of oil shale fragmentation in burning zone - is solved by means of proposed our technical method.

Fluid Inclusions in the Metamorphic Rocks of the Elat Area

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Data on fluid inclusions in matrix quartz of low- and high-grade metasediments, granite gneisses and calc-alkaline Elat Granite, quartz segregations and pegmatite veins obtained by the method of microthermometry led to the following principal conclusions:

a) The nearly pure CO_2 inclusions are connected with the first wave of fluid flow during the main metamorphic event (first deformation phase F1), and their appearance corresponds to the enrichment of fluid at equilibrium with the magmatic chamber in non-polar gases. H_2O-CO_2 inclusions over- and undersaturated in salt represent a second wave of fluid flow during the main metamorphic event (F2), which contemporaneous with the intrusion of granite. Infiltration of H_2O-CO_2-salt fluids into the system reflects the enrichment of fluid in salt (salt oversaturated H_2O-CO_2-inclusions) and then in water (salt undersaturated H_2O-CO_2-inclusions) during the processes of progressive crystallization of the granite body. Fluid had a nearly water-rich composition on the last stages of metamorphic and igneous evolution. So, the following classical trend of fluid flow composition changing connected with the process of the degassing of crystallizing magmatic body is observed: CO_2-rich—>H_2O-CO_2-oversaturated—>H_2O-CO_2-undersaturated—>H_2O-rich;

b) The following pressures of metamorphism in different metamorphic zones were obtained: 3.2–2.0 kbars at T=550–600 °C in the biotite zone, 4.6–2.2 kbars at T=600–650 °C in the garnet zone, 4.2–2.0 kbars at T=600–650 °C in the staurolite-cordierite-Al_2SiO_5 zone;

c) The partitioning of fluid components in fluid flow in accordance with metamorphic grade, was supported by the study: CO_2 and H_2O-CO_2-salt composition of fluid in the biotite and biotite-garnet, and staurolite-cordierite-Al_2SiO_5 schists and brine fluid in the biotite and biotite-muscovite schists.

Current Stress Field In Israel: Observations and Modeling

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We present known in-situ stress data in Israel and an analytical model that relates the observed stresses to slip along the Dead Sea transform. Observations were evaluated according to the World Stress Map Project. The 69 stress observations (Table) include 42 focal solutions (FM), 10 breakouts (BB), 14 geologic indicators (GI), 2 hydrofractures (HF), and 1 overcoring (OC). 16 focal mechanisms located on the main faults of the Dead Sea transform were excluded from the analysis. The quality ranking of the data indicates 5 points of A level (highest), 12 of B, 20 of C, and 16 of D.

The dominant stress state is transitional from strike-slip regime to normal faulting regime. The orientations of maximum horizontal stress σ_{Hmax} vary regionally (Fig. 1); five domains, each with relatively consistent stress orientations, were delineated (Table). In the western Negev the rare occurrence of distinct breakout zones, the inconsistent orientations of some of these zones and the low level of regional seismicity indicate low horizontal shear stresses. The low stresses apparently explain the wide scatter of observed data. The observed stress field was modeled with dislocation calculations. Eight fault segments were delineated along the Dead Sea transform; these segments are regarded as vertical left-lateral dislocations within a linear elastic half-space. The seismogenic zone is assumed locked and uniform slip of 1 m was applied on these segments from 10 km depth (≈base of seismogenic zone) to 100 km (≈base of lithosphere). The angle between the observed trend of σ_{Hmax} at a site and the calculated trend for this site is defined as misfit angle. Four domains: Arava, Western Negev, Carmel and North, indicate small misfit angles (Table). The Jericho domain is an exception in both large misfit angle and thrusting stress state. These discrepancies can be resolved, in part, by incorporating in the model the coseismic slip of 0.5 m of the M = 6.2 Jericho earthquake, 1927. We conclude that deep, uniform left-lateral slip along the Dead Sea transform explains most of observed orientations of in-situ stresses in Israel.

Domain	Types of stress data	Observed trend of σ_{Hmax}, mean ± SD	Misfit angle, mean ± SDz
Arava	GI, FM, OC	133° ± 36°	8° ± 31°
Western Negev	BB, GIN	14° ± 42°	-1° ± 42°
Jericho	FM	99° ± 15°	-37° ± 14°
Carmel	FM, GI0	101° ± 10°	-17° ± 19°
North	GI, FM, HF	159° ± 18°	12° ± 20°

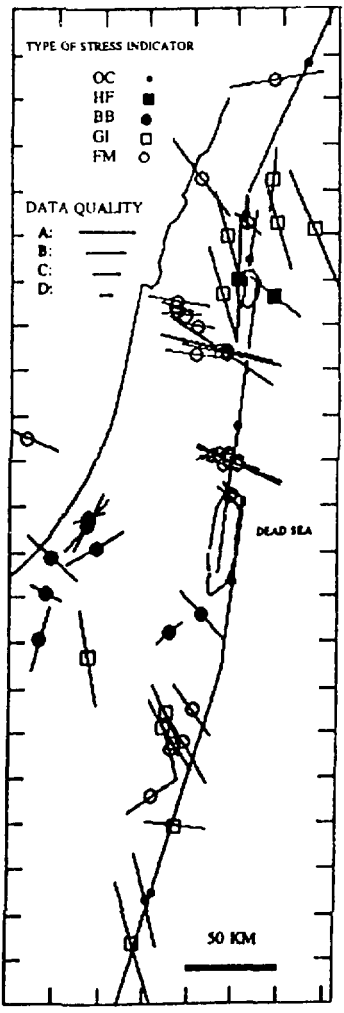

Fig. 1. Observed trends of σ_{Hmax}

Identification of Saline Waters in the Coastal Aquifer of Israel: The Formation of a Salt Plume in the Be'er Tuvia Region

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Several saline water bodies with distinguished chemical composition have been identified in the Coastal Aquifer of Israel. Salinization of ground waters occurs both along the edges and within the aquifer. A typical salt plume within the aquifer of an area of 12 km^2 and a chlorinity of up to 800 mg/l is located in the Be'er Tuvia region. Intensive pumpage since the 50's formed a hydrological depression in the area of Be'er Tuvia. The decrease of water levels from 12 m. to 5 m. (autumn levels) was accompanied, since 1956, by salinization of the ground waters. Since the early 70's however, pumpage volume has decreased. Consequently, water levels have risen, in some wells up to the original levels. Due to the recovery of water heads, the hydrological depression became gradually shallower, and diminished completely by the late 80's. Nevertheless, the salinity has been continuously increased and salt plume has expanded at a rate of 50 m/year. In addition, due to rising of the water levels, levels of contaminated wells were equalized with that of neighboring wells, which consequently contaminated the latter. It seems that the salinization processes in this area is irreversible, at least in the time frame of 1970–1992. It is predicted that towards the years of 2000 the chlorinity of groundwater in this area will reach to a level of 1000 mg/l.

The formation of a salt plume in the Be'er Tuvia region is a result of both reducing water levels and upwelling of deep saline waters. The chemical composition of groundwater suggests contribution of two saline water bodies with a Ca-chloride signature and a marine Br/Cl ratio: (1) brackish water with a chlorinity range of 300 to 500 mg/l, characterized by low Na/Cl (>0.6), SO_4/Cl, and B/Cl ratios, we estimate the chlorinities of the two saline end-members: Type A — 570 to 2700 mg/l, and Type B — 800 to3350 mg/l. The chemical composition of the first group resembles the chemical signature of the Ca-Chloride saline waters which have been identified in sub-aquifers A and B along the western margin of the Coastal Aquifer, in the interface zone. The chemical composition of the second group is similar to thatt of brines that have been identified in the deep dub-aquifer D in teh A'zza strip. The actual location of such saline water bodies in the investigated area is not known. It is suggested that they can be found in restricted zones at the botttom of the aquifer, or in shallow lumachelle layers at the upper Yaffo Formation of the underlying Saqiye Group.

The Faults of Western Part of Sinai Massif

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Three directions of faults can be traced at the western part of Sinai Massif to the northwest , west and southwest of Katherina pluton.

1. Faults trending N40–45W which are part of the fault system tracing from the southern most Sinai Peninsula the northwestward along the border of the el-Qa'a Plain. These faults are seen near the southern contact of Umm Shomer pluton. The faults can be traced for some kilometers and distance between them is about 2 km. They are right-lateral shears along which rhyolitic dikes trending N50W are displaced by up to 200–250m and can also be indentified through the Quaternary sediments.

2. Faults trending N to NNE belonging to the fault system which is excellently pronounced on the western shore of the Gulf of Elat. Some small submeridional faults are seen between the Katherina pluton and the Abu Tabil pluton. They are left-lateral shears with horizontal displacement up to 20–30 m. Nevertheless, there are two large submeridional faults, which,on the contrary to the faults of the Gulf of Elat system, are right-lateral shears. The first is traced at 15 km westward of the western boundary the Katherina pluton with about 1 km dextral movement established by displacement of acid dikes trending N70E. The second large right-lateral shear fault is situated 12 km westwards and displacement attains 1.7 km. It may be suggested that the right-lateral shears extend far to the NNE and disturb the sedimentary cover in central and, possibly, northern parts of Sinai Peninsula. One of the evidence is the S-shaped form of the southern border of the sedimentary cover of Sinai.

3. A left-lateral shear system trending EW along the southern contact of the Katherina ring-structure. The shears form a zone of about 7 km width, which consists of 8–10 subparallel faults. The distance between neighboring faults is 0.3–0.6 km. Left-lateral displacements along individual faults are about 50–100 m established by displacement of vertical meridional mafic dikes and acid dikes NE trending. The possible cumulative left-lateral displacement along this zone is more than 1 km. It is important to note that the left-lateral shear zone on the southern border of the Katherina ring-structure is parallel to the Central Sinai-Negev shear zone which, on the contrary, is characterized by right-lateral displacement.

The Geothermal Gradient of the Nubian Sandstone Aquifer in the Arava Rift Valley, Central Negev Heights and Sinai

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In the framework of the present study, the geothermal gradient of the Nubian sandstone aquifer was calculated within the area of the Arava Rift Valley, central Negev Heights and Sinai. Comparison has been carried out with former published data from Egypt. All the considered thermal gradients were evaluated between surface and the total depth of each well, during long- term pumpage or artesian flow.

The Nubian sandstone aquifer is the only hydrostratigraphic unit that keeps a continuous hydrological extension from the fringe of the crystalline basement of Sinai and northward, while most of the subsurface flow is under confined regime. The average gradient for the whole area reaches 17.6 mK/m ± 2.3, without significant variation between well fields within the Arava Rift Valley and west of it up to Sede Boqer - Mashabei Sade in the central Negev. The linear equation for temperature (T) and total depth (TD) dependence is

$$T(°C) = TD\ (meters) \times 0.0176 + 25 \qquad (r = 0.93;\ n = 23)$$

This gradient value is close to that found in Egypt at Kharga - Bahariya Oases (16.5 mK/m ± 3.6) and is obviously higher than that of Dakhla (10.3 mK/m ± 2.4).

The regional geothermal gradient of the Nubian sandstone aquifer, as was deduced from our survey, verifies the model of low gradient and low heat flux within the eastern Mediterranean basin and the Israeli-Egyptian terrain bordering it. All the major positive gradient anomalies are located along structural trends as the western fault escarpment of the Dead Sea (31.3 mK/m) and the Suez Gulf (26.7 mK/m ± 5). Similar phenomena is inferred also from the few wells located along the synclinal structure of Pharan-En Yahav (as Pharan 20 and Zofar 20).

The 1992 Landers Earthquake Sequence: Detection of Crustal Deformation Using Continuous Geodetic Measurements

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The April 1992 Joshua Tree (Ms 6.1) Earthquake, and the June 1992 Landers (Ms 7.5) and Big Bear (Ms 6.5) Earthquakes are the most substantial earthquake sequence to occur in the last 40 years in California. Fortunately, in the spring of 1990, a network of 5 continuously operating Global Positioning System (GPS) receivers was established in Southern California and detected surface displacement induced by the Landers Earthquake. This network, which monitors spatial and temporal details of crustal deformation, provides for the first time very precise observation of far field displacements. Ten weeks of daily observations centered on the day of the earthquake indicate significant coseismic motion at all sites. Postseismic motion was observed at the two sites closest to the fault which decayed within 15–25 days. However, there is no indication of preseimic deformation (precursors).

The observed total displacement of the 5 sites can be explained by an homogeneous elastic half-space dislocation model. The model assumes a pure strike-slip Landers fault that contains 6 vertical planar segments oriented to coincide with the epicenter and the curvilinear pattern observed in the surface break and aftershock distribution and one vertical planar segment of the Big Bear fault. Good agreement between the model and the observed displacements suggests significantly less slip in the northern half of the Landers rupture and a geodetic moment of 0.8 x 1020 N–m, which is 10–20% lower than the seismic moment. These data show that a continuously operating GPS array can provide reliable, precise and rapid determination of crustal motion, in particular seismically induced deformation.

The Gerar Reservoir — Potential Site for Wastewater Injection

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The Gerar reservoir is one of seven different reservoirs that were selected as potentially suitable for wastewater injection in Israel.

This reservoir is composed of the Jurassic Ardon-Zohar Formations. The sequence of the potential host rocks attains a total thickness of at least 985 m in the Gerar borehole (which partially penetrated the reservoir) of which 869 m are permeable carbonate and sandstone rocks.

The reservoir is unconformably underlain by the confining units of the Mohilla and Mish'hor anhydrite and shale, respectively. These formations were not penetrated in the Gerar reservoir area and their thickness in the adjacent Hazerim–1 and Pleshet–1 boreholes is 126 m and 83 m, respectively.

The reservoir units are overlain by the Kidod Formation, having a thickness of 108 m at the Gerar borehole, of which 79 m is shale. New interpretation of existing seismic data prepared specifically for this area included lines that were not considered in previous mapping. The results suggest a structurally undisturbed area of about 120 km^2 available for the reservoir. When multiplied by the thickness of the reservoir units (~1 km) a total roch volume of ~120 km^3 is attained.

The top of the Gerar reservoir is highest at the east where it reaches –1200 m. The altitude of the top slopes to the west where it reaches a depth of –2500 m.

Groundwater salinity in the Gerar was 33,000 mg/L Cl in the Gerar borehole (Zohar Formation). It varied from a minimum of 19,465 mg/L Cl at the Sharsheret–1 borehole. Zohar Formation to a maximum of 31,950 mg/L Cl in the Sharsheret–2 borehole (Zohar Formation).

The Multifactor Technique of Automatic Lithological and Stratigraphical Identification (LSI) of the Seismic Horizons with the Use of References

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The technique is designed to study of alteration of lithological properties of geological sections and for stratigraphic mapping of the complex structure.

The technique is based on concepts: a) alteration of lithological properties leads to variations of the amplitudes and frequency composition of reflection (refraction) waves; b) groups reflections refers to the one and the same stratigraphic horizon, if their amplitudes and frequency composition are changed slightly. Lithological properties are determinated with both interval velocity and density of the thin layers, the last ones predetermine both amplitude and frequency composition of reflected waves. As to the stratigraphical identification itself, it depends additionally from the location of thin layers in the geological section.

The technique consists in the study of variations of the amplitudes and frequency composition reflection (refraction) waves relatively to the reference, which is founded on the seismic cross-section in the vicinity of the well with the known seismogeological conditions or on the mapped horizon. Multifactor comparative analysis in time or frequency domain are used.

The technique, possesses high resolution, high signal/noise relation, and high efficiency of the seismic survey in the solving different geological problems. In stratigraphy these problems include classification, automatic correlation and identification of the seismic horizons for complex structure and tectonics dislocations. In lithology the problems are - lithological identification, facies analysis, contouring water suturated and water inpenetrable objects from reflection and refraction waves. In evolution and prediction of the oil and gas potential the problems involve the forecast and the contouring of oil and gas traps from reflection waves and determination of optimum drilling locations.

The technique is used for seismic cross-section with the data obtained by other geophysical methods and with the sonic log, modeling of synthetic seismograms (SS).

Following examples was obtained for this technique:

1. Lithological Identification.
2. Stratigraphic Identification.

The processing of the customers data may be formed.

The Clay Interlayers in the Coastal Plain Aquifer: Their Impact on Groundwater in Selected Cross Sections

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The Coastal Plain aquifer is composed primarily of calcareous sandstone divided by marine and continental clay and silt interlayers. The number and lithology of these interlayers are spatially variable. In this study, the hydraulic connections between the sand subunits were explored. We focused our investigation on two selected cross sections which parallel the general direction of groundwater flow, i.e. from east-southeast to west-northwest. The selection of these cross sections involved hydrological, geological and hydrochemical considerations. In each cross section we monitored and sampled wells penetrating different sand subunits. We assumed that if the clay interlayers form an effective hydraulic partition between the various sand subunits, the latter's groundwater will have different chemical and isotopic compositions. In addition, a different response to recharge and discharge of the groundwater in each subunit is expected. Some questionable well logs were redefined to better understand the nature of the dividing interlayers. Water level fluctuations in the wells were monitored for 18 months, and the degree of water confinement in the deep sand subunits was checked using pressure transducers. Groundwater was sampled from each well for chemical and isotopic analyses (carbon-14, tritium, oxygen-18, deuterium and nitrogen-15). In addition to the newly collected and generated data, existing hydrological and hydrochemical data collected by the Israeli Hydrological Service were also processed and interpreted.

GSIPAL: A Computerized System for Paleontological Data Retrieval

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Routine paleontological examinations are carried out in the Geological Survey, either as a service for other GSI research projects or for external companies. To date, more than 50,000 of these analyses have been made. The purpose of most examinations is to define the paleontological assemblage and to determine the biozone, age and depositional environment of the sample. The results for each sample are manually recorded on a special form which includes details such as: geographic and lithostratigraphic position, nature of sample (core, cutting, outcrop), biozone, age, fossil content, and depositional environment. This recording process is time-consuming, and does not enable a simple and rapid search and retrieval of the biostratigraphic information.

GSIPAL, developed at the GSI, has been designed to solve these problems. It operates with a PC and can be used for the following operations:

* Automatic recording of details pertaining to each sample.

* Rapid and reliable recording of paleontological results.

* Rapid and simple search and retrieval of paleontological data.

GSIPAL is user-friendly, and is operated by selection from on-screen menus. It consists of a number of dictionaries that contain lists of fossils, fornmations, ages, biozones, drill-cores, etc. The dictionaries are interlinked and permit logical searchs - e.g., a user request for the retrieval of all Maastrichtian samples which were examined for their nannofossil and foraminifera content in a given area defined by coordinates.

The planned completion date for the GSIPAL is late 1993, and will include both simple and complex default retrieval options.

The Sea of Marmara as the Key to Understanding the Pleistocene Interactions Between the Black Sea and the Mediterranean Sea

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Much is known about the Quaternary sedimentation and paleoceanography of the Black Sea, as well as the Mediterranean. The intervening area, the Sea of Marmara, is virtually unstudied. Information on the Sea of Marmara is an essential key to understanding the oceanographic response and the hydrologic interplay between the two seas.

Today the Black Sea is connected to the Sea of Marmara via the Bosporus, through which there is a stratified current system for water exchange. Low salinity (~17.5‰) water flows from the Black Sea southwards, while a denser (38.5‰) underlying current brings saline Mediterranean derived water from the Bosporus northwards. However, this pattern is very sensitive to the influence of glacial melt water and the effects of glacial lowering of sea level.

During the end of the Last Glacial Maximum - from 15.0–10.8 ka BP, the Black Sea level was 30 m lower than the present. The subsequent melting of glaciers diluted the Black Sea water to a salinity of only 3–5‰. As the Black Sea had a significantly higher stand than that of the Mediterranean, the only current that flowed was from the Black Sea southwards. The low density Black Sea water covered the Sea of Marmara, resulting in anoxic conditions - as evidenced by the Protosapropels found in the Sea of Marmara (dated to 13,5 ka BP, Stanley and Blanpied, 1980). The low density waters progressively advanced, penetrating into the Aegean Sea. The protosapropels formed at this time were dated to 12.0–9.0 ka BP.

The advance of this Black Sea water into the Mediterranean was halted during the Younger Dryas. The sea level of the Black Sea dropped to –50 to –60 m lower than today's. The Bosporus probably look like an exposed river valley. The S1 sapropels that later formed in the eastern Mediterranean could not have been influenced, as some propose, by a Black Sea intrusion.

There were atleast six other interconnections between the Mediterranean and Black Seas during the Pleistocene; however, the nature of the interactions is unknown. Information from the key Sea of Marmara is lacking. It is known that the Pleistocene sediments in the Bosporus are only 7.4 ± 1.7 ka BP. Was this due to erosion, tectonic uplift or lack of deposition? Middle Pleistocene outcrops are found near Gallipoli and Murefte, at the southern end of the Sea of Marmara. They contain fauna of a typical Black Sea origin. Where then was the connection if not via the Bosporus? Partial evidence may suggest a more westerly passage, while Brinkman [1971] argues rather for a more easterly route through the Izmit Bay. Research is needed on the Sea of Marmara to clarify the timing, direction, intensity and the climatic/tectonic controls that governed the Pleistocene connection between the Black Sea and the Mediterranean Sea.

Dynamic Processes at the Interface Zone Between a Surface Water Body and Groundwater — An Example from the Dead Sea

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The Dead Sea is a dynamic system in which the water level has decreased at an average rate of about 0.5 m/yr for the last 30 years. This rate enables the real time examination of processes occuring in the interface zone between saline and fresh groundwater in coastal aquifers.

The water level changes in the surface water reservoir were found to be followed by a relative quick response (order of magnitude of days) of groundwater potential in the adjoining clastic phreatic aquifer. For example, a fast response was detected in the rise of the Dead Sea water in the winter of 1992. The total rise in the lake was about 2 m whereas the groundwater potential in the Turiebe wells rose by about 0.5 m. Transmissivity values of about 30–60 m2/day were obtained using a regression model utilizing a 20 year water level record obtained in observation wells in the Turiebe area.

On the other hand, in the same studied system, mass transport (water itself) through porous media is, as expected, much slower (order of magnitude of hundreds of years). This phenomenon is expressed by the occurence of very saline groundwater without tritium (<2 T.U.) adjacent to the Dead Sea and the evaporation ponds (which have an average tritium content of 9 T.U.). The slow rate of mass transport is also indicated by the existance of water bodies of different chemical compostion and densities in the same area. These are relics of ancient water bodies that were in contact with the aquifer in the past. The Ghyben-Herzberg law does not allow the simple determination of the location of the present interface. Additional modifications are needed to describe the true situation where water bodies of different densities coexist. Similar systems were found in other coastal aquifers which are not connected to recent seawater.

The Evolution of the Neotethyan Basin Onshore and Offshore Israel During the Mesozoic, a Quantitative Basin Analysis

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The results of the current study highlight three major tectonic events which took place in the Levant peninsula during the Mezosoic era. The earliest massive tectonic activity of the Mezosoic started during Late Triassic time. Lithospheric stretching and breakup generated the opening of an oceanic rift zone in the Eastern Mediterranean, westward off the recent Israeli continental shelf. This tectonic event started some 220–230 m.y. ago, causing rapid tectonic subsidence in the Levant over the subsequent 20–30 m.y. It was followed by a slow thermal subsidence, which continued during most of the Jurassic time. The total subsidence of the rift zone and the nearby areas was due to stretching and thinning of the lower and upper parts of the lithosphere by factors of approximately 2.5–3.0 (delta) and approximately 1.5–2.0 (beta), respectively.

The next widespread regional uplift in the Levant took place during Late Jurassic times. This event was followed by a short rapid tectonic subsidence during Early Cretaceous time. These opposite vertical movements were caused by two different tectonic events which occurred at that time in the west. The massive uplift and the subsequent widespread erosional event was probably a regional expression of the reactivated Neotethyan rift during Late Jurassic-Early Cretaceous times. Its influence was marked by the regional uplift of its easternmost continental margin — the Levant. The origin of the rapid tectonic subsidence which followed the uplift was apparently the reactivated rifting which pushed the Turkish microplate or other Mediterranean terranes to the northwest.

A relatively young event in Late Cretaceous time, forming a widespread fold system throughout the Arabian plate, known as the Syrian Arc, terminated the Mezosoic tectonic cycle. This event, which resulted from the African plate rotating and pushing the Levant in the east, marked the beginning of a closure and convergence process of the ancient Neotethyan ocean.

The major tectonic events (stretching and thinning of the lithosphere) in the west, which caused an increased heat flow penetrating to the basin's floor, affected the maturation of potential source rocks for gas and oil. The major part of the current oil window includes Middle-Upper Jurassic rock sequences. In the offshore, younger sediments of the Lower Cretaceous Gevar'am Group are located within the oil window. The presence of these rocks is limited to a defined geographical zone located in the recent continental shelf and coastal plain near shoreline sediments. Triassic sediments are included in the oil window in the onshore.

Trace Fossils from the Triassic of the Negev

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Trace fossils are structures imprinted in the substrate by organisms behaving in one of several ways. Various trace fossils are recorded in marine and lagoonal Triassic deposits of the Negev. They belong to main ethological groups of trace fossils: Resting traces (Cubichnia, Ruhespuren), Feeding burrows (Fodinichnia, Fressbauten), Dwelling burrows (Domichnia, Wohnbauten), Crawling Trails (Repichnia, Kriechspuren).

The distribution of trace fossils can be used to understand the paleoenvironment. Simple (straight) traces are characteristic of shallow and turbulent paleoenvironment. Complex branchlike and curved traces are characteristic for still as well as for deep water.

In carbonates from the Ra'af Formation at Har Arif, among crinoids, there are Ophiomorpha Lundgren while Scolithos Haldeman are rare. Marine Glossifungites - Skolithos components along with non-marine Scoyenia are present in the Waterstones Formation (U.Scythian-Anisian) of north Cheshire England and in the Upper Buntsandstein Formation (=Rot) of south German Basin. Lingulichnus burrows, striat oblique burrows are present along with Lingula shells while bivalves Myophoria vulgaris are associated with trace fossils Thalassinoides. Both of them are found at the middle part of the Gevanim Formation of Har Gevanim. They are identical to associations of trace fossils as well as to fossils that are characteristic of the Lower Keuper Marl of north Cheshire and Lower Muschekalk of south Germany.

There are specimens of Rhizocorallium and Thalassinoides associated with Helminthoida in the thick Helminthoid limestones of the Saharonim Formation. Some components of the trace fossil assemblages from Helminthoid beds of the Saharonim Formation are identical to the trace fossils from Upper Muschekalk of the German basin in Thuringia.

This study of trace fossils should be regarded as tentative. Further study of trace fossils is required to understand the paleoenvironmental dynamics as well as the regional and interregional correlation of paleoenvironment in sedimentary basins.

Characteristics of Recorded Strong Motions in Israel

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Strong motion seismometers have been operational in Israel since 1978 and seven earthquakes, with magnitudes ranging from 3.7 to 5.2, have been recorded producing 14.accelerograms.

The values of the observed peak ground motions from this limited data set serve as constraints in choosing a regional ground motion attenuation relationship from the empirical relationships available in the literature.

Spectral analysis suggests that certain features are characteristic of the response spectra obtained from local strong ground motion for our region, for example motions are amplified mainly in the frequency range 2–10 Hz.

The response spectra of the recorded local earthquakes will be presented and compared to those of the Israel building code for seismic design.

The effects of local geology on ground motions in Israel are presently under investigation. An improved assessment of response spectra for anticipated strong earthquakes will be obtained when the site effects evaluated from local small earthquake ground motion spectra are taken into consideration.

Empirical Determination of the Dynamic Parameters of a Building

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The only real solution for the mitigation of earthquake catastrophes is the proper planning and construction of buildings throughout the country. This requires a detailed dynamic analysis of the behavior of structures under seismic loads. In order to perform this analysis, information regarding the dynamic characteristics of the analyzed structure is required. In this study we have implemented an empirical approach on an arbitrarily chosen a nine story, reinforced concrete structure. The experiment was conducted with the following objectives:

a) Experimental determination of the fundamental translational and torsional frequencies of a real construction/building.

b) Evaluation of the stability of natural frequencies as determined by various experiments using different sources of excitation.

c) Comparison of the natural frequencies determined experimentally with those obtained from empirical formulae.

d) Examination of the ability to determine the damping ratio of the structure and its mode shape.

The experiment comprised 74 recordings, 27 of which are of nearby, low yield explosions. From our results, we conclude the following:

1. The spectral analysis of the building's response to ambient excitation from wind and to excitation from nearby explosions provides the fundamental translational frequencies (in two perpendicular, horizontal directions), fundamental torsional frequencies and damping.
2. The high accuracy demonstrated during this experiment suggests that this procedure may be used to detect changes in the characteristics of structures.
3. It has been demonstrated that commonly used relationships for estimating natural frequencies of structure are significantly different from the real situation.

In the light of these conclusions we recommend that dynamic testing of real structures be conducted all over Israel.

An Empirical Study of the Flow Pattern in the Mountain Aquifer

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In the framework of the red line project, we study the flow direction and intensity at different locations of the mountain aquifer in order to investigate the physical processes involved in the water movement. The ultimate goal of this research is building an adequate conceptual model of the groundwater flow for this aquifer. Questions such as the influence of the fractures on the flow, validity of the Darcy's law and the Dupuit assumption in the karstic aquifer, sea intrusion in the northern part are investigated on the basis of the water table measurement existing at the hydrological service.

The whole aquifer is separated in ten different regions, and we first analyse the flow pattern in each region using a multi-regression analysis between the water table levels and the spatial coordinates and thus at two different periods of the year, for different years. These correlations permit to build a rough estimate of the flow gradient in each region at different periods of the year and for different typical years. The results of this study permit to select regions where Darcy's law may be valid, to evaluate the possible flow inside the fractures.

In the second part of this study, we analyse the influence of the history of the pumping on the evolution of the salination in the northern part of the aquifer and in the Taninim springs. The multi component analysis permit to characterize the process of salination in terms of a sea water intrusion problem.

A Mathematical Model for the Salination Mechanisms of the Deep Aquifers in Israel

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It is claimed that the main salination mechanism of major underground hydrological systems in Israel are due to the hydraulic gradient that exists between the Mediterranean Sea and the Rift Valley, which slowly but effectively causes a large scale groundwater flow from the west to the east into deeper aquifer system, including seawater inclusion. This theory is quantitatively tested by a mathematical-physical model of groundwater flow through multi-aquifer systems.

A conceptual model of groundwater flow is developed for a simple cross section which includes a basin below the sea level, separated by a mountain chain. The crosss-section contains a number of layers with different hydraulic conductivity values, where each of them is homogenous and anistropic. The computer code permits to model the rain infiltration at the top of the mountain and pumping at its bottom, in such a way that steady state conditions are reached in the whole system. The model computes the potential and the velocity fields in the cross section using a Finite Element code.

The main phenomenon found is the horizontal movement of the underground water divide with respect to depth. In other words, for small depth, the water divide is located below the replenishment area in the mountain; for average depth the water divide is shifted towards the deep basin. Moreover, at a larger depth, the flow is completely in the east direction. The velocity field is strongly dependent on the values of the hydraulic conductivity and their ratio. In addition, the flow field is affected by the pumping and replenishment rates.

The model is implemented on a full stratigraphic cross section between Ashdod and the Dead Sea in order to validate the present theory. (See Gvirtzman and Zeitoun, this conference).

Long Term Observations of Unsaturated Zone Solutions' Geochemical Regime Under Irrigation

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The observations were carried out in the Southern Ukraine by taking pore solutions' samples from constant points of the cross-section in 6 special boreholes with a diameter of about 1 m. The boreholes were ,drilled in the typical environmental conditions to depths of 0.5–1m above groundwater table. Borehole walls were suitably insulated by an impermeable material. Tensiometers and ceramic caps for a vacuum extraction of pore solutions were put into soils (sedimentary rocks) at different depths through holes in the walls. Sampling and measuring points were situated at distances of 0.4–0.5 m from borehole walls and from each other. Pore water samples were taken once a month during 3–5 years.

The unsaturated zone was built of soils and loess loams underlain by clays. It contained soluble salts, mostly sulphates, in quantities less than 0.5–1% of mass. Pore solutions' concentrations were 1–40 g/l. Groundwater table was situated at depths of 13–24 m. Irrigation of about 400 mm/year was performed by sprinklers. Precipitation was also about 400 mm/year.

Tensiometers' observations have shown that the preferential water flow existed to depths of 2–3 m only. Above these depths the water motion occured in different directions, deeper - downward only.

In the upper 0.5–1 m layer the inflowing water composition was totally changed. From HCO_3–Ca it changed to SO_4-Na-Mg or SO_4-Mg-Na. The total concentration increased by the factor of 10–100. Under this layer a leaching front was formed. Its lowering rate, calculated by Cl ions, was 0.5–0.7 m/year. Below this front the small transition zone with almost constant solutions' concentration was observed. Beneath, their concentration decreased down to groundwater level by the factor of 1.5–2. However their chemical composition remained constant.

In the upper 0.5–0.7 m layer the solutions' concentration might increase or decrease. Beneath, the concentration changed in one direction only - decreased at the leaching front zone and above, and slightly increased in the capillary fringe zone. When the total concentration decreased from 40 to 13 g/l, the quantity of NaCl and $MgSO_4$ decreased to 0.005–0.1 g/l. The solutions' composition changed from SO_4-Cl-Na-Mg and SO_4-Cl-Mg-Na to SO_4-Na-Mg. With further concentration decrease, solutions' composition almost did not change. At depths of 1–2 m only, when the total concentration decreased below 3–4 g/l, sometimes soda appearance was observed. It was a result of Ca-Na exchange between inflowing water and buried soils with alkalinization signs, which laid at the above depths. In the capillary fringe zone during 3–5 years of irrigation the total concentrations of pore solutions increased by about 1 g/l. Their chemical composition did not changed.

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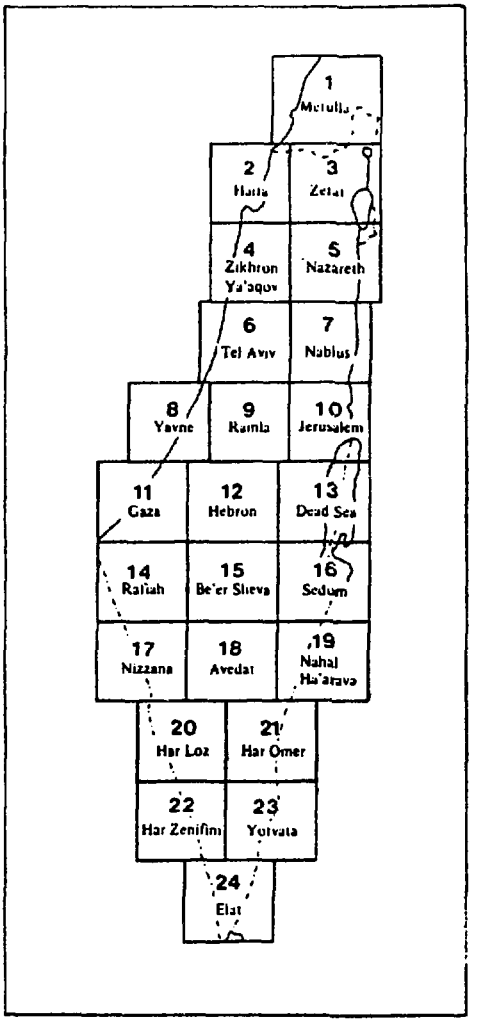

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DEAD SEA, 1:100,000 - coloured

GULF OF ELAT, 1:250,000 - coloured

NORTHEASTERN MEDITERRANEAN, Includes the coasts of southern Turkey, Syria, northern Lebanon and Cyprus, 1:625,000 - coloured

SOUTHEASTERN MEDITERRANEAN, Includes the coasts of southern Lebanon, Israel and Egypt, 1:625,000 - coloured

MEDITERRANEAN COAST OF ISRAEL, 1:250,000 - coloured

SEA OF GALILEE, 1:50,000 - coloured

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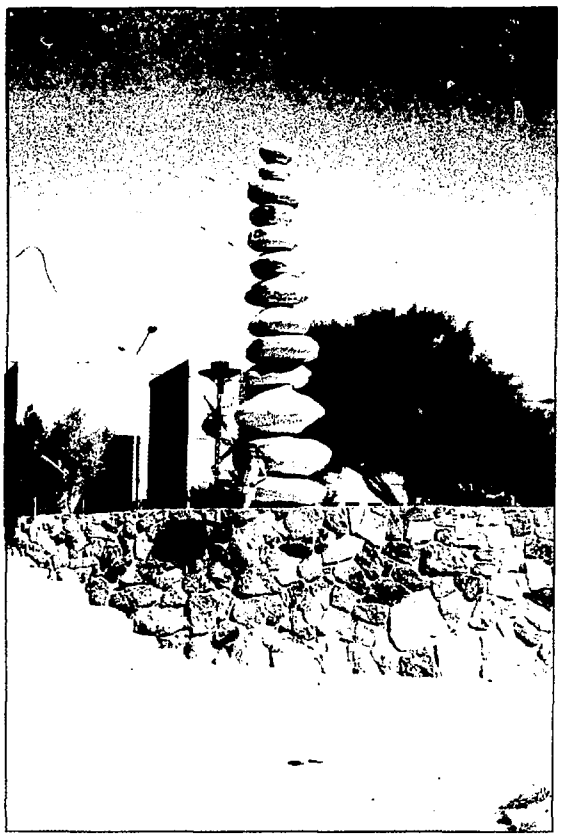

כב' –כה' אדר תשנ"ג

15 – 18 במארס 1993