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Multiparametric data analysis for seismic source identification in the Campanian area: merging of seismological, structural and gravimetric data

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ABSTRACT This paper deals with an interdisciplinary research that has been carried out to investigate the neotectonic activity of the Campanian plain and surrounding areas (southern Italy), affected by Plio-Pleistocene tectonics and volcanic activity. Three thematic data sets have been generated for this area, "fault", "earthquake" and "gravimetric" data sets, respectively. These data sets allow an integrated analysis of the structural, seismic and gravimetric data in GIS environment with the aim of identifying the active structural lineaments that accommodate the local stress through seismic activity. In detail, an original map with Plio-Quaternary tectonic structures of the Campanian plain and its margins, constrained by morpho-structural analysis and/or geophysical exploration data, is presented. The available earthquake data sets have been merged in a single data set, including seismicity in the Campanian area from 217 b.C. to 2010; processing of seismic data for new precise earthquake locations have been carried out for some clusters of events with poor data, for better constraining existence and activity of some outcropping and buried tectonic structures. As regards the gravimetric data set, a Multiscale Derivative Analysis (MDA) of the gravity field of the area has been performed, relying on the high resolution properties of the Enhanced Horizontal Derivative (EHD). MDA of gravity data allowed localization of several linear and close trends, identifying anomaly sources whose presence was not previously detected. Our integrated analysis shows that a strong correlation occurs among the new hypocentral locations of the seismic clusters matching the fault systems of the Massico Mt. and Avella Mts., and the MDA lineaments from gravity data relative to the same tectonic structures.

Key words: seismic sources, seismicity, gravimetry, geology, Campania, southern Italy.

1. Introduction

The Campania region is one of the Italian most active areas, from a geodynamic point of view, since it is characterized by intense and widely spread seismic activity. The seismicity of the area is concentrated mainly along the southern Apennines chain. The Campanian plain and the offshore of the Tyrrhenian sea are characterized by minor activity with seismicity of energy lower than that of the southern Apennines chain. The seismicity mainly occurs along its margins and shows the existence of seismic sources buried in the Campanian plain. The volcanic areas of Vesuvio, Campi Flegrei and Ischia island are also characterized by seismic activity with low energy. The stress field acting in the Campanian plain is strongly debated. Structural observations on the Pleistocene faults suggest prevalent normal motion for the NW–SE and the NE–SW trending faults, and minor oblique motion, consistent with deformation style of the southern Apennines (Oldow *et al*., 1993; Hyppolite *et al*., 1994).

The structural setting of the Campanian plain has been investigated performing the Multiscale Derivative Analysis [MDA: Fedi (2002)], a method based on the derivative high-resolution properties of the Enhanced Horizontal Derivative [EHD: Fedi and Florio (2001)]. MDA is suitable for enhancing the different contributions of the field at the several scales involved in the measured field. MDA has been successfully applied to the magnetic field of the Ischia island offshore (Bruno *et al.*, 2002). Moreover MDA has been applied to the Tyrrhenian (Fedi, 2002) and to the southern Apennines gravity anomalies (Fedi *et al*., 2005; Cella *et al*., 2009). In the present case, a specified resolution has been selected for performing the MDA of the gravity field of Campanian plain, since a new EHD setup was chosen. Therefore, it has been possible to provide further information with respect to previous studies (Fedi *et al*., 2005) that already highlighted local structural trends in the investigated area. MDA confirmed to be a valuable tool for identification and interpretation of several geologic structures, most of which are not directly visible at surface and are not described before.

The aim of this paper is an attempt to better constrain the main active, outcropping and buried fault systems of the Campanian plain area, and its surrounding massifs, through an integrated analysis of structural, seismic and gravimetric data in GIS environment, to identify the active tectonic lineaments that accommodate the local stress through seismic activity. The Campi Flegrei and Vesuvio volcanic seismicity has not been considered in our study, being the object of other scientific papers.

2. Geodynamic framework

The geodynamic framework of the Campanian area is the result of a complex sequence of tectonic events associated with the collision between Africa and Europe along the southern margin of the Tethys Ocean. During Neogene, the Apennine fold-and-thrust belt has been built as the consequence of the west-dipping subduction of the Adriatic-Ionian lithosphere underneath the European plate (Malinverno and Rayan, 1986; Doglioni *et al*., 1996, 1999). Thrusting with a general sense of transport towards NE involved the Mesozoic and Paleogenic sedimentary carbonate platform domains and their interposed basins of the African margin.

Starting from the Late Tortonian, the thrust front migrated from west to east whereas the back-arc basin opening of the Tyrrhenian Sea has occurred with stretching and thinning of the continental crust and the counterclockwise rotation of the Italian peninsula (Patacca *et al*., 1990; Patacca and Scandone, 2007). Since the early Pliocene, the basin extended progressively to the east, involving the internal sector of the orogenic wedge and causing the formation of coastal grabens (peri-Tyrrhenian basins) along the western flank of the chain, which were partly filled by Pliocene-Quaternary sequences of volcanic and sedimentary deposits up to 3-5 km thick (Ippolito *et al*., 1973; Cinque *et al*., 1993; Brocchini *et al*., 2001; Caiazzo *et al*., 2006). The origin of the

Campanian plain graben is related to this extensional tectonic regime; the Plain represents the major Plio-Pleistocene structural depression located in southern Italy between the eastern side of the Tyrrhenian Sea and the Mesozoic carbonate massifs of the southern Apennines chain (Scandone *et al*., 1991).

The main extensional deformation phases affecting the Tyrrhenian margin of Campania has occurred through two major fault systems: a) NE-SW trending fault system (peri-Tyrrhenian grabens of Garigliano, Campanian plain, Salerno Gulf and Sele River plain); b) NW-SE trending fault system, with extensional deformation still active, as derived from focal mechanisms data of large earthquakes in southern Apennines (Pondrelli *et al*., 2006). Moreover, E-W, N-S and NNW-SSE oriented faults systems have contributed to the recent collapses of the plain with a vertical subsidence rate of about 2 mm/y during the whole Quaternary (Brancaccio *et al*., 1991; Cinque *et al*., 2000). An important consequence of the Quaternary extension has been voluminous volcanic activity occurred mainly along the western margin of the plain giving rise to many volcanic centres (Roccamonfina, Campi Flegrei, Ischia, Procida and Vesuvio).

Since middle Pleistocene, the eastward propagation of the extensional tectonics involved the axial portion of the chain (Hippolyte *et al*., 1994); a severe regional uplift affected the inner sectors of the southern Apennines and was responsible for the formation of large intermountain basins along NW-SE normal and oblique faults (Westaway, 1993).

The crustal structure of the Campanian plain, interpreted from seismic refraction profiles and teleseismic receiver functions is characterized by strong lateral velocity variations. A major crustal discontinuity separates the Campi Flegrei from Vesuvio. The Moho discontinuity is about 25 km beneath the Campi Flegrei and deepens asymmetrically down to depth of about 35 km, both towards the NW (Massico Mt.) and SE (Vesuvio and Sorrento Peninsula) (Ferrucci *et al*., 1989; Gaudiosi *et al*., 2007).

The southern Apennines seismicity concentrates in the uppermost 15-20 km of the crust mostly along NW-SE striking normal faults with destructive events (I_o = X-XI MCS) occurred in 1456, 1688, 1702, 1732, 1805, 1851, 1857, 1930, 1962, and 1980 (M_w=6.9) (Gasparini *et al*., 1985; Valensise and Pantosti, 2001a, 2001b; Gruppo di Lavoro CPTI, 2004).

The Campanian plain seismicity is characterized by less energy than seismicity of the chain; in particular a few events spread out inside the plain and offshore the margin of the Thyrrhenian coast, whereas earthquakes of moderate energy mainly occur along the NE-SW and NW-SE carbonate massifs bordering the plain. In the volcanic areas of Campi Flegrei, Vesuvio and Ischia the recent seismicity is prevalently of swarm-type with low/moderate energy.

3. Thematic data set

The analysis of the available seismic, tectonic and gravimetric data of the studied area has been carried out under a Geographic Information System (GIS) environment. The GIS provides the capability for storing and managing large amount of spatial data from different sources.

The implementation of the GIS system has been affected by both completeness of information, and quality of geographic data in the specific research fields. For this reason, special attention has been dedicated in our system to collect all the existing relevant data together with the updated territorial information about the Campanian area.

In this paper territorial, geographic and part of geophysical data have been extracted from the SISCam system (Vilardo *et al*., 2001, 2009; Nappi *et al*., 2008) as well as from other databases.

In particular, the database creation has consisted of these main steps: a) collection and acquisition of digitalized aerial photos, numeric cartography, Digital Terrain Model (DTM) data and geophysical data; b) generation of the vector cartographic database and alpha-numerical data; c) image processing and features classification; d) cartographic restitution and multi-layers representation.

The UTM-WGS84 reference system has been used for geocoding the whole data set.

3.1. Fault data set

The active fault systems of the Campanian area are not completely known and not comprehensively reported in up-to-date and reliable neotectonic maps. In the present paper, we have compiled a fault data set by examining the available structural maps and many recent geological and geophysical papers of literature, extracting useful information about the main outcropping and buried faults in the whole area, which are of wide consent among authors.

The geological and structural maps of reference for our analysis have been the following: Carta Geologica d'Italia 1:100,000 (Foglio n.160 Cassino, n.172 Caserta, n.183-184 Ischia-Napoli, n.185 Salerno); Carta Geologica dell'Appennino Meridionale 1:250,000 (Bonardi *et al*., 1988); Neotectonic Map of Italy 1:500,000 (Ambrosetti *et al*., 1986); Structural Map of Italy 1:500,000 (Bigi *et al*., 1992), Geological map of Italy 1:1,250,000 (APAT, 2004). Moreover, using the available geological and geophysical papers (Orsi *et al*., 1996; Milia and Torrente, 1999; Cinque *et al*., 2000; Bruno *et al*., 2003; D'Argenio *et al*., 2004) we have also included in our database the Campanian Plio-Quaternary active structures bordering the margin of the southern Apennines chain, the structures located inside the Campanian plain and those around the Campanian volcanic districts. In particular, we have included only the Plio-Quaternary faults also constrained by morpho-structural analysis and/or geophysical explorations data. The final fault data set consists of the extracted lineaments, in vector format, which have been digitized and geocoded from the original maps in raster format. The obtained faults are plotted on the shaded relief map of Campanian area of Fig.1. The study sector of Campanian area is characterized by two main faults systems: NE-SW oriented faults, mainly responsible for the peri-Tyrrhenian graben of the Campanian plain, and probably active since early Pleistocene (Cinque *et al*., 2000); NW-SE oriented faults mainly bordering the Campanian Apennines internal margins, and probably active since middle Pleistocene, therefore of more recent activity. Moreover, WNW-ESE and NNW-SSE minor faults systems are also present. The Campanian plain is also intersected by buried fault systems, which existence and activity can be hypothesized and established only by combined seismicity and gravimetric data analysis.

The most important tectonic structures recognized in this paper, of which only a few can be considered active due to seismic events concurrence, are:

- NW-SE oriented faults bordering the Campanian Apennines along their internal margin and representing the eastern boundary of the Campanian plain;
- WNW-ESE oriented faults bordering and intersecting the Avella Mts.;
- NE-SW oriented faults bordering the Mt. Massico massif to the north and south;
- NW-SE oriented fault bordering the Roccamonfina volcano along its eastern side;

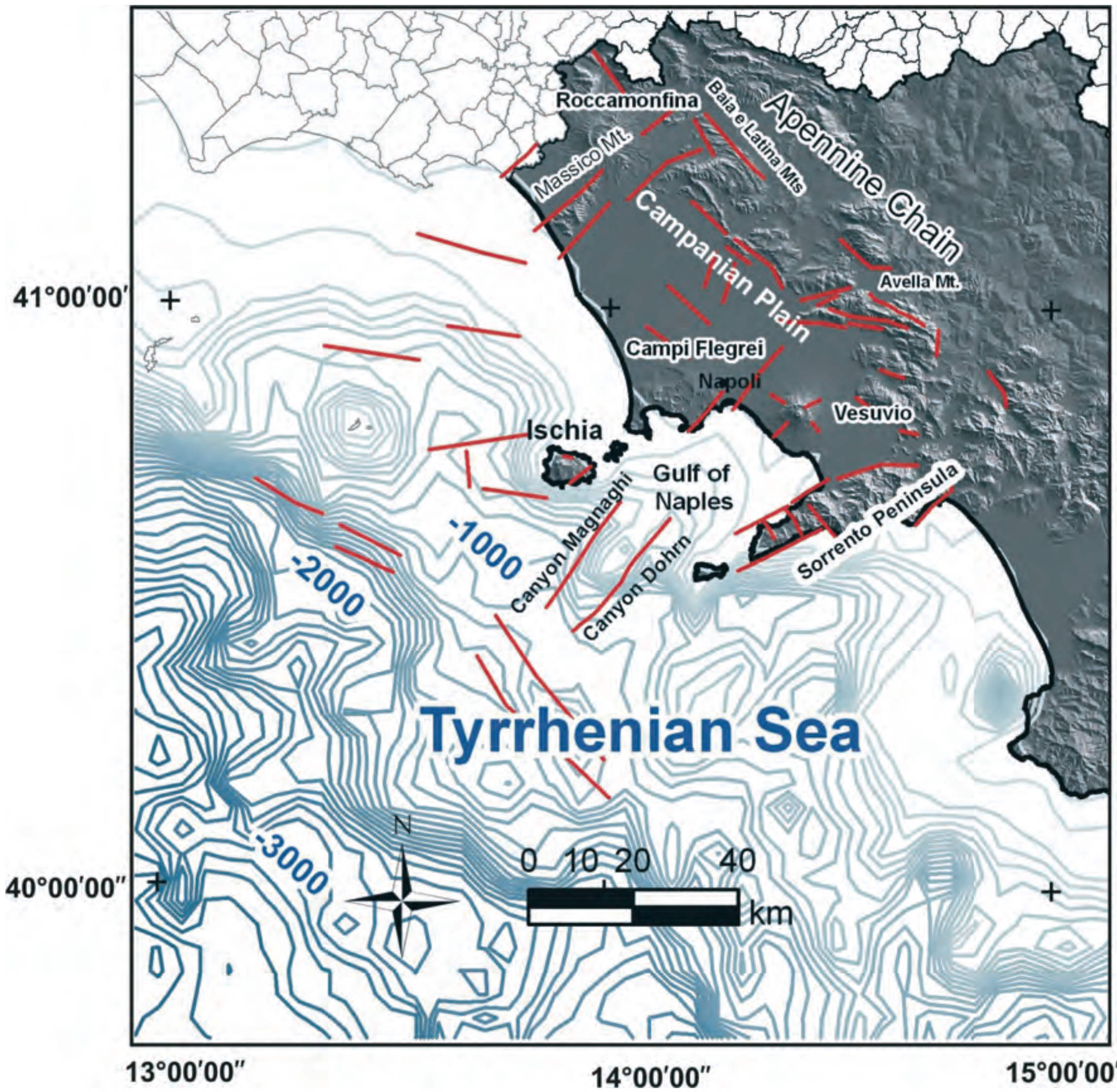

Fig. 1 - Map of the faults (red lines) extracted from literature of wide consent among authors, overlapped on the shaded relief of the area.

- NW-SE and NE-SW oriented faults located inside the Volturno plain and buried;
- NE-SW oriented fault known as the Sebeto valley fault located to the east of Campi Flegrei and intersecting the town of Napoli;
- NE-SW oriented faults located to the north and south of the Sorrento Peninsula and NW-SE faults intersecting the peninsula itself;
- NE-SW oriented faults located offshore the Napoli Gulf and associated with the Dohrn and Magnaghi submarine canyons;
- NW-SE oriented fault system located offshore the Napoli Gulf and associated with the

platform-continental slope margin.

3.2. Earthquake data set

The seismic data used in this study are relative both to the historical and recent seismic activity, collected by the following catalogues:

- Catalogue of Parametric Italian Earthquakes CPTI04 (Gruppo di Lavoro CPTI, 2004), which consists of the revised macroseismic catalogues and contains the seismic parameters (hypocentres, intensity and equivalent magnitude) of historical and recent earthquakes from 217 b.C. to 2002;
- Catalogue of Instrumental Italian Earthquakes CSI [Castello *et al*. (2006)], which consists of the revised seismicity (1981 to 1996) of the previous catalogue (CSTI Working Group, 2001) recorded by the Italian permanent seismic network. It also contains relocated earthquakes of 1997-2002 recorded by all available networks;
- Italian Seismic Bulletin, of the Istituto Nazionale di Geofisica e Vulcanologia (INGV) (2002 - today), a semi-monthly web-catalogue since January 2002, including information of all earthquakes recorded by the Italian seismic networks;
- LabOV [Seismic Data Base of Osservatorio Vesuviano (OV), Istituto Nazionale di Geofisica e Vulcanologia] consisting of a catalogue of all seismic events recorded from 1998 to 2010 by the permanent seismic networks operated by OV in the Campanian Apennines and in the volcanic areas of Vesuvio, Campi Flegrei and Ischia;
- SisCam Catalogue (Seismotectonic Information System of the Campanian Region) (1980-2000), which is a database of all earthquakes occurred in the Campanian region and neighbourhood. This data set consists of new location of seismic events recorded by the permanent and mobile seismic networks of OV integrated with data from other seismic networks.

Seismic data have been standardized in the same format into the GIS and merged in a single catalogue (Fig. 2). This final catalogue includes the historical and instrumental seismic events occurred in the Campanian area from 217 b.C. to 2010. In particular the CPTI04 provided data from 217 b.C to 1980; the LabOV and SISCam databases provided data from 1980 to 2010, that represent the best located earthquakes recorded by the OV seismic networks due to a good network geometry. Moreover, seismic events missing in the above described catalogues have been extracted from CSI 1.1 and Seismic Bulletin of INGV.

The map of seismicity relative to the final seismic catalogue (Fig. 2) shows the earthquake spatial distribution in the area under study. In detail, the epicentres of seismic events mainly concentrate along the NW-SE and WNW-ESE oriented carbonate massifs of the southern Apennines (Baia and Latina Mts., Avella Mts.) and along the NE-SW oriented relief (Massico Mt. and Sorrento Peninsula), bordering the Campanian plain (Fig. 2). The Campi Flegrei, Vesuvio and Ischia volcanic areas are characterized by clusters of seismicity, while scattered earthquakes have been located inside the plain.

In order to improve the location accuracy of seismic clusters of some minor tectonic structures, such as the Avella Mts., Massico Mt. and the Campanian plain buried faults, new precise earthquake locations have been carried out and correlated to the other available geophysical data, allowing a better constraining of the existence and activity of such fault

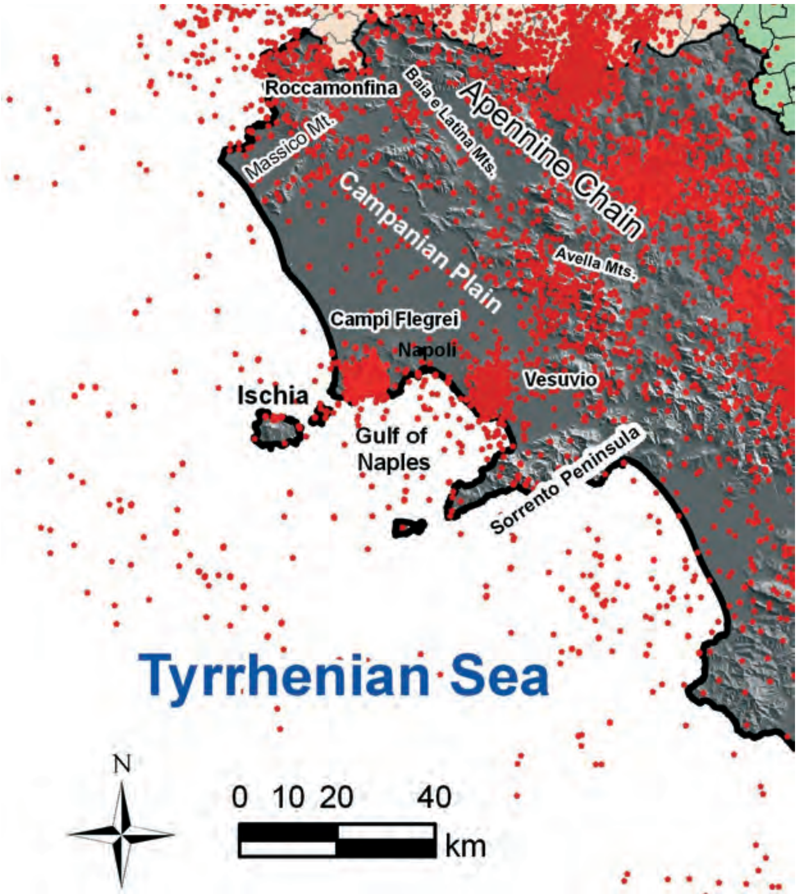

Fig. 2 - The map of seismicity in Campanian area relative to the final seismic catalogue obtained by merging the available catalogues.

systems.

Seismic events of Avella Mts. and Massico Mt. have been relocated using Hypo71 algoritm (Lee and Lahr, 1975) and a multilayer velocity model. The magnitude of the events estimated from seismograms duration (M_D) is generally less than 2.5, only a few events have M_D greater than 3.0. In the Massico Mt. region, the strongest event was an historical earthquake (May 10, 1967 I_o=VII MCS) with equivalent magnitude of 4.8, while in the Avella Mts. region some clustered events with $3.0<M_D<4.0$ have been recorded in recent years. Due to the low energy of many events and high gaps in the networks azimuthal coverage, not all the recorded earthquakes can be located with sufficient accuracy. Therefore, only events with errors less than 2.5 km for both horizontal and vertical coordinates and rms values less than 0.5 s have been selected and mapped in Fig. 4 (yellow circles). The seismic clusters of Massico Mt. and Avella Mts. areas have been plotted in Figs. 5 and 6, where both epicentral locations and vertical cross sections of the relocated hypocentres are shown; the maximum depth of earthquakes is about 25 km and 20 km, beneath the Massico Mt. and Avella Mts., respectively. It can be observed that earthquakes are concentrated around the local structural lineaments (NE-SW faults of the Massico Mt. massif, and WNW-ESE faults for the Avella Mts.). Their trend seems to be compatible with the activity

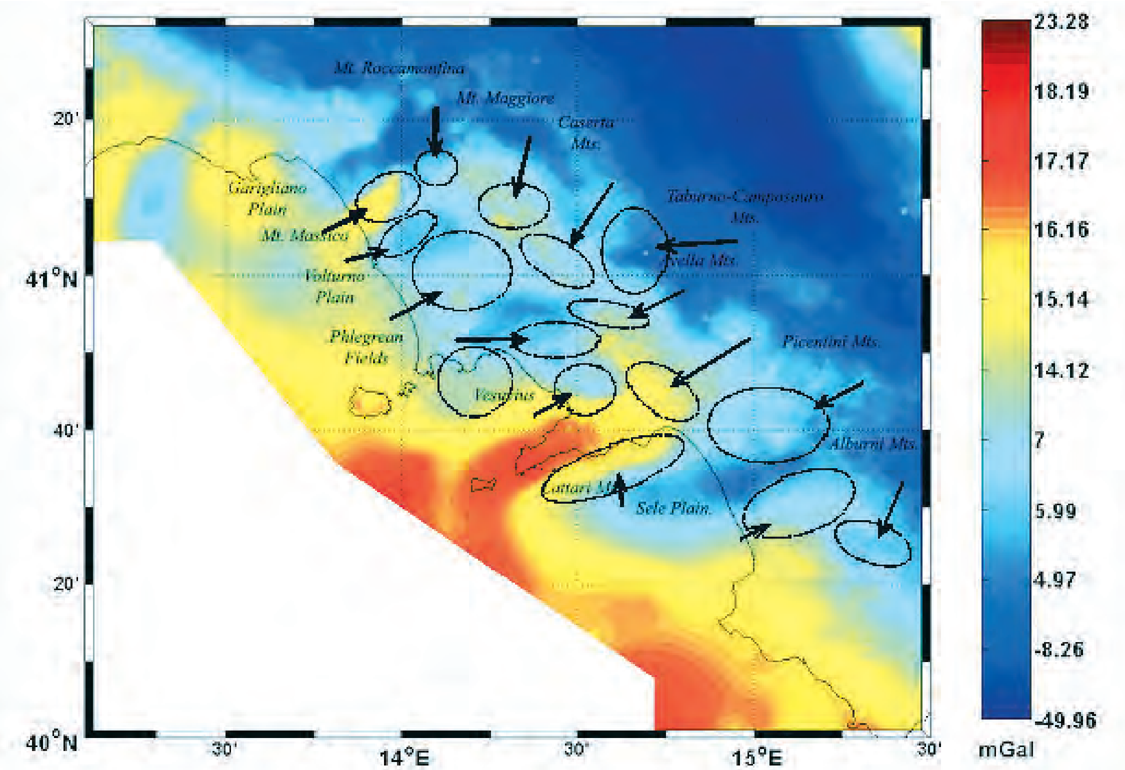

Fig. 3 - Bouguer anomaly gravity field of the Campanian region windowed from the Bouguer gravity anomaly map of Italy published by the CNR (Carrozzo *et al.*, 1986) and integrated with data from the ISPRA website.

of local seismogenic lineaments with normal motion (Milano *et al.*, 2004).

3.3. Gravimetric data set

The investigated Bouguer anomaly field covers an area from 13°06' E to 15°30'E, and from 40°00'N to 41°33'N. Gravity data are derived from the Bouguer Gravity Anomaly Map of Italy published by the CNR (Carrozzo *et al.*, 1986) and from public domain data provided by the ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale) website.

The Bouguer anomaly field of the studied area (Fig. 3) shows the presence of many anomalies with small or intermediate wavelength superimposed on a regional field corresponding to i) an elongated low running along the axis of the Apennine belt and ii) a broad high centred on the bathyal plain of the Tyrrhenian basin.

Some anomalies roughly coincide with geomorphological elements of the relief. This is the case of local negative anomalies coinciding with the central axes the main coastal plains (Sele plain, Volturno plain and Garigliano plain) and of some gravity highs centred on carbonate massifs, like the Mt. Massico, Mt. Maggiore, Mt. Taburno-Camposauro, Avella Mts., Caserta Mts., Lattari and Picentini Mts., Alburni Mts.

Also the volcanic reliefs of Roccamonfina, Campi Flegrei and Vesuvio are marked by the existence of a certain correlation with small negative anomalies.

The correspondence between gravity and morphostructures can occur in a Bouguer anomaly map and is mostly caused by the fact that morphologic elements often correspond to structural discontinuities at depth. However, some caution is needed in these cases because such a correlation with topography could also be due to an unavoidable imprecision in the choice of the density value adopted for terrain corrections.

4. Multiscale Derivative Analysis of the Bouguer gravity anomaly field in the Campanian area: theory and interpretation of the main EHD trends

The Multiscale Derivative Analysis is based on the Enhanced Horizontal Derivative (EHD). EHD (Fedi and Florio, 2001) is defined as:

$$EHD\,(x,y) = \sqrt{\left(\frac{\partial \phi}{\partial x}\right)^2 + \left(\frac{\partial \phi}{\partial y}\right)^2}\;, \qquad (1)$$

where

$$\phi(x,y) = w_0 f(x,y) + w_1 f^{(1)}(x,y) + w_2 f^{(2)}(x,y) + \ldots + w_m f^{(m)}(x,y), \qquad (2)$$

and $f^{(1)}$, …, $f^{(m)}$ are the m-order vertical derivatives of the field f, while, $w_0 \ldots w_m$ is a set of weights.

The numerical computation of high-order vertical derivatives of the potential fields required to build the EHD function, implies the use of the Integrated Second Vertical Derivative method [ISVD: Fedi and Florio (2001)]. This technique provides smoother derivatives than those achievable by usual Fourier techniques. ISVD is structured on two phases: 1) stable vertical integral of the field computed in the frequency domain; 2) second vertical derivative of the transformed field computed from the Laplace equation.

The horizontal derivatives are rather stable when performed in the space domain by means of splines or by finite-difference algorithms.

The horizontal derivative of the sum of the terms of Eq. (2) emphasizes the signal along the source boundaries and tends to suppress the rest of spurious maxima appearing within the single derivative terms of different order. Therefore, the position of the EHD maxima will outline the source boundaries. When sources of different depth/extent generate effects at various scales, different images of the body edges can be obtained by opportunely choosing the starting and last terms of the derivative and by an effective set up of the weights. The result consists in a combination of derivative terms which enhances the effects at a specific scale. Consequently, even if MDA does not perform a quantitative depth estimate, the analysis of EHD acts like a multiscale boundary analysis. It can be exploited over regions where the coexistence of sources at different depths causes the superposition of large and short scale effects allowing a qualitative separation among deep, shallow and intermediate sources within the crust. This is the case of the Apennines

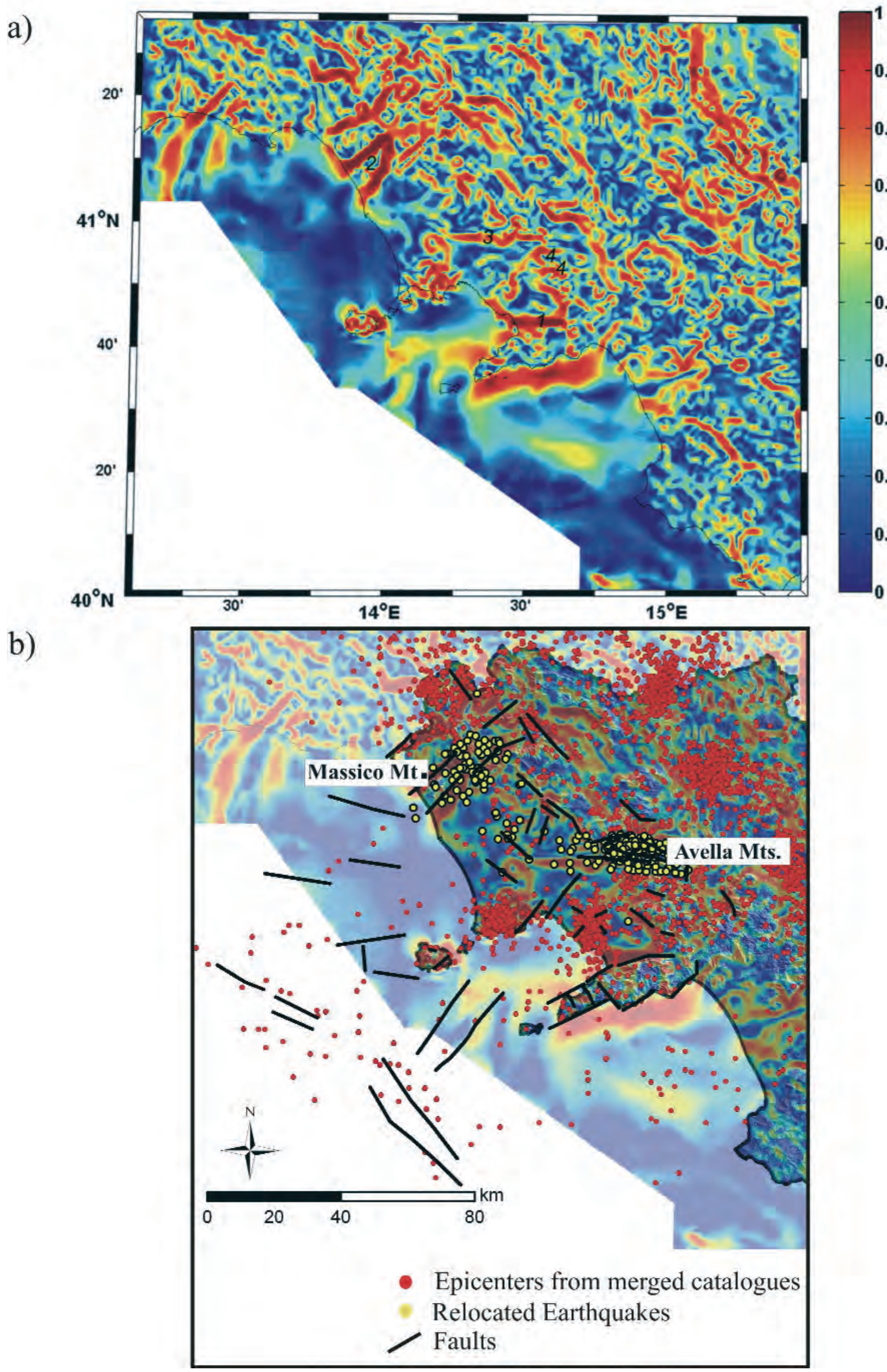

Fig. 4 - a) Short scale MDA map of the Bouguer anomaly gravity field in the Campanian region; the lineaments are identified by trends of local maxima, which are graphically determined by the normalized color scale; small numbers indicate the trends described in the text; b) map of different thematic layers overlapped on shaded relief and on short scale MDA map: seismic epicentres from the final catalogue obtained from merging the available Catalogues (red circles); relocated seismic events (yellow circles); faults extracted from literature of wide consent (black lines).

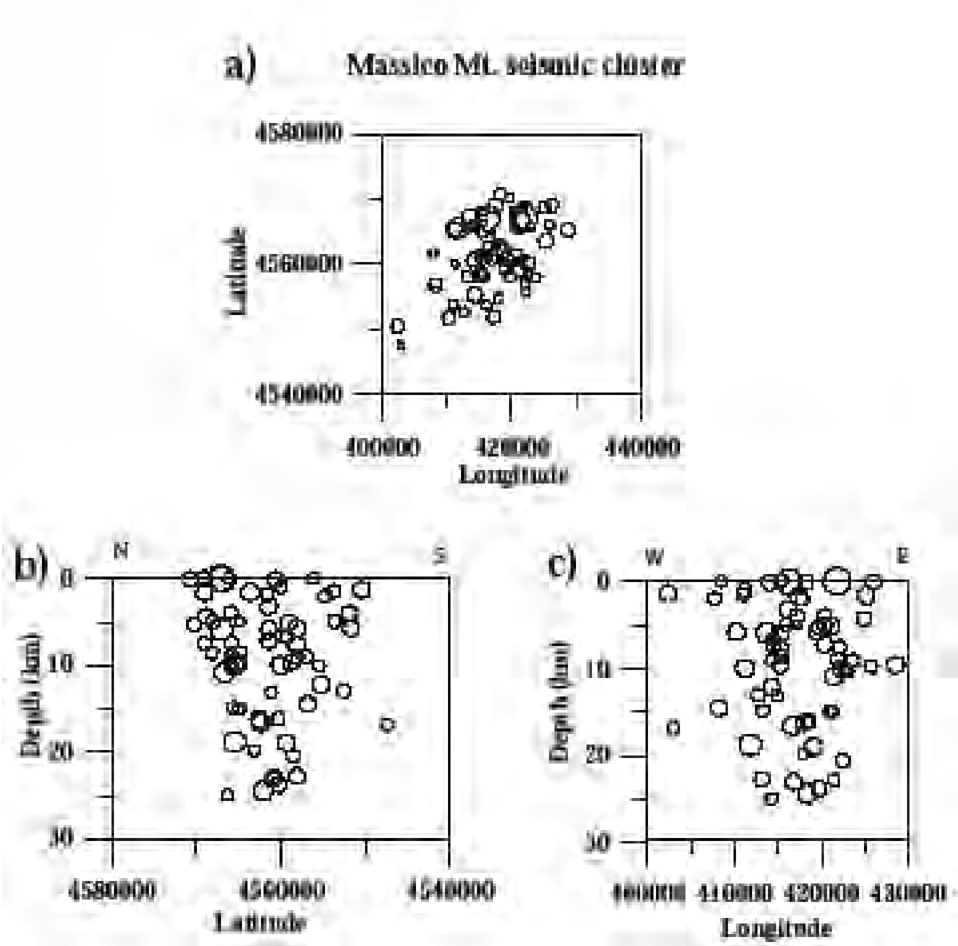

Fig. 5 - a) Spatial distribution of Massico Mt. seismic cluster; b) hypocentres projected onto a N-S vertical section; c) hypocentres projected onto 2 W-E vertical section. The dimension of the circles is proportional to earthquake magnitude.

Chain and surrounding regions where thrusts and/or folds, vertically displaced by younger normal fault systems, generated neotectonic basins and volcanic districts along the western side of the chain. The potential fields anomalies associated with such a structural framework show a complex patterns of local/regional components that can be investigated by means of MDA.

The MDA of the gravity field of the Campanian region (Fig. 4) confirms that the amount of information directly extracted by a simple qualitative map analysis dramatically increases passing from the Bouguer anomalies to the EHD signal.

Given the small extent of the investigated area, our study was targeted to the shallow (a few kilometers) or intra-crustal structures with local significance. To this aim a short scale MDA map was analyzed (Fig. 4). It was obtained starting from the gravity field, as the first EHD summation term, to the 5th order vertical derivative and by using unit weights.

The high number of trends shown by the short scale EHD map demonstrates that there are many more structures of geological interest than those directly visible on ground or by official

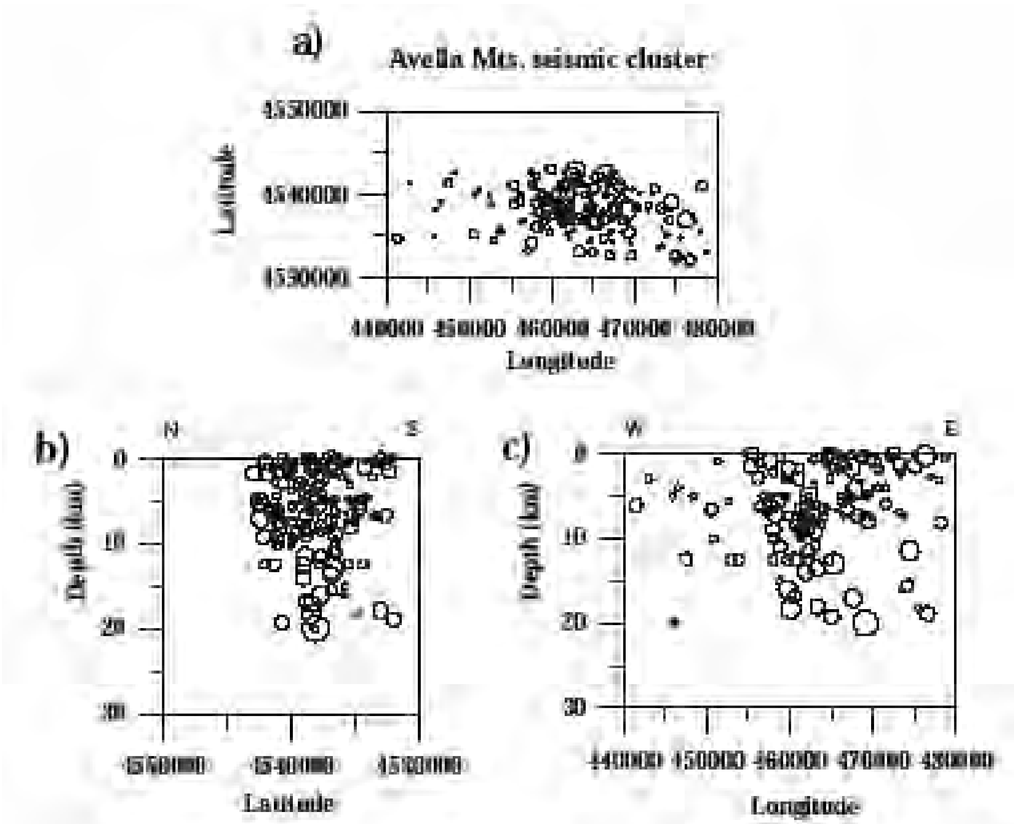

Fig. 6 - a) Spatial distribution of Avella Mts. seismic cluster; b) hypocentres projected onto a N-S vertical section; c) hypocentres projected onto a W-E vertical section. The dimension of the circles is proportional to earthquake magnitude.

geologic maps.

5. Discussion and conclusions

In this paper a multiparametric data analysis has been applied to the Campanian plain for investigating the local neotectonic activity, through merging of seismicity, tectonic and gravity data, with the aim of identifying structural lineaments responsible for seismic activity.

Accordingly, three thematic data sets have been generated for this area, “fault”, “earthquake” and “gravimetric” data set in order to collect and integrate the whole set of existing information. Moreover, new processing of seismic and gravimetric data has been carried out for identifying the active structural lineaments that significantly accommodate the local stress. The GIS system has proved to be a necessary tool and a powerful instrument for such interdisciplinary research, allowing managing and combining large amount of geological, geophysical and territorial data.

In detail, we have compiled a fault data set by examining the available structural maps and recent literature, extracting useful information about the main outcropping and buried faults in the whole area, which are of wide consensus among authors; from the fault data set a new map with the well constrained Plio-Quaternary structures of the Campanian plain and its margins has been generated (Fig. 1). The Campanian area is characterized by two main fault systems: NE-SW oriented faults, mainly responsible for the peri-Tyrrhenian graben of the Campanian plain, and NW-SE oriented faults of more recent activity mainly bordering the Campanian Apennines internal margins, and probably active since middle Pleistocene. Moreover, WNW-ESE and NNW-SSE minor fault systems are also present, while the Campanian plain is also intersected by probably buried fault systems.

Among the most important tectonic structures recognized in this paper, we have concentrated our investigation on the NE-SW oriented fault system bordering the Massico Mt. to the north and south, and on the WNW-ESE oriented fault system bordering and intersecting the Avella Mts., since they were not well studied in the past. These structures are characterized by intense concentration of epicentres, as it is shown in Fig. 4, therefore are considered active seismogenetic faults. Consequently, new precise earthquake locations have been carried out, merging seismic phases from the unified earthquake data set implemented in this paper and processing new hypocentre locations relative to clusters of events coinciding with the Massico Mt. and the Avella Mts. tectonic structures (Figs. 5 and 6). Furthermore, we have also relocated the scattered events occurred inside the Campanian plain for correlating the seismic activity and the buried structures detected by geophysical investigations (Fedi *et al*., 2002).

As regards gravity data we performed an MDA of the Bouguer anomalies of the Campanian area, allowing localization of several linear and closed trends and identifying anomaly sources whose presence was not previously detected (Fig. 4). Most of the known faults of the area are clearly shown, together with several trends pointing out structures that do not match with structural elements at surface. Merging the relocated earthquakes together with selected faults and MDA lineaments (Fig. 4), two main NW-SE and NE-SW active fault systems are evident. Remarkable features of the EHD signal in this area are the two strong linear trends that bound the Campanian plain at its southern and northern edges. Southwards, this signal indicates the presence of the well known normal fault (Cinque *et al*., 2000; Caiazzo *et al*., 2006) displacing downwards the Campanian plain with respect to the carbonate ridge of the Sorrento Peninsula (see trend 1 in Fig. 4a). Along the northern margin of the plain, high values of EHD signal form two considerable trends that bound both the northern and the southern boundaries of the Massico Mt. (see trend 2 in Fig 4a). This feature, together with the high amplitude gravity associated with the relief, suggests that the Massico Mt. represents a structural horst of the carbonate basement characterized by noticeable displacement. The hypocentral depths beneath the Massico Mt. (Fig. 5) reach about 25 km supporting the hypothesis that this structure deepens at crustal depths. In addition, the position of the two EHD lineaments is not symmetric with respect to the Massico Mt. In fact, the southern trend appears shifted southwards with respect to the slope of the relief, thus indicating that the master fault plane does not outcrop, but is hidden by the sediments of the plain; this effect could be explained through a gradual retreat by erosion of the outcropping edge of the fault plane, up to reach the present position of the Massico southern flank.

Another significant feature of the EHD signal is the E-W trend elongated from longitudes 14°15’ to 14°35’. It surrounds the Acerra low (see trend 3 in Fig 4a), located just in the middle of the Campanian plain, and probably evidences a local deepening of the buried carbonate basement, which could represent a westward continuation of the WNW-ESE fault system controlling the outcropping carbonate massif of the Avella Mts. Southwards, the relations between the EHD signal and the morpho-structural boundaries of the outcropping carbonate massifs are represented by a trend marking the western structural limit of the Sarno Mts. (see trend 4 in Fig. 4a).

Finally, we remark the strong correlation among the new hypocentral location of seismic clusters matching the fault systems of the Massico Mt. and Avella Mts., and MDA lineaments from gravity data relative to the same tectonic structures (Fig. 4). The relocated hypocentres are concentrated along the above-mentioned geologic structures (Figs. 5 and 6), and appear also coincident with the local MDA lineaments from gravity data. On the other hand, inside the Campanian plain spread seismicity, apparently not linked with already known buried faults and with gravimetric EHD lineaments has been observed (Fig. 4).

In conclusion, the results obtained in this work show that an integrated analysis of different data in areas characterized by both intense concentration of epicentres and strong EHD lineaments would significantly enhance our knowledge of the local structural setting, improving the definition of the active outcropping and buried local fault systems.

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