Seismological observations of micro-earthquake clusters, Dead Sea Basin

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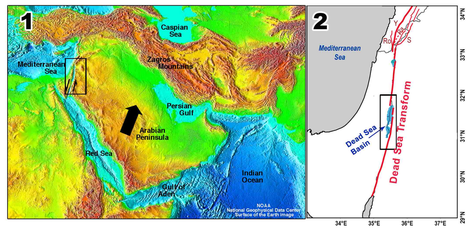
Our study explores the relationship between the microearthquakes and the internal structure of the seismically-active Dead Sea Basin. We examine the distribution of the seismic activity and the aspects of seismic clustering based on time, location, waveform, focal mechanisms, and a stress inversion.

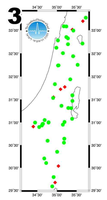
Geological Backround

The Dead Sea Basin (DSB) is a seismically active graben located within the Dead Sea Transform, which separates the Arabian and African plates ***(Fig 1,2)*** and controlled by a left lateral motion (~5mm/y).

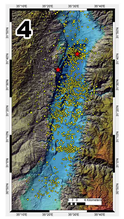


Seismological Data

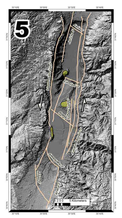
The seismic catalog used in this research been collected by the Israel Seismic Network (ISN, ***Fig 3***), operated by the Geophysical Institute of Israel (GII). The catalog includes ~1200 earthquakes from the years 1985 - 2010. At first sight the relation between micro-seismicity ***(Fig 4)*** and the mapped fault ***(Fig 5)*** in the DSB is not clear.



The Israel Seismic Network; 40 channels of short-period station (green) and 8 broad band station.



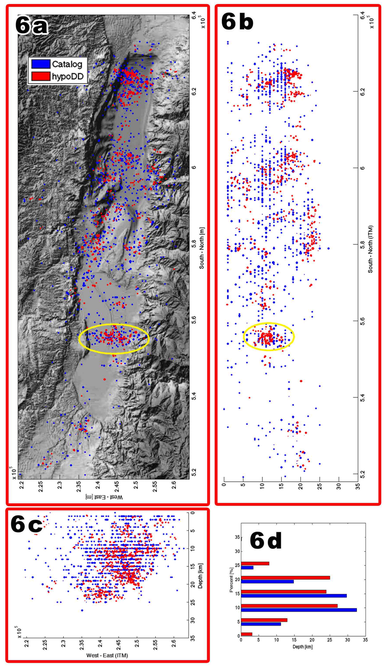
Earthquake Catalog, 1985-2010. Totla of ~1200 events; M>5 shown in red stars.



Mapped faults, (after Neev and Hall, 1979; ten Brink and Ben-Avraham, 1989; Ben Avrham et al.,1993)

Relocation

In order to improve the location of the events we use **hypoDD** (Waldhauser and Ellsworth, 2000).



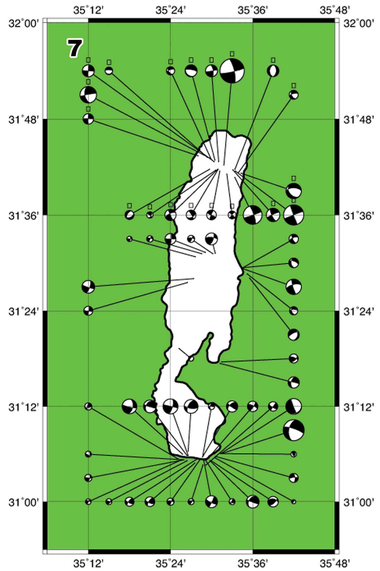
Relocation Results: Fig **6a** *Map view. Fig* **6b** *North-South-Depth view. Fig* **6c** *West-East-Depth view. Fig* **6d** *Distribution of earthquakes in depth.*

Results

- Micro-earthquakes are more common on the Western DSB ***(Fig 6a-6d)***.
- Seismogenic zone reaches 25 km depth.
- Clusterring is noted at the Southern DSB, marked in yellow circle. no mapped fault.

Focal Mechanisms

Focal mechanism was calculated for every event based on the relocated catalog (more then 10 phases). We use the **HASH** *algorithm (Jeanne Hardebeck and Peter Shearer, 2008; USGS)*



Focal Mechanism Solution.

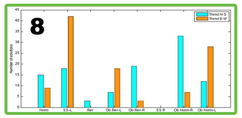


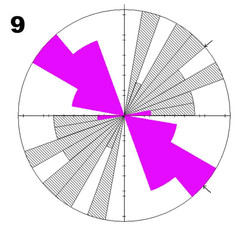
Fig **8** *Focal mechanism motion. Two types of double couple solution for any given fault. The solutions are devided to two groups: Trend North-South and Trend East-West.*

Results

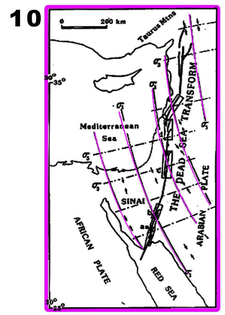
- *About 50% of the E-W trending planes show left strike slip motion while ~50% of the N-S trending planes show oblique right normal motion.*

Stress Inversion

Full stress inversion is calculated using the **SATSI** algorithm (Hardebeck and Michael, 2006). It is compared with geologically calculated stresses ***(Fig 10)***. In this process we divide the Dead Sea Basin into cells of 10 x 10km, and calculate the local stress field in every cell of the grids.



Rose Diagram of the principle stress. Sigma-1 is shown by the magenta roses and sigma-3 black stripes.



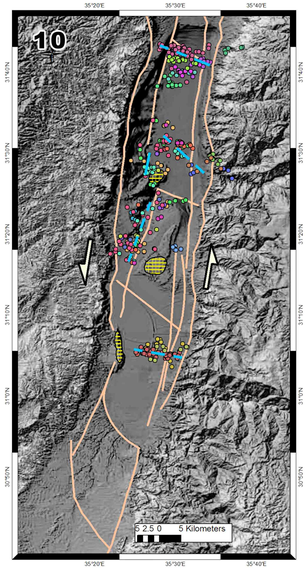
A general view of the Dead Sea. Lines mark sigma1 and sigma3 directions of maximum and minimum comprassion. Image is from Reches 1986

Results

- The stress inversion ***(Fig 9)*** shows a ~10° shift from the geological results ***(Fig 10)***.

Synthesis

We divide the relocate catalog to clusters based on time and the spatial distribution ***(Fig 10)***.



Mapped faults - geology and geophysical surveys (pink), and interpratation of micro-earthquake data (blue dashed lines). The dots represents the micro-earthquakes, and color represents the cluster.

Results

- Some of the mapped faults show micro-seismic activity.
- Some micro-seismic activity is observed where no fault was mapped. (***Fig 10).***
- Some faults are not seismicly active and thus they could be locked at the present.

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