P096 DETAILED MAGNETIC/PALEOMAGNETIC DATA ANALYSIS IN THE SEA OF GALILEE AND ADJOINING AREAS

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Summary

Sea of Galilee (Lake Kinneret) is one of the main sources of fresh water in Israel. The sea is located in the area of complicated tectonic setting at the northern continuation of the Dead Sea Rift. Practical absence of wells in the Sea of Galilee basin sufficiently complicates geophysical data interpretation. Magnetic map of the total magnetic field of the sea area shows a complex pattern of the magnetic field distribution caused by a combined influence of the basalt flows surrounding this lake and magnetic sources occurring this sea. Positive and negative magnetic anomalies were recognized in the Sea of Galilee basin corresponding to the basalts of normal and reverse magnetization, respectively. These anomalies in the sea were investigated using modern procedures developed specially for complicated geological conditions. Applying these procedures quantitative parameters of the targets were determined and their classification was performed. A 3-D modeling of the magnetic field has been successfully carried out for refining the data obtained at the previous stage and to computing effects due to proposed geological boundaries and bodies. Developed paleomagnetic map of basalt associations framing Sea of Galilee basin was correlated with the paleomagnetic zones revealed in the sea. The recognized paleomagnetic zones in the sea basin basically are in accordance with the western and northern framing of the sea and have some disagreement with the eastern and southern framing. Analysis of radiometric and paleomagnetic data allowed us to conclude that in western part of the sea are developed Early Pliocene basaltic associations.

Introduction

Sea of Galilee (Lake Kinneret) is located in the northern part of the Jordan Rift Valley at the northern continuation of the Dead Sea transform. This lake is a main source of a freshwater in Israel with an averaged volume of 4.1×10^9 m^3. Geometric parameters of the sea are following: length – 20 km, maximum width – 12 km and maximum depth – 42 m. The structure of the Sea of Galilee basin appears to be more complex than that of other pull-apart basins along the Dead Sea transform (e.g. Dead Sea basin). The complexity of the area results from the fact that several fault systems occur in this area, the main ones being the N-S transform system, and the E-W and NW-SE fault systems which break up the Galilee (Ben-Avraham et al., 1996). The sea and the plain south of it are located in a depression bounded on the east and west by fault scarps with steep gradients.

Geological studies indicate that the rocks outcrops in this area and rock samples discovered in wells range from Jurassic to Quaternary. The present study was aimed to investigate in detail the sources of magnetic anomalies in Sea of Galilee basin and their possible correlation with surrounding basalts.

Main Results

Performed analysis of geological, geophysical and paleomagnetic data allowed to suggesting that the most probable source of the magnetic anomalies in Sea of Galilee are the Pleistocene and Pliocene basalts (Eppelbaum and Ben-Avraham, 2002). Age of these basalts, according to numerous published data, ranges in the interval from 5.3 to 0.25 Ma.

The interpretation stage involved the application of methods developed specially for quantitative interpretation of magnetic anomalies under complex environments (Khesin et al., 1996). The methods were tested on the Zemah magnetic anomaly with known geological section (Zemah 1 well was drilled at the point some 2 km south of the Sea of Galilee). The results of quantitative interpretation (determined upper edge of magnetic body was 515 m) have a close agreement with the drilling data (489 m) (Fig.1).

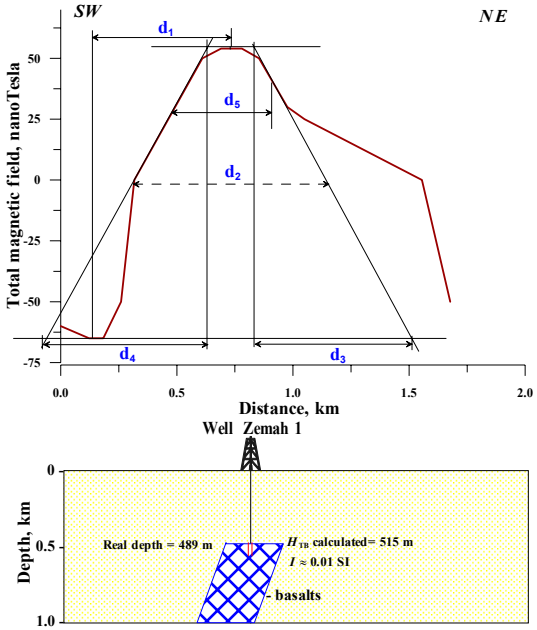

Figure 1. Quantitative interpretation of Zemah magnetic anomaly

The recognized magnetic anomalies in the sea (both positive and negative) were interpreted using these methods (two interpretation models were applied – thin bed (*TB*) and horizontal circular cylinder (*HCC*)). Generalized results of the interpretation are presented in Figure 2. Comprehensive analysis of anomaly **A** permits to determine that this anomaly is produced by integrated effect of a few different magnetic sources occurring at different depth. However, the largest contribution to anomaly **A** is due to magnetoactive body having isometrical form (approximated by *HCC*). A calculated depth to the center of *HCC* is 1300 m, and according to our estimation, an upper edge of this body is at the depth of 1000-1050 m. Anomaly **B** (here a model of *TB* was used) has been interpreted twice: W-E direction and S-N direction with the similar results (the depth for the upper edge of the disturbing body is 450 m for latitudinal profile and 440 m for meridional profile, e.g. interpretation error was 2%). For reverse anomaly C (*HCC* model) obtained depth of the *HCC* center is 700 m. The upper edge of this body, by our calculations, is at the depth of 550 m. Two reverse magnetic anomalies – D and E – have been interpreted using *TB* model. Depth of the upper edges of these disturbing bodies is 325 and 460 m, respectively. Other anomalies (**F** - **J**) have been analyzed by the same manner. The determined depth of the magnetic sources (upper edge) range in the interval from 1000 m (anomaly **A**) to 300 m (anomaly **J**). Obtained values of target magnetization range in the interval from 0.016 to 0.06 **SI** unit that is in accordance with the available measurements of basaltic samples in the Sea of Galilee vicinity. Performed 3-D modeling of magnetic anomalies confirmed in general the obtained results. Absence of magnetic anomalies in the central part of the Sea of Galilee was explained as submersion of basalts in this area to the depth of 1.1-1.3 km.

Magnetic field in the southern part of the sea significantly differs from the magnetic field characteristics observed in other parts of the sea. Analysis of the magnetic field distribution with following 3-D modeling of magnetic field allowed to suggesting that this effect is caused

by magnetized basaltic plate dipping from NE to SW at 25-30°. This value is in a good agreement with the value obtained by hypsometrical way using analysis of basalt occurrence at the framing zones.

The developed magnetic/paleomagnetic map on the geological basis (Fig. 3) includes only the most essential sections, zones and sub-zones of paleomagnetic scale. Identification of selected paleomagnetic zones was realized by the way of correlation between the paleomagnetic and radiometric data in each tectonic block. The revealed paleomagnetic associations cover their practically continuous sequence from the Late Pleistocene to the uppermost of Late Miocene: 1n, 2n, 2r, 2An, 2Ar, 3n, 3r, 3An & 3Ar (Fig. 3). Zones of direct and inverse polarity recognized using magnetic field analysis in the Sea of Galilee (Fig. 2) in the most of cases transfer to respective zones framing the sea. At the same time we must note that eastern and southern parts of the sea are not in direct accordance with paleomagnetic characteristics of Cover Basalts of the rim area.

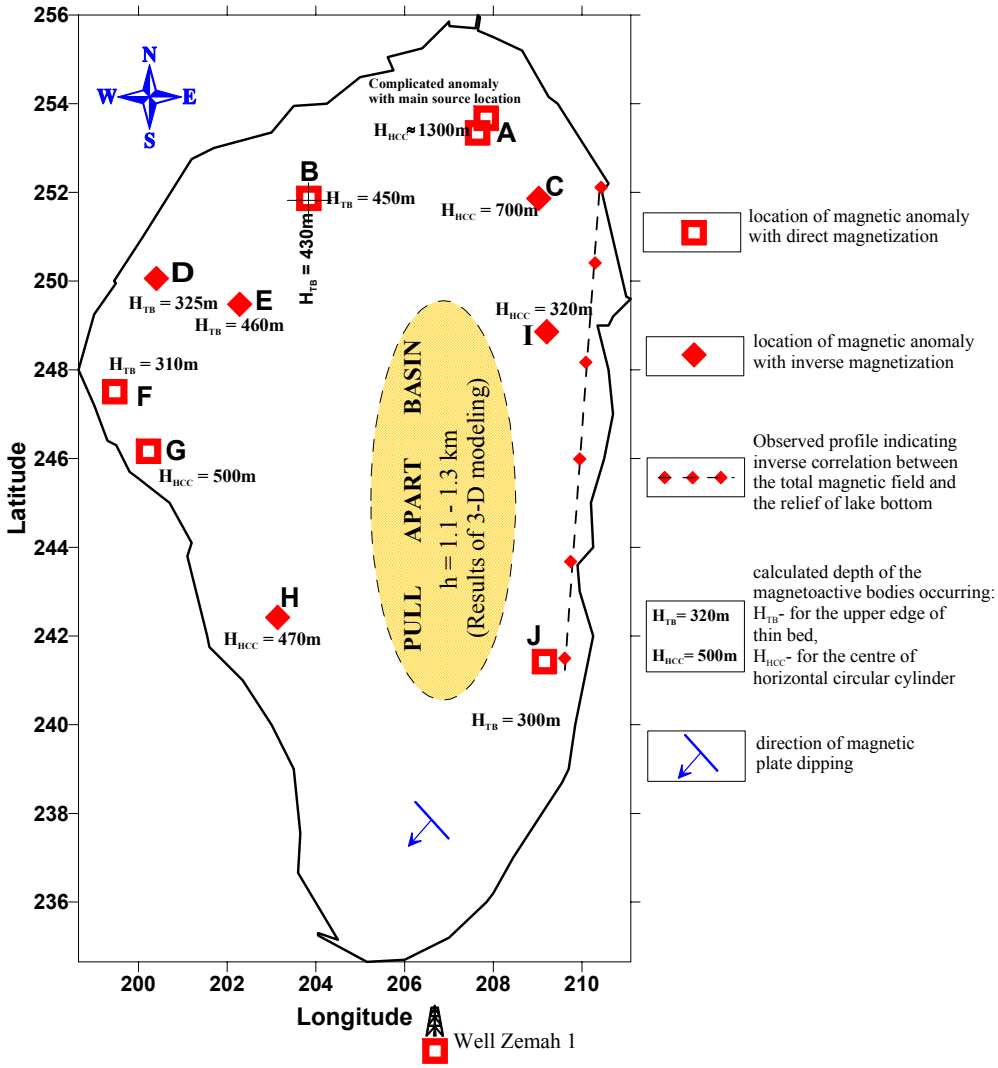

Figure 2. Results of magnetic anomaly interpretation in the Sea of Galilee basin

Conclusion

Detailed analysis of magnetic anomalies in the Sea of Galilee area allowed to developing a quantitative scheme of basaltic sources' distribution in the sea. The recognized magnetic anomalies have been classified by their type, characteristics and depth of occurrence. Paleomagnetically the recognized anomalous zones in the sea are in accordance with the respective zones in western and northern framing of the sea. At the same time the recognized

anomalies have some discrepancy with the eastern and southern framing. The performed integrated analysis of magnetic and paleomagnetic data allowed to identify that interpreted magnetic anomalies (A - J) in the sea correspond to zones of 3r and 3n of the standard paleomagnetic sequence.

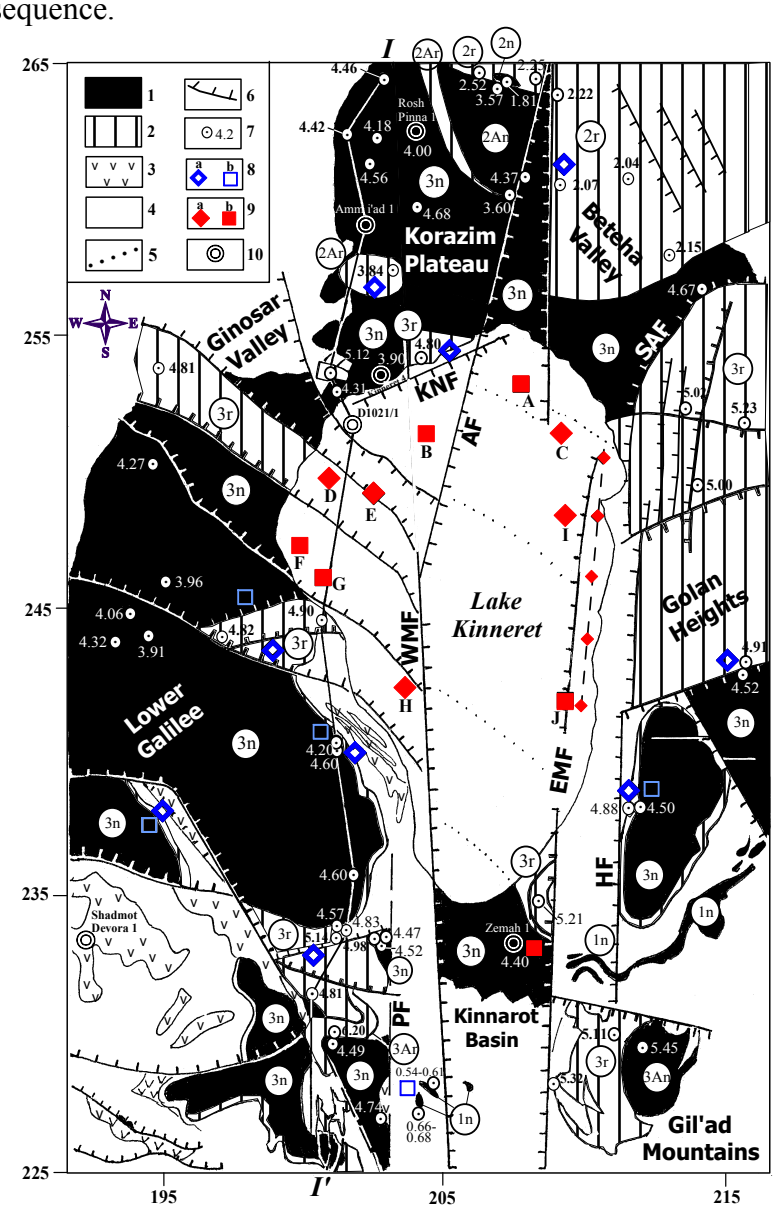

Figure 3. Scheme of paleomagnetic, magnetic and radiometrical characteristics of basalt formations in the Sea of Galilee area

1 – directly magnetized basalts, 2 – reversly magnetized basalts, 3 – Neogene basalts with complicated paleomagnetic characteristics, 4 – sediments, 5 – suggested boundaries of paleomagneic zones in the Sea of Galilee, 6 – faults, 7 – radiometric age of basalts, 8 – data of surface paleomagnetic measurements: a – reverse magnetization, b – direct magnetization, 9 – data of magnetic field analysis: a – reverse magnetization, b – direct magnetization, 10 – boreholes

References

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