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- **Name of professor / teacher** : prof. Antonio Rapolla
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Analysis of magnetic data in the Bay of Naples, Southern Italy

In this short essay I present and discuss the analysis and the interpretation of magnetic data acquired in the Bay of Naples. The data were acquired during two surveys, performed in 1998 and 2000 and organized by CNR-IAMC Institute of Research (Geomare Sud), in collaboration with the Parthenope University and the Earth Science Department of the University of Naples, Federico II. A magnetic anomaly map of the Bay of Naples based on the data acquired during these surveys has already been published by Siniscalchi et al., (2002). I reprocessed the same data to produce the maps of the pole reduced, analytic signal and horizontal derivative data (Secomandi, 2002).

The Bay of Naples is located in Southern Italy in a structural depression, the Campanian Plain, formed during Plio-Pleistocene as a result of the foundering of a carbonate platform related to the complex geodynamic events connected to the Tyrrhenian opening and to the anti-clockwise rotation of Italian Peninsula (Scandone et al., 1991). As a consequence, the Tyrrhenian margin was interested by a tensile tectonics and by an intense phase of volcanism, producing the volcanic districts of Somma-Vesuvius and Phlegrean Fields (http://www.ov.ingv.it/), which limit the Bay of Naples northeastern and northwestern respectively. In the Bay of Naples a morphologic structure formed by a continental shelf, a continental slope and a basin can be singled out (Milia, 1999; Aiello et al. 2001). The bay is dominated by two submarine canyons, the Magnaghi and the Dohrn canyons, both having a preferential northwest-southeast direction.

During these surveys about 1000 km of magnetic profiles were acquired in the Bay of Naples (fig. 1). The acquisition was made by a proton magnetometer, with an instrumental resolution of 0.5 nT and a sampling time of 3 seconds. Refer to Siniscalchi et al. (2002) for other data acquisition details.

The data were corrected for the offset, repositioning the magnetic data acquired by the magnetometer dragged behind the boat in correspondence of the position of the GPS on board. The magnetic field diurnal variation correction was performed using the magnetic data acquired by the Geomagnetic Observatory of L'Aquila (Italy) (http://www.ingrm.it/geomag/laquila.htm). Generally, if the base station is far from the surveyed area or if the investigated area is particularly wide, as in this case, the use of a base station data to monitor the diurnal variation and the consequent diurnal variation correction are not sufficient to cancel the effects of the time-varying magnetic field. Because of this, magnetic surveys are normally performed along intersecting orthogonal lines, in order to obtain a set of intersection points with a double value of the magnetic field. The values at the intersection points between the survey lines and the tie lines will generally not be equal, mainly because of the time-varying magnetic field, but also because of position errors (especially in areas of high horizontal gradients) and of random noise. The process of minimizing the differences at intersection points (miss-tie) between the two data set is called leveling (e.g. Mauring et al., 2002). The magnetic data acquired in the Bay of Naples were leveled by subtracting for each line a function approximating the miss-tie values.

After the leveling, the IGRF (International Geomagnetic Reference Field) was removed in order to subtract Earth's main magnetic field from the measurements values.

The obtained data were then processed to compute the reduction to the pole (Baranov, 1957), a frequently utilized and well-known linear transformation of the original field performed in the frequency domain, which simplify the shape of magnetic anomalies measured at intermediate latitudes, making them similar to the anomalies that would be measured above the same sources having vertical magnetization at the magnetic pole. However, even after the pole reduction, some magnetic anomalies in the Bay of Naples continue to show a significant dipolar shape (fig. 2).

For this reason the analytic signal (Nabighian, 1984) of the data was computed (fig. 3). The analytic signal is a complex function constituted by a combination of the horizontal and vertical gradients of anomaly field, whose amplitude is a bell-shaped function having its highs localized on the magnetic structure lateral boundaries. When the resolution of the field is not very high, the analytic signal displays a single high localized above the magnetic sources, allowing to readily identify the position of sources, similarly to the pole reduced anomalies. The main advantage of the analytic signal with respect to the pole reduction is that analytic signal is almost insensitive to the direction of the total magnetization vector.

In order to estimate more clearly the boundaries of the sources of magnetic anomalies I computed the horizontal derivative (Graunch and Cordell, 1987) of the pole reduced data (fig. 4). The horizontal derivative is constituted by a combination of the horizontal gradients of the anomaly field. The highs of amplitudes of the horizontal derivative corresponds to the lateral boundaries of the magnetic structure but, unlike the analytic signal, this transformation depends on the direction of the total magnetization vector and should be computed on pole reduced data. The assumption, common to both methods, is that the magnetization contrast between body-source and surrounding rocks is abrupt and nearly vertical, otherwise the boundaries are shifted towards the dipping direction.

The analysis of the obtained maps (figg. 2-4) clearly shows that the Bay of Naples is divided into two domains: a volcanic one in the northwestern and northeastern parts, characterized by strong anomalies often correlated with the bathymetry, and a sedimentary one in the south-east area, magnetically quiet and characterized by low gradients. In most cases the horizontal derivative map seems identifying the borders of the magnetic sources more precisely than the analytic signal map. In the Phlegrean area the maps clearly evidence the pattern of the southern rim of the Phlegrean caldera (south of Pozzuoli) and sub-circular anomalies often correspond to volcanic structures, some of them already known in literature.

As regards to the canyon of the Bay of Naples, the Magnaghi Canyon is correlated to several magnetic anomalies and can be therefore interpreted as an active lineament, where magma upwelling may occur, unlike most of the Dohrn Canyon, which is not correlated to any magnetic structures and so is not characterized by volcanic activity. In the Vesuvian area some intense circular anomalies, aligned in northwest-southeast direction, are localized in the Torre del Greco and Torre Annunziata offshore, related to the submerged part of Vesuvius structure and possibly connected to buried vents.

The analysis of the Bay of Naples magnetic data confirms the strong correlation between tectonic and volcanism in the Campanian area, already pointed out by other geophysical survey, especially on land (e.g. Carrara et al., 1973; Florio et al., 1999). The main Campanian volcanic districts (Roccamonfina, Phlegrean Fields-Ischia Islands and Vesuvius) are connected to fault systems. The magnetic structures singled out in this study, compared to other geophysical data, shows that this correlation continues offshore. In particular, the map of the magnetic structures, together with the seismic lineaments located by Milia and Torrente (1999) and Bruno et al. (2003) (fig. 5) evidences the presence in the bay of anti-Apenninic lineaments (northeast-southwest), characterized by magnetic signatures and volcanic activity in the Phlegrean area, and Appenninic lineaments (northwest-southeast), correlated to magnetic anomalies in the Vesuvius off-shore.

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FIGURE CAPITONS

Fig.1. Navigation lines. Black lines were surveyed during the 2000 cruise, red lines during the 1998 cruise.

Fig. 2. Map of the pole reduced anomalies of the Bay of Naples.

Fig. 3. Map of the analytic signal of the magnetic data of the Bay of Naples.

Fig. 4. Map of the horizontal derivative of the magnetic data of the Bay of Naples.

Fig. 5. Map of the main magnetic structures (in red) of the bay and seismic lineaments (Milia and Torrente, 1999; Bruno et al., 2003) (in black) and bathymetry of the area. The bathymetry is obtained by single beam data acquired during these surveys, integrated with the data of the nautical map of the gulf. Barbs are on the downthrown side of faults, arrows indicate the direction of the strike-slip movement. IB: Ischia Bank; MB: Miseno Bank; NB: Nisida Bank; PPB: Pentapalummo Bank.

Fig. 1

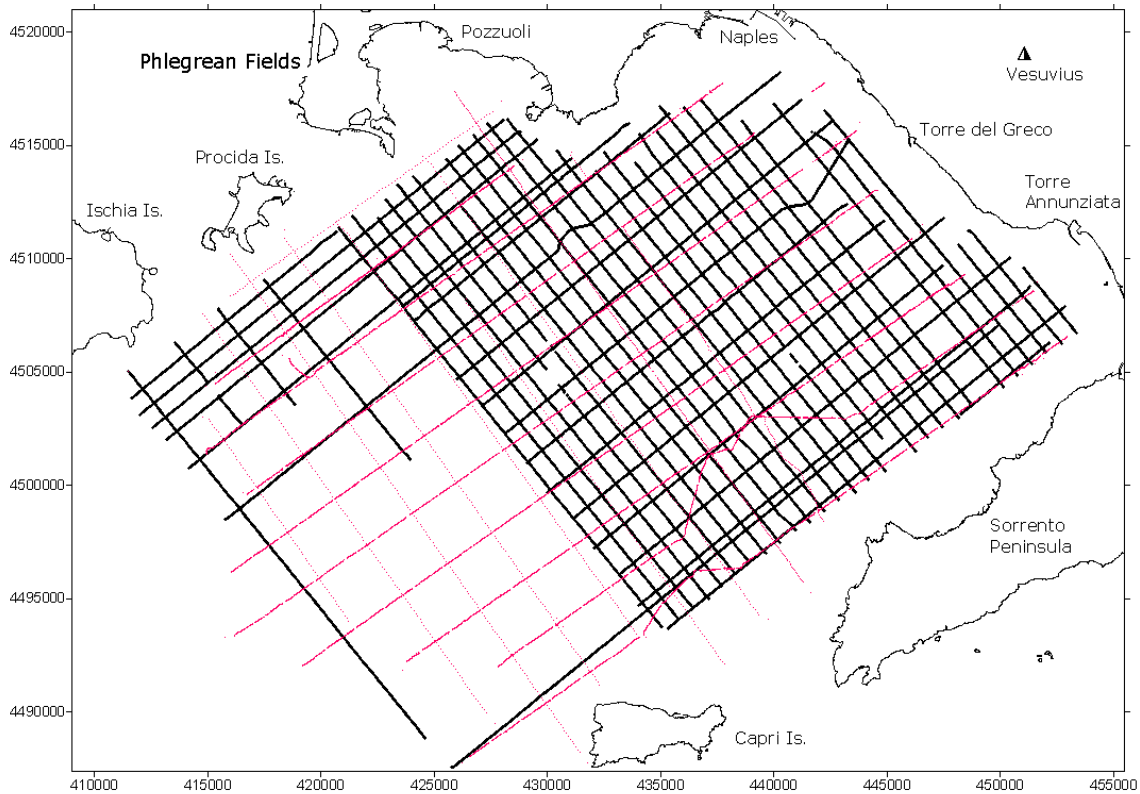
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Fig. 2

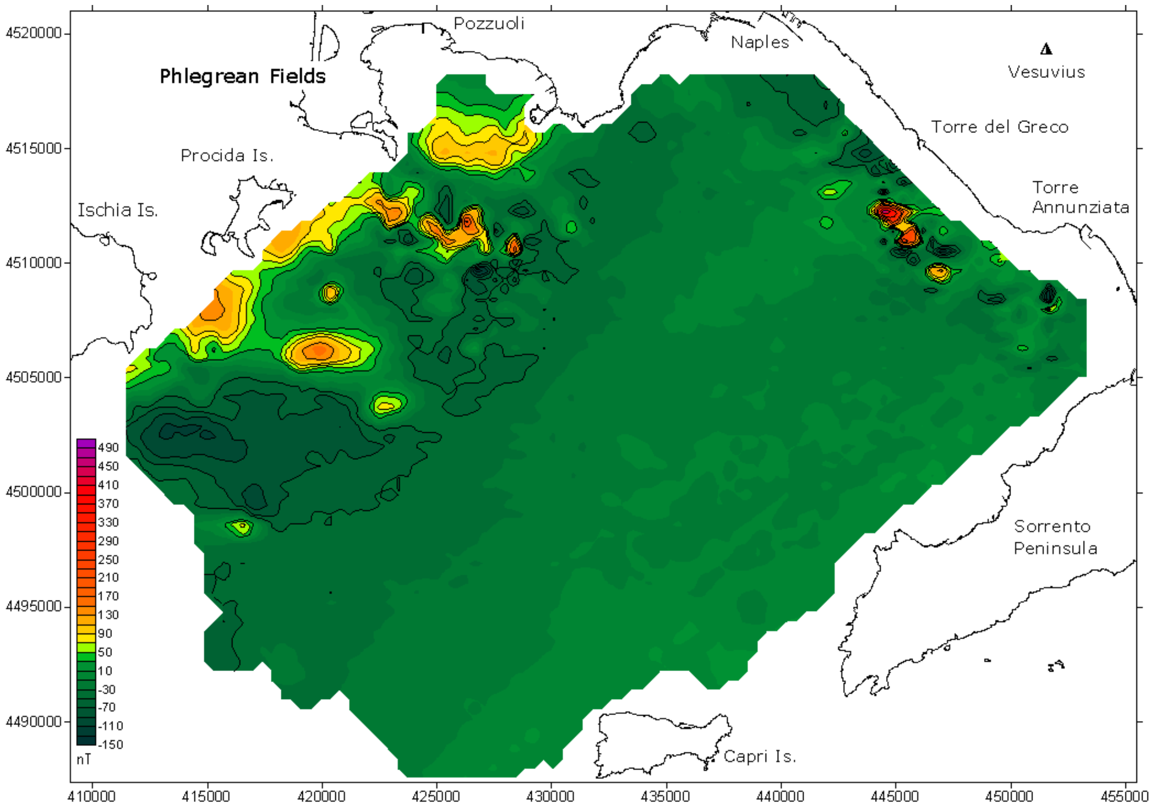
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Fig. 3

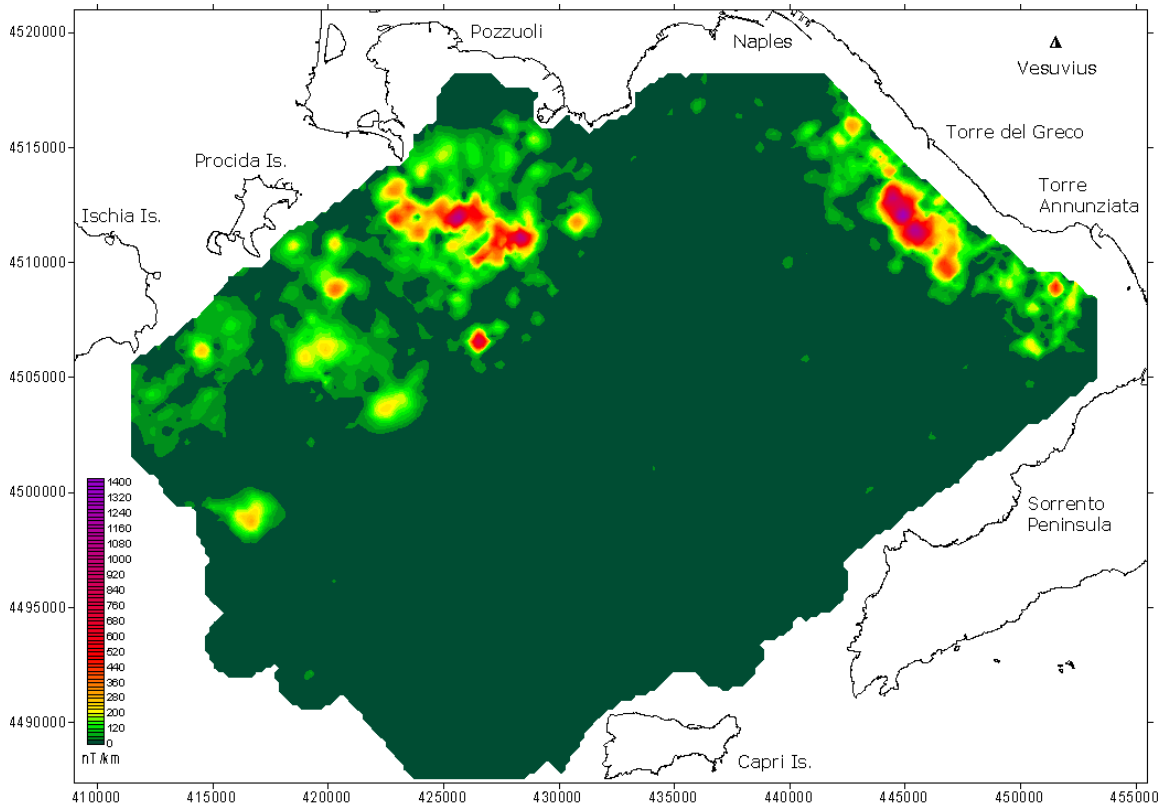
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Fig. 4

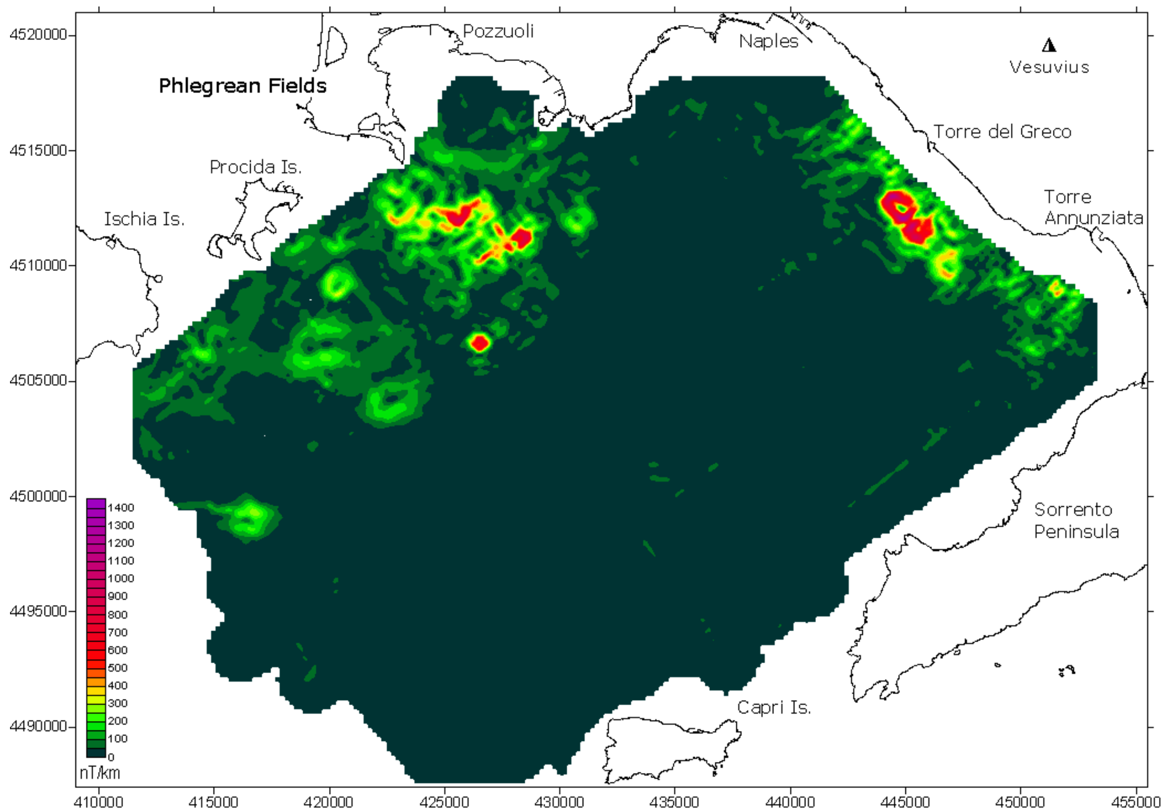
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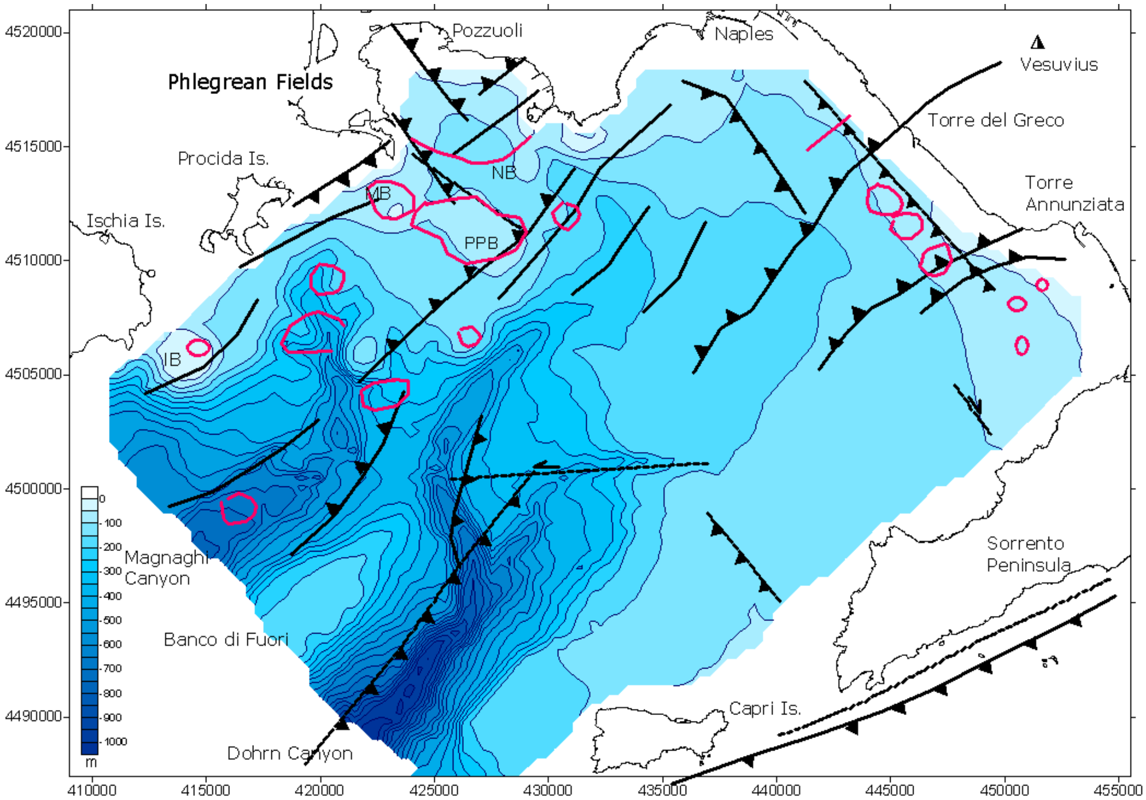
Fig. 5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