# ESTIMATION OF BASEMENT DEPTHS IN THE NEOGENE MYGDONIAN BASIN, GREECE USING GROUND AND MARINE MAGNETIC DATA.

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## Abstract

A high resolution ground and marine magnetic survey was executed to image the subsurface structure and determine the thickness of the sedimentary cover in the Mygdonian Basin. The total magnetic field was observed at 804 magnetic stations with an interval distance of about 500 m and 250 m in ground and marine magnetic survey, respectively in order to cover an area of about (22 × 15) km$^2$. To achieve this goal, edge detection and depth estimation techniques were applied on the magnetic data. The depth to the basement inferred from magnetic data starts from near surface to 600 m. The 2D forward magnetic modeling with constrains of the existing boreholes along four selected profiles provides the presence of alternative horsts and grabens resulted from parallel normal faults. The dominating structural trends inferred from the edge detection techniques are N-S, NW-SE, NE-SW and E-W and they are in agreement with the geological setting. Finally, a detailed structural map was constructed based on the integration of all the gained results showing the magnetic blocks and the structural architecture of the Mygdonian Basin.

## Magnetic Survey

We used the Gem-system GSM-19T proton magnetometer (Fig.3b) to sample the total magnetic field along the profiles with an interval of 500 m. It has a 0.05 nT sensitivity. The sensor was in a height of 2.8 m. For measuring the diurnal variations, a Geonics G-856AX magnetometer (Fig.3a) with a large sensor head was used as base station at the EUROSEISTEST to sample the total magnetic field every 60 s. A marine magnetic survey (Fig.3c) was also conducted at the western part of Volvi Lake. The magnetic susceptibilities were measured for typical rock outcrops (336 readings) using a SM30 magnetic susceptibility meter (Fig.3d).

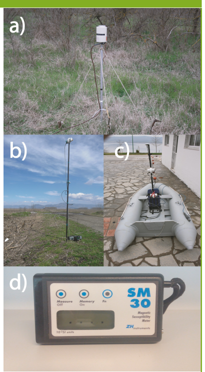
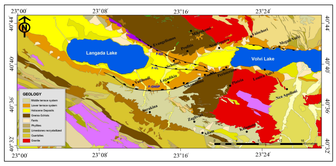



Fig (3): a) Geonics G856AX magnetometer. b) Gem-System GSM-19T proton magnetometer. c) GSM-19T proton magnetometer in marine survey. d) SM30 magnetic susceptibility meter.

## Geology and Tectonic Setting

The Mygdonian Basin is considered one of the most seismic active zones in northern Greece and the surrounding area. It is situated between two lakes; Volvi and Langada (Fig.1). A geological and structural map of the Mygdonian basin is shown in Fig. 2. The valley of Mygdonia is located at the border area of two geotectonic zones; the Circum-Rhodope-Belt (CRB) in the west and the Serbo-Macedonian Massif (SMM) in the east. . The sediments filling the basin can be classified into two main units. The lower unit, the pre-Mygdonian system was deposited during the Neogene. The upper unit, the Mygdonian system was deposited within the younger grabens during the Quaternary.

Fig (2)




## RTP Magnetic Map

The total magnetic field values of the stations were corrected for the diurnal variations to construct the total magnetic intensity (TMI) map . After that, the Definitive Geomagnetic Reference Field (DGRF) values were subtracted from the TMI values. Finally, the TMI values were gridded and reduced to the north magnetic pole using the Geosoft Oasis Montaj software (I= 57.57° , D= 3.77° ) (Fig. 4).

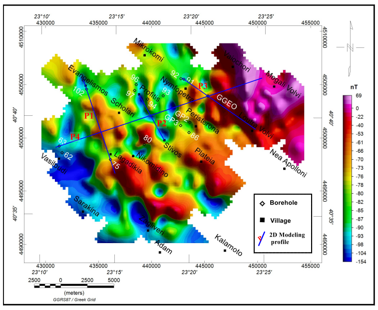



Fig (4) RTP magnetic map of the Mygdonian Basin.

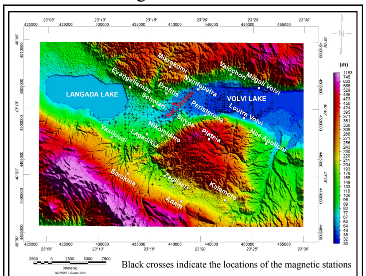



Fig (1) Topographic map of the study area.

## Magnetic Data Processing

**EDGE DETECTION TECHNIQUES:**

- Total Horizontal Derivative (THDR): $THDR = \sqrt{(\frac{\partial H}{\partial x})^2 + (\frac{\partial H}{\partial y})^2}$
- Analytic Signal (AS): $|A(x,y)| = \sqrt{(\frac{\partial H}{\partial x})^2 + (\frac{\partial H}{\partial y})^2 + (\frac{\partial H}{\partial z})^2}$
- Enhanced total horizontal gradient of tilt angle (ETHDR): $\mathrm{ETilt} = \tan^{-1}\left[k\frac{(\frac{\partial H}{\partial z})}{\sqrt{(\frac{\partial A}{\partial x})^2 + (\frac{\partial A}{\partial y})^2}}\right]$ $ETHDR = \sqrt{(\frac{\partial ETilt}{\partial x})^2 + (\frac{\partial ETilt}{\partial y})^2}$

Where $H$ is the observed magnetic field at (x, y), ($\delta H/\delta x$, $\delta H/\delta y$ and $\delta H/\delta z$) are the two horizontal and vertical derivatives of the observed field, respectively. K= (1/(Sqrt($\Delta x^2+\Delta y^2$)) the dimensional correction factor, $\Delta x$ and $\Delta y$ are the sampling intervals in the x and y direction. Fig (5).

**DEPTH ESTIMATION TECHNIQUES:**

- Spectral Analysis: Depth Z = - (Φ) / 4π (Fig. 6).

Φ: the dip angle of a straight line interpolating the diagram of the log-power versus the wavenumber.

- Tilt derivative (TDR): $\mathrm{TDR(H)} = \tan^{-1}(\frac{\partial H/\partial z}{\sqrt{(\partial H/\partial x)^2 + (\partial H/\partial y)^2}})$

The half-distance between –π/4 to π/4 radian contours is used to calculate the depths to the top of the contact of magnetic sources (Fig. 7).

- Source parameter imaging (SPI) technique:

$$Depth = \frac{1}{K_{max}} \qquad K = \sqrt{(\frac{\partial A}{\partial x})^2 + (\frac{\partial A}{\partial y})^2} \qquad A = \tan^{-1}\left[\frac{(\frac{\partial H}{\partial z})}{\sqrt{(\frac{\partial H}{\partial x})^2 + (\frac{\partial H}{\partial y})^2}}\right]$$

$K_{max}$ is the peak value of the local wavenumber $K$ over the step source, H: total magnetic field anomaly grid, and A: the tilt derivative (Fig. 7).

- 2D forward magnetic modeling. (Fig. 9).

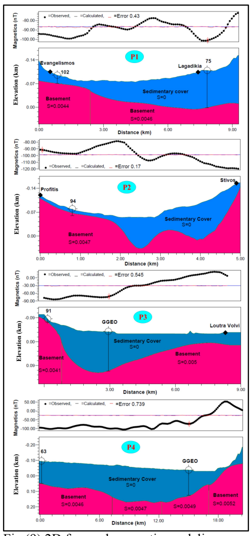



Fig (9) 2D forward magnetic modeling.

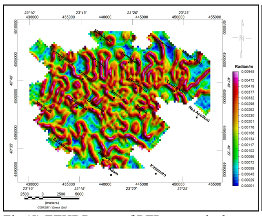


Fig (5) ETHDR map of RTP magnetic data.

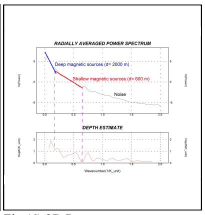



Fig (6) 2D Power spectrum curve

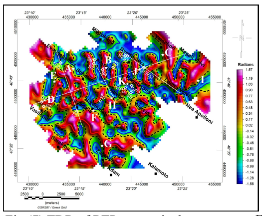


Fig (7) TDR of RTP magnetic data.

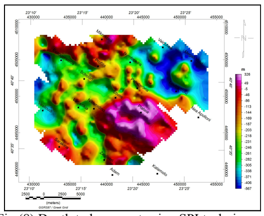


Fig (8) Depth to basement using SPI technique.

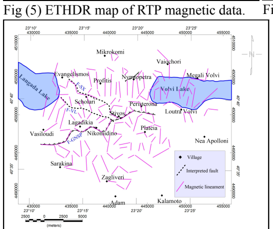


Fig (10) Interpreted magnetic faults/lineaments.

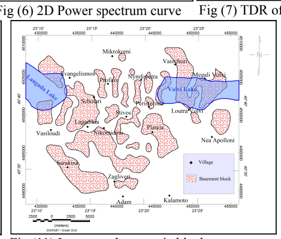


Fig (11) Interpreted magnetic blocks.

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## Results and Conclusions

-The depth to the basement constrained by the available boreholes ranges from 0 to 400m inside the basin. It reaches depth of 600 m in the area of the lakes.

-A detailed interpreted structural map (Fig.10) is constructed showing the structural architecture of the Basin.

-The dominating structural trends inferred from the lineament analysis of magnetic maps are N-S, NW-SE, NE-SW, and E-W.

-The magnetic sources were traced based on the results of the TDR technique where the magnetic blocks (Fig.11) were inferred.

-For future geothermal explorations, we suggest the area around the western part of Volvi Lake and also the horst type structure in the area between Profitis and Stivos.