Structural settings of the carbonatic «basement» and its relationship with magma uprising in the Gulf of Naples (Southern Italy)

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Abstract
The carbonatic «basement» of the Gulf of Naples, a peri-tyrrhenian basin located on the western side of the Southern Apenninic chain, was studied in detail by means of seismic reflection profiles both on the mainland and in the sea. The carbonatic «basement» dips toward the north-west with an angle of 10° and is affected by brittle extensional tectonics. This structural setting is related to the extension of the Tyrrhenian Sea, which caused the development of horst and graben-like structure along the western margin of the Apennines. Some normal faults with a regional relevance were recognised: 1) a N110° trending fault responsible for the sinking of the carbonatic «basement» below Mount Somma-Vesuvius; 2) a N10° trending fault, along which five submarine volcanoes are aligned; 3) a N70° fault, which separates the Gulf of Naples from the Gulf of Salerno. The first two faults, arranged radially with respect to the shallow magmatic chamber of Phlegraean Fields, are interpreted as the main uprising route for magma in this area. The carbonatic «basement» cannot be recognized in seismic profiles in the Phlegraean area; a tectonic feature responsible for this is hypothesized.

Key words *carbonatic «basement» – Gulf of Naples – magma uprising*

1. Introduction

The Gulf of Naples, located along the Tyrrhenian coast of Southern Italy (fig. 1), is one of the most studied volcanic areas in the world. It has been interpreted as a peri-Tyrrhenian basin, that formed as a consequence of the extensional tectonics, which affected the inner part of the Apenninic chain, after the end of the Mio-Pliocene piling-up of the Apenninic chain (Royden *et al.*, 1987; Patacca *et al.*, 1990). The extensional tectonics in the Apenninic chain is related to the rifting of the Tyrrhenian Sea which began during Tortonian times (Rehault *et al.*, 1987; Malinverno and Ryan, 1985; Trincardi and Zitellini, 1987).

The Gulf of Naples is bordered to the south by the Island of Capri, the Sorrentina Peninsula and Lattari Mounts (fig. 1); they form a narrow promontory interpreted as a horst resulting from the extensional tectonics related to the opening of the Tyrrhenian sea (Fusi and Garduno, 1992). This horst is characterized by the outcrop of the carbonatic «basement», Mesozoic in age, covered by Miocene arenites (Scandone and Sgrosso, 1965) (fig. 1). Massive Triassic and Jurassic platform limestones, partly dolomitized and massive and layered Cretaceous platform limestones, with Hippurites (Scandone and Sgrosso, 1965; Carta Geologica d'Italia, Sorrento-Isola di Capri, 1965; Carta Geologica d'Italia, Amalfi, 1965; De Blasio *et al.*, 1981; Perrone, 1988) form the carbonatic «basement». Both Mesozoic platform limestones and Miocene arenites are mantled by lenses of pyroclastic rocks of vesu-

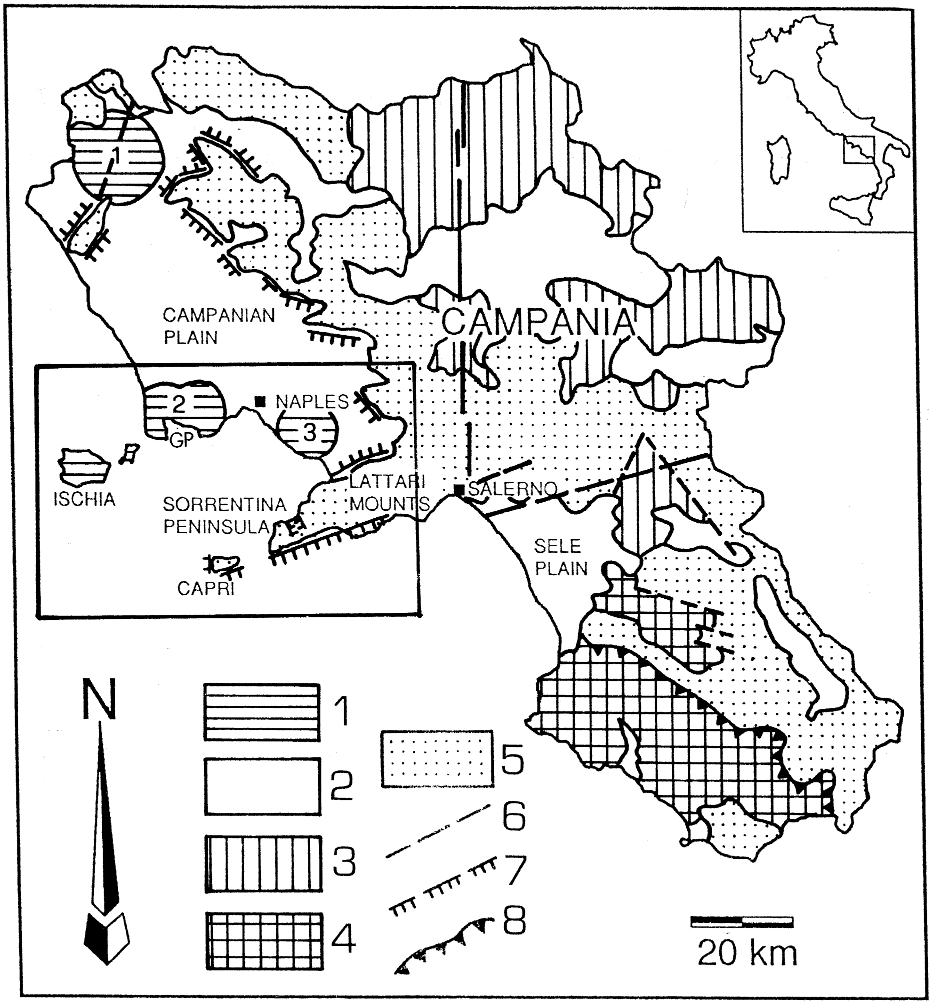


Fig. 1. Structural and geological sketch map of Campania (geology after Ippolito *et al.*, 1973; structure after Fusi and Garduno, 1992): 1 = volcanic areas (1 = Roccamonfina, 2 = Phlegraean Fields, 4 = Somma-Vesuvius); 2 = alluvial plains; 4 = Sicilids units; 4 = Cilento units; 5 = carbonatic units; 6 = lineaments; 7 = normal faults; 8 = thrusts; GP = Gulf of Pozzuoli.

vian and phlegraean origin (De Blasio *et al.*, 1981; Perrone, 1988).

The horst of Sorrentina Peninsula and Lattari Mounts is bordered to the north by the Campanian Plain, a graben-like depression characterized by widespread volcanic activity (Phlegraean Fields, Islands of Ischia, Procida and Vivara and Somma-Vesuvius; fig. 1), which started about 0.5 Ma ago (Principe *et al.*, 1987) and has lasted until today with the historical eruptions of Vesuvius, Phlegraean Fields and Ischia (Principe *et al.*, 1987; Vezzoli, 1988). The volcanoes of the Gulf of Naples have been grouped, with other potash-rich volcanoes of Southern and Central Italy, in the Roman Comagmatic Province (Washington, 1906). The tectonic significance of this volcanism is still an open question: it has been interpreted as a shoshonitic member of an orogenic association related to converging plates (Ninkovich and Hays, 1972) or as the alkaline product of the initial stages of a continental rifting (Cundari and Le Maitre, 1970). Most probably these Quaternary volcanoes are related to the extensional tectonics caused by the opening of the Tyrrhenian Sea since Tortonian times (Scandone, 1978; Scandone *et al.*, 1991).

The structural setting of the carbonatic «basement» in the Gulf of Naples has been partly investigated by previous authors. Finetti and Morelli (1974), interpreting a grid of multichannel seismic reflection profiles, recognized the monoclinal structure of the basement in the submerged zone near the Sorrentina Peninsula and mapped some normal faults; their identification of the carbonatic «basement» in the Phlegraean area, where even 2800 m deep wells did not recover it (Rosi and Sbrana, 1987), seems excessive. On the mainland the alignments of parasitic cones on Somma-Vesuvius have revealed the existence of a system of appenninic (NW-SE) and anti-appenninic (SW-NE) regional faults (Principe *et al.*, 1987).

Aim of the present study is to give a complete picture of the geological and tectonic setting of the carbonatic «basement» in the Gulf of Naples and to suggest some possible uprising route for the volcanic products.

2. Seismic data aquisition

The single channel seismic reflection profiles here presented (fig. 2a) were collected in 1990 and 1991 with the CNR owned R/V Bannock for a research project regarding the Gulf of Naples. The participants in the project were the Institute of Oceanology of the Istituto Universitario Navale (Naples) and the Department of Earth Sciences of the University of Milan. To collect these profiles an unusual large sparker array (46 electrodes), designed at the Institute of Oceanology of the Istituto Universitario Navale (Naples), was employed. This particular kind of sparker allows the acquisition of seismic data in water depths ranging from 50 m to 1000 m, with a maximum penetration of about 1 s two-way travel time. In shallow water multiples prevent observation of reflections beyond a few tenths of a second two-way travel time. The resolution obtained with this seismic system is in the order of about 2 m. Some air gun profiles collected in the Gulf of Pozzuoli (fig. 2b) were interpreted in order to support the analysis of sparker profiles. Several seismic profiles collected by the Italian oil company (AGIP) on the south-eastern flank of the Somma-Vesuvius (fig. 2c) were also interpreted, in order to define the structural setting of the carbonatic basement on the mainland.

The interpretation of unmigrated seismic profiles was performed at the Department of Earth Sciences of the University of Milan. The identification of the acoustic basement was based on seismic facies, stratigraphic position and relationships with the nearby outcrops on the mainland. As part of the seismic profiles here studied were collected for private company projects (AGIP), original seismic lines are not shown, but only the line drawing. Line drawings were made by tracing enough of the major real events to produce faithful schematic representations of the actual sections.

Velocity analysis is available only for some air gun profiles. On its basis, a velocity of about 1700 m/s was considered representative for the Plio-Quaternary seismic units, about 2000 m/s for the Messinian seismic units and about 3000 m/s for the Mesozoic carbonates.

3. Seismic facies of the acoustic basement

The acoustic basement was identified in high resolution seismic reflection profiles in a submarine area bordering the Sorrentina Peninsula and the Island of Capri, while in the submarine area of the Pozzuoli Gulf and around the Island of Ischia the acoustic basement cannot be identified either in sparker on air gun profiles. On the mainland the acoustic basement can be recognized in seismic reflection profiles from the south-eastern flank of Mount Somma-Vesuvius.

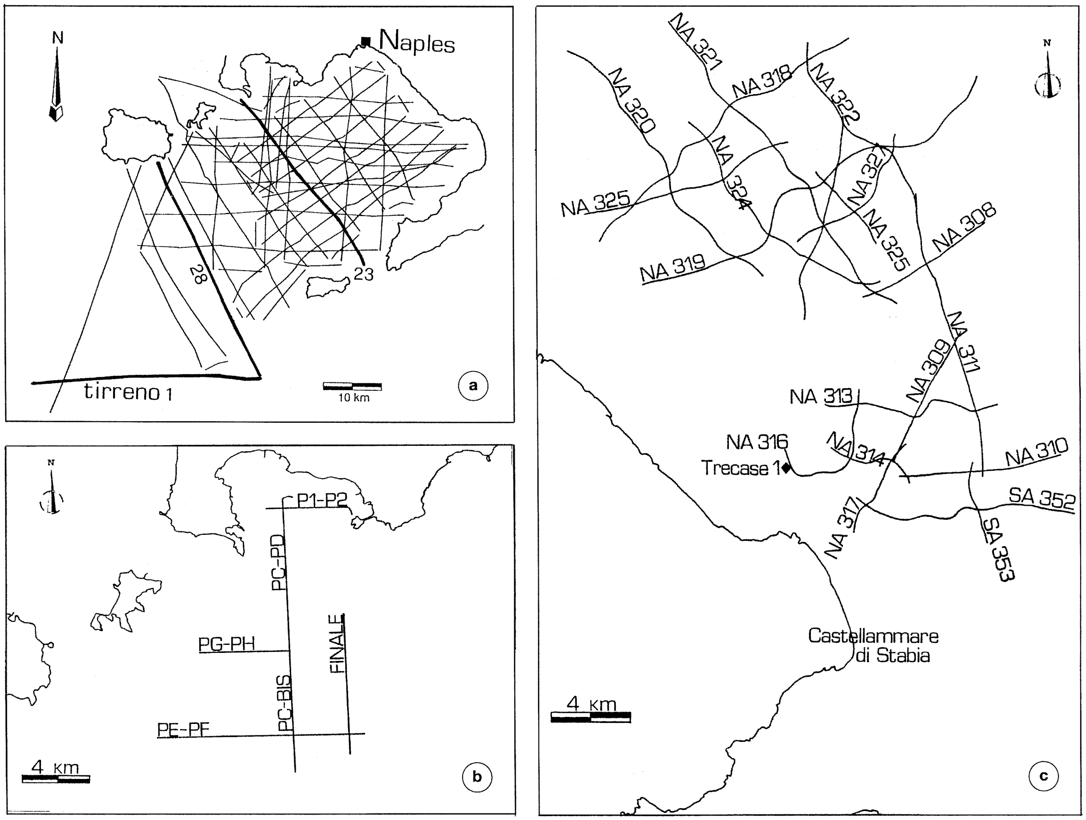


Fig. 2a,c. General location maps of seismic profiles analyzed in this paper: a) high resolution sparker seismic reflection profiles from the Gulf of Naples; b) water gun seismic reflection profiles from the Gulf of Pozzuoli; c) seismic reflection profiles from the south-eastern flank of Mount Somma-Vesuvius.

3.1. *Gulf of Naples marine area*

The seismic facies of the acoustic basement is characterized by chaotic reflectors with variable frequency and amplitude (unit «a» in fig. 3b). Near the mainland the top of this unit is marked by an erosional surface, while toward the centre of the gulf the acoustic basement is onlapped by the reflectors of a younger seismic unit (fig. 3a,b). The top of the acoustic basement dips to the north-west, that is toward the centre of the Gulf of Naples, the average dip being 10°. At about 5 km from the coast the acoustic basement is no longer recognisable in high resolution seismic reflection profiles, due to its dipping and to the presence of multiples.

In the centre of the gulf a topographic high of about 800 m is present, with its south-eastern flank steeper than the north-western one (fig. 4a,b). This submarine relief is called Banco di Fuori (Carta Geologica d'Italia., Sorrento-Isola di Capri, 1965). In high resolution seismic profiles it is characterized by a seismic unit with chaotic reflections, similar to that described for the acoustic basement in the submarine area around the Sorrentina Peninsula (fig. 3a,b).

a

b

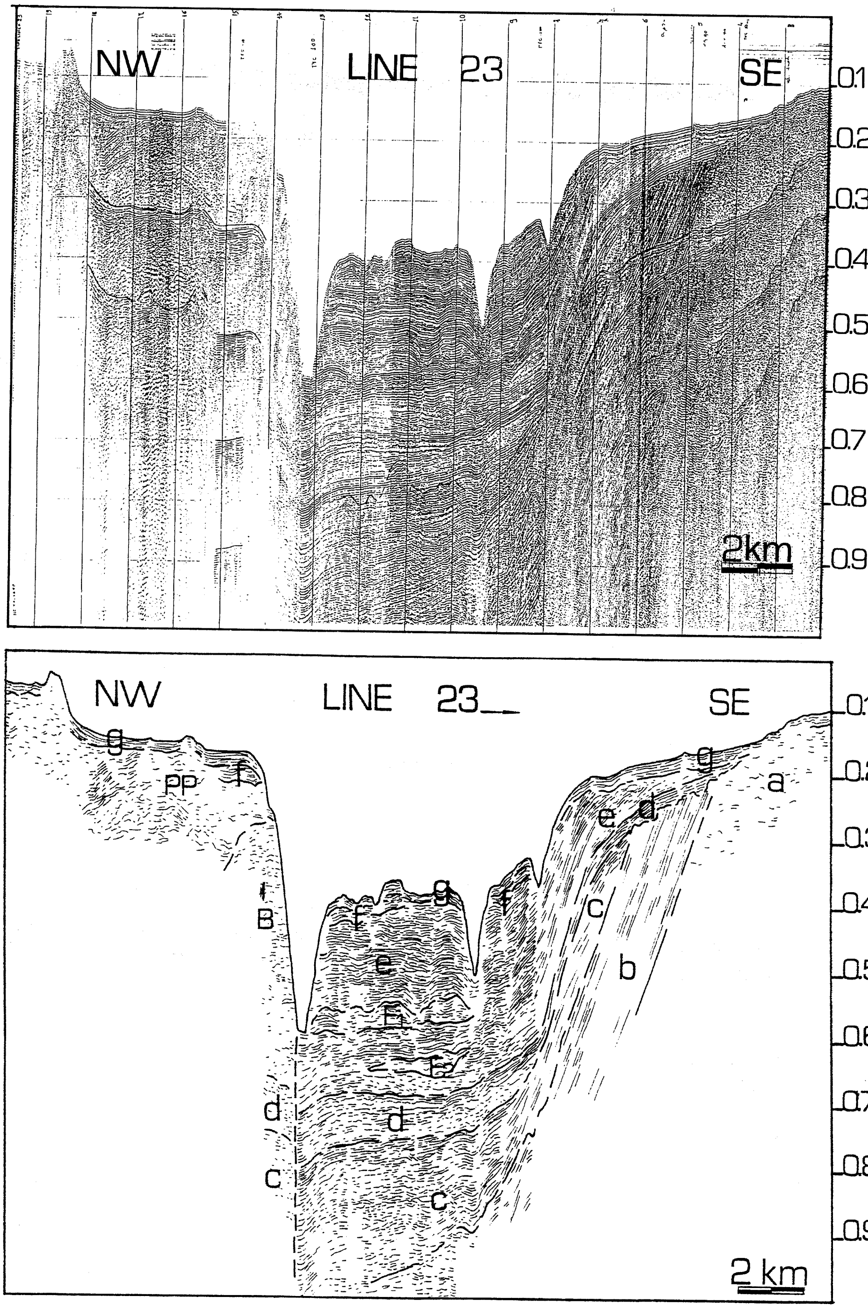
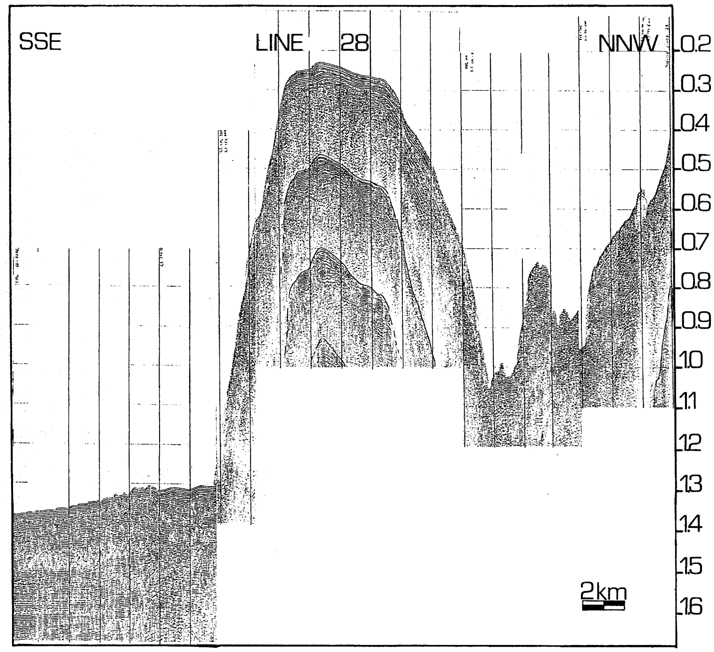


Fig. 3a,b. Line 23 (for location see fig. 2a). a) Uninterpreted sparker profile; b) line-drawing and interpretation: a = acoustic basement; b = Miocene arenites; the other letters indicate Plio-Quaternary sedimentary and volcanic seismic units (for their explanation see Fusi *et al.*, 1991). Vertical scale: seconds two way travel time.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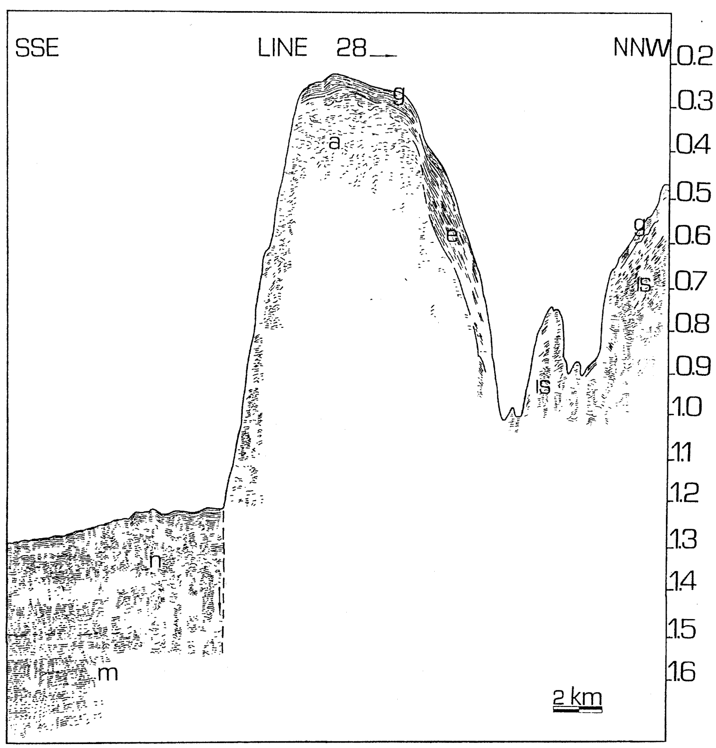
4 (a)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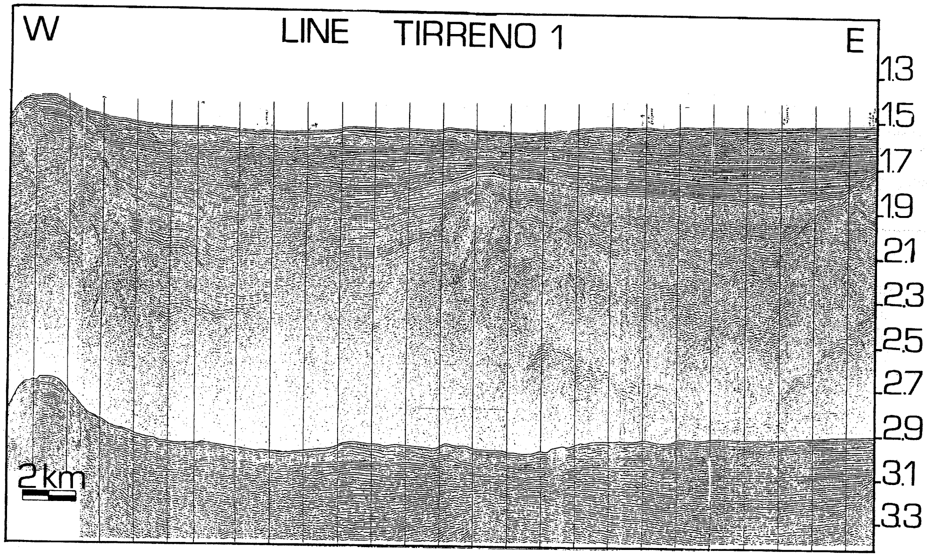
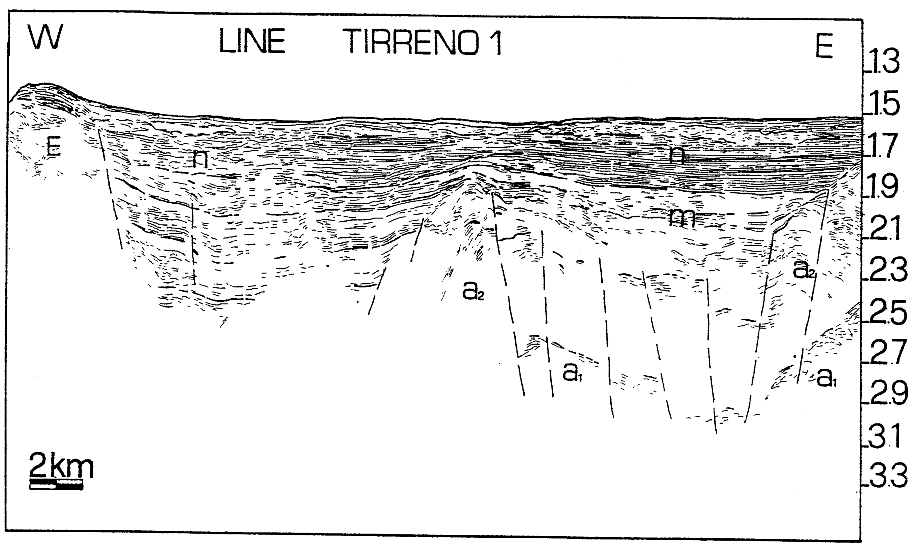


5 (a)



5 (b)

Fig. 4a,b. Line 28 (for location see fig. 2a). a) Uninterpreted sparker profile; b) line-drawing and interpretation: a = acoustic basement; b = Miocene arenites; IS = volcanic complex of Ischia; m = clastic Messinian unit (see also Scandone and Sgrosso, 1965); the other letters indicate Plio-Quaternary sedimentary seismic units (for their explanation see Fusi *et al.*, 1991). Vertical scale: seconds two way travel time.

Fig. 5a,b. Line Tirreno 1 (for location see fig. 2a). a) Uninterpreted sparker profile; b) line-drawing and interpretation: a = acoustic basement (a1 = lower sub-unit, a2 = upper sub-unit); m = clastic Messinian unit (see also Malinverno *et al.*, 1981); n = Plio-Quaternary seismic unit. Vertical scale: seconds two way travel time.

In high resolution seismic reflection profiles collected in the bathyal Tyrrhenian plain, where the penetration of the acoustic signal is of about 2 s due to the high depth of the water, the acoustic basement consists of two thick sub-units (a1 and a2, fig. 5a,b), both characterized by chaotic reflections, separated by an acoustically opaque interval. As the bottom of the acoustic basement is not visible, it is not possible to determine its real thickness; however, assuming an average seismic velocity of about 3000 m/s, it can be inferred that it is of at least 2000 m. In the bathyal Tyrrhenian plain this unit is affected by brittle extensional tectonics (fig. 5a,b), which generates horsts and grabens. Throws are in the order of 0.4 s (fig. 5a,b).

3.2. *Gulf of Pozzuoli marine area*

The Gulf of Pozzuoli marine area was investigated by means of sparker and air gun profiles. In sparker profiles the acoustic basement cannot be identified, while in air gun profiles it is recognisable only in the area far from the Gulf of Pozzuoli. Its seismic facies, characterized by chaotic reflectors with variable amplitude and frequency is similar to that described for the sparker profiles from the submarine area of the Gulf of Naples; sometimes a few continuous reflectors in the upper part of this unit show gentle folds (fig. 6), suturated by continuous reflectors of younger units. Some normal faults, with throws of a few tenths of seconds, cut these folds. The top of the acoustic basement is marked by a strong reflector or by an erosional surface (fig. 6).

3.3. *Mount Somma-Vesuvius area*

In most of the seismic reflection profiles collected from the SE flank of Mount Somma-Vesuvius the acoustic basement is composed of two different acoustic sub-units (figs. 7 and 8): 1) a lower sub-unit (al) characterized by chaotic reflectors, with low frequency and high amplitude; 2) an upper sub-unit (a2) characterized by chaotic reflectors with low amplitude. The two sub-units are separated by an acoustically opaque interval. At the top of the upper sub-unit (a2) a few continuous, gently folded reflectors were identified; these reflectors are truncated by an erosional surface, onlapped by continuous reflectors of more recent seismic units (fig. 7). In this area both the acoustic basement and the overlying more recent seis-

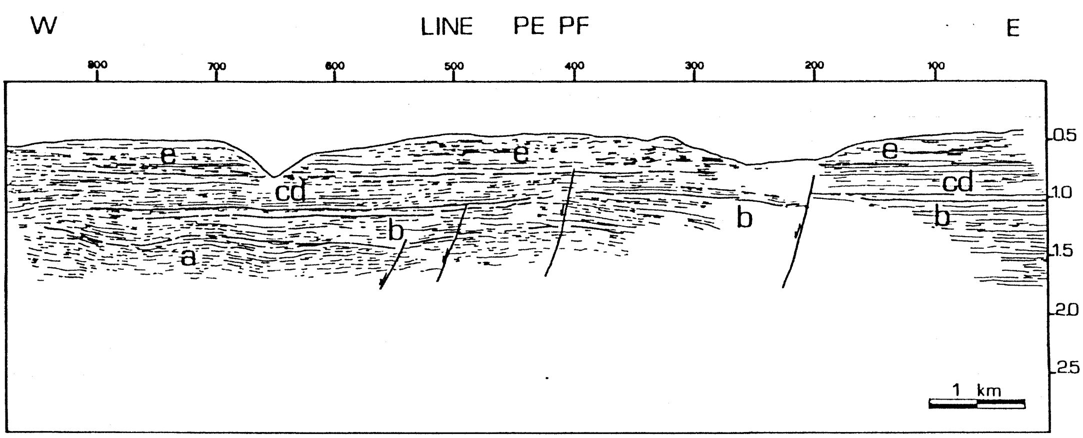


Fig. 6. Line PE PF (for location see fig. 2b): a = acoustic basement; b = Miocene arenites; the other letters indicate Plio-Quaternary sedimentary and volcanic units (for their explanation see Fusi *et al.*, 1991). Vertical scale: seconds two way travel time.

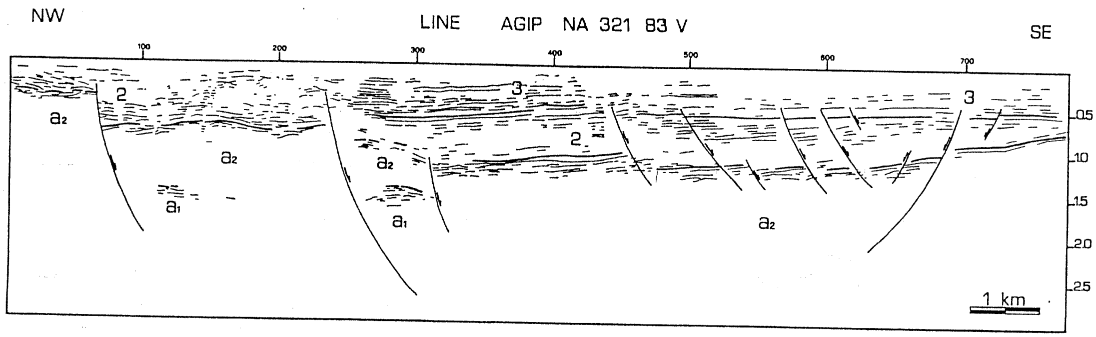


Fig. 7. Line NA 321 (for location see fig. 2c): a = acoustic basement (a1 = lower sub-unit, a2 = upper sub-unit); the other numbers indicate Plio-Quaternary sedimentary and volcanic units, as described in Trecase 1 well (Balducci *et al.*, 1976). Vertical scale: seconds two way travel time.

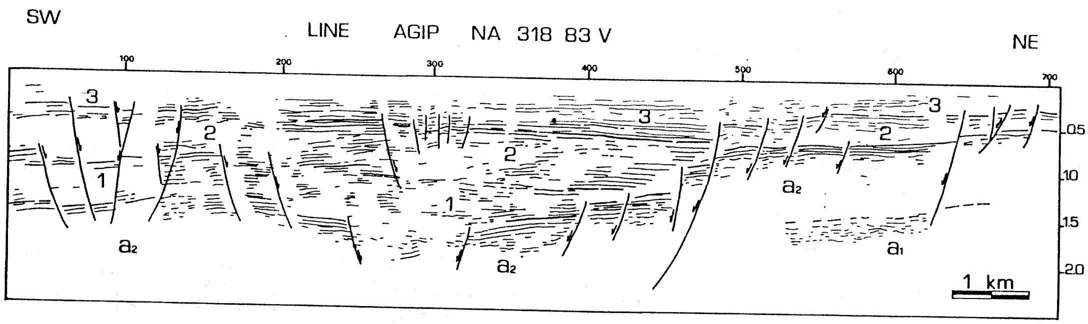


Fig. 8. Line NA 318 (for location see fig. 2c): a = acoustic basement (a1 = lower sub-unit, a2 = upper sub-unit); the other numbers indicate Plio-Quaternary sedimentary and volcanic units, as described in Trecase 1 well (Balducci *et al.*, 1976). Vertical scale: seconds two way travel time.

mic units are affected by brittle extensional tectonics. Two sets of conjugate normal faults, partly sealed by the reflectors of recent units and partly synsedimentary with these seismic units, can be seen. The master fault, with throws in the order of 0.5 s, dips southward.

4. Discussion

The acoustic basement has been interpreted as the carbonatic «basement», due to the direct correlation between seismic profiles and outcrops of the carbonatic «basement» both around the Campanian Plain and on the Sorrentina Peninsula (Carta Geologica d'Italia, Sorrento-Isola di Capri, 1965; Carta Geologica d'Italia, Amalfi, 1965). The two sub-units (a1 and a2) recognized in the acoustic basement on the south-western flank of Mount Somma-Vesuvius (figs. 7 and 8) and in the bathyal Tyrrhenian Plain (fig. 5a,b) have been interpreted as different acoustic facies due to a different degree in dolomitisation. On the basis of stratigraphic position, in fact, the lower sub-unit seems to correspond to Triassic and Jurassic limestones, which are highly dolomized, while the upper sub-unit to Cretaceous limestones, where no dolomitisation phenomena occurred (Carta Geologica d'Italia, Sorrento-Isola di Capri, 1965; Carta Geologica d'Italia, Amalfi, 1965). The gentle folds sometimes recognisable at the top of the carbonatic basement (figs. 5a,b, 6 and 7) have been related to some slumpings recognized at the top of the Mesozoic sequence on the mainland (Scandone and Sgrosso, 1965). In fact, these folds affect only a particular stratigraphic interval at the top of the acoustic basement, while younger and older units are unaffected.

The general setting of the carbonatic «basement» has been reconstructed in two isochrone maps (figs. 9a and 10a). A three-dimensional view of the isochrone map, with the vertical scale exaggerated by a factor of 6, is also shown (figs. 9b and 10b).

4.1. *Gulf of Naples marine area*

The carbonatic «basement» sinks regularly from the Sorrentina Peninsula toward the north-west, that is toward the centre of the Gulf of Naples and the Gulf of Pozzuoli, reaching at least the 1.4 s isochrone (fig. 9a,b), corresponding to a depth of about 1100 m. The general structure of the carbonatic «basement» is thus a monocline, dipping north-west with an angle of about 10°. In the south-western part of the gulf an abrupt rising of the carbonatic «basement» has been identified (fig. 9a,b). This rising coincides with a submarine positive topographic feature, called Banco di Fuori (Carta Geologica d'Italia, Sorrento-Isola di Capri, 1965). Its peculiar asymmetry, with the south-eastern flank steeper than the north-western one, and its seismic facies, with chaotic reflections, support the interpretation of this submarine topographic high as a carbonatic horst.

The south-eastern flank of Banco di Fuori is affected by a normal fault (fig. 11), trending N10°. The Banco di Fuori fault divides the submarine part of the Gulf of Naples into two completely different parts: 1) the western part, which can be considered a volcanic field; here, in fact, the Phlegraean Fields, the volcanic islands of Ischia, Procida and Vivara and several submarine volcanoes (Fusi *et al.*, 1991) are located; 2) the eastern part, characterized only by sedimentary units with a monoclinal structure (Fusi *et al.*, 1991).

South of the Sorrentina Peninsula and the Island of Capri the abrupt sinking of the isochrones from 0.1 to 1.7 s, corresponding to about 1400 m, identifies a normal fault, trending N70° (fig. 10a,b). In this interpretation, this fault joins the so-called Capri-Vulture Line on the mainland (Fusi and Garduno, 1992). No evidence for the NE-SW trending «vesuvian faults» (Finetti and Morelli, 1974) were found. The Capri-Vulture fault has the same trend as the normal fault bordering the SE side of the Campanian Plain (fig. 11).

A short fault, trending north-south, borders the western side of the Island of Capri, with throw of about 0.6 s.

The N10° Banco di Fuori fault and the N70° Capri-Vulture fault dissect the carbonatic «basement» of the Gulf of Naples, causing a horst and graben-like structure (fig. 12). As at least five submarine recent volcanoes are aligned along the Banco di Fuori fault (Fusi and Garduno, 1992) (fig. 11), this fault can be considered one of the main uprising routes for magma in the Gulf of Naples. The arrangement of this fault is radial with respect to the volcanic area of the Phlegraean Fields, where a shallow magmatic chamber is recognized (Dvorak and Mastrolorenzo, 1991; Cortini *et al.*, 1991). The Banco di Fuori fault is also radial with respect to the Acerra graben, a volcanic depression, along whose borders the active volcanoes of the Gulf of Naples are located (Scandone *et al.*, 1991; Scarpati *et al.*, 1993).

The Capri-Vulture fault borders the Gulf of Naples to the south and separates it from the Gulf of Salerno (Bartole, 1984; Sacchi *et al.*, 1995) (fig. 11), characterized by different sedimentary characters, such as the presence of Messinian evaporites in the sedimentary sequence (Finetti and Morelli, 1974), and completely lacking volcanism. This fault is a different tectonic feature, as it has no relationship with the Phlegraean magmatic chamber and plays no role in magma uprising.

4.2. *Gulf of Pozzuoli marine area*

In the north-western part of the Gulf of Naples, near the volcanic area of the Island of Ischia and Phlegraean Fields, the carbonatic

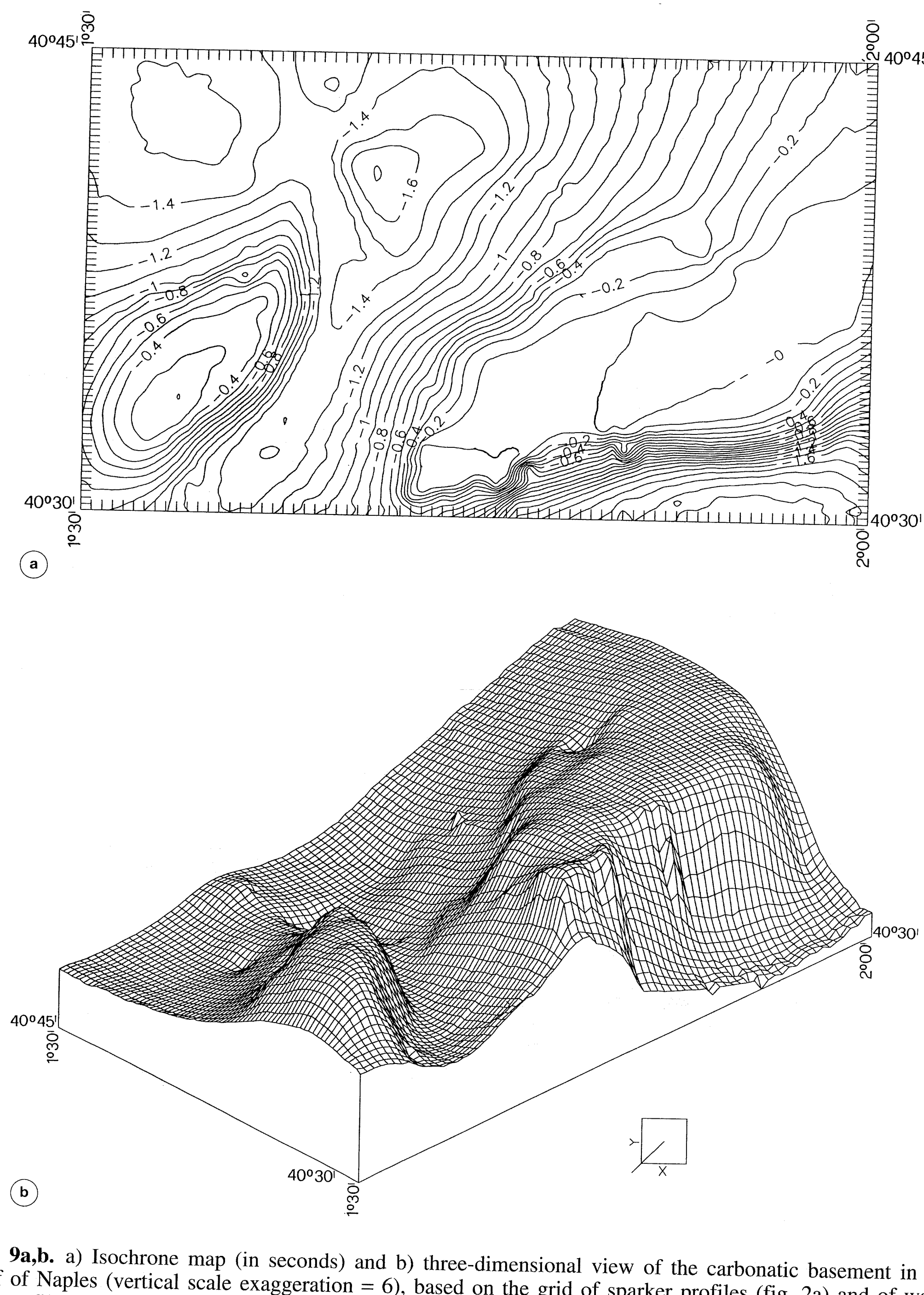


Fig. 9a,b. a) Isochrone map (in seconds) and b) three-dimensional view of the carbonatic basement in the Gulf of Naples (vertical scale exaggeration = 6), based on the grid of sparker profiles (fig. 2a) and of water gun profiles (fig. 2b). Isochrone 0 coincides with coast of the Sorrentina Peninsula and Capri.

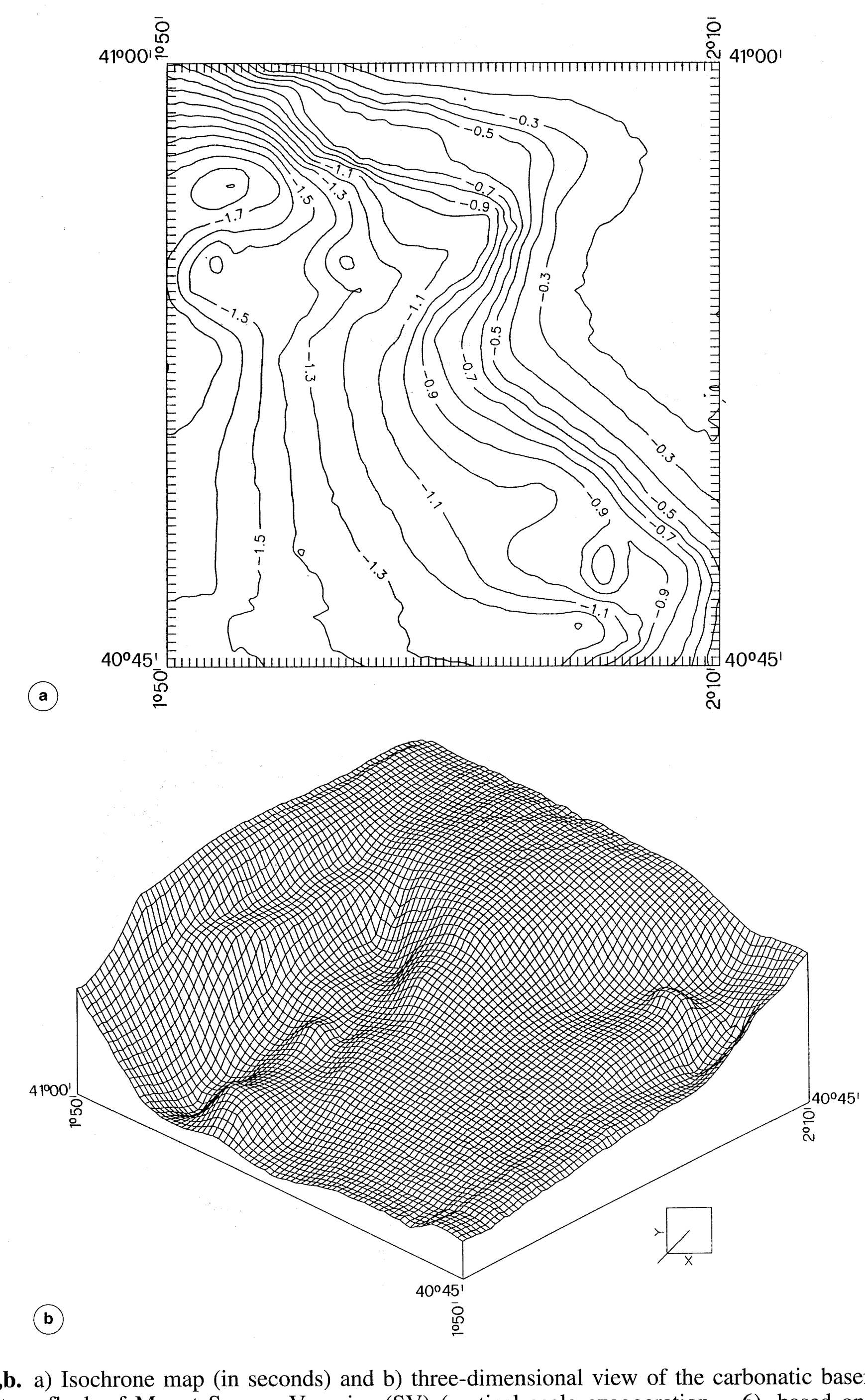


Fig. 10a,b. a) Isochrone map (in seconds) and b) three-dimensional view of the carbonatic basement on the south-eastern flank of Mount Somma-Vesuvius (SV) (vertical scale exaggeration = 6), based on the grid of seismic reflection profiles of fig. 2c.

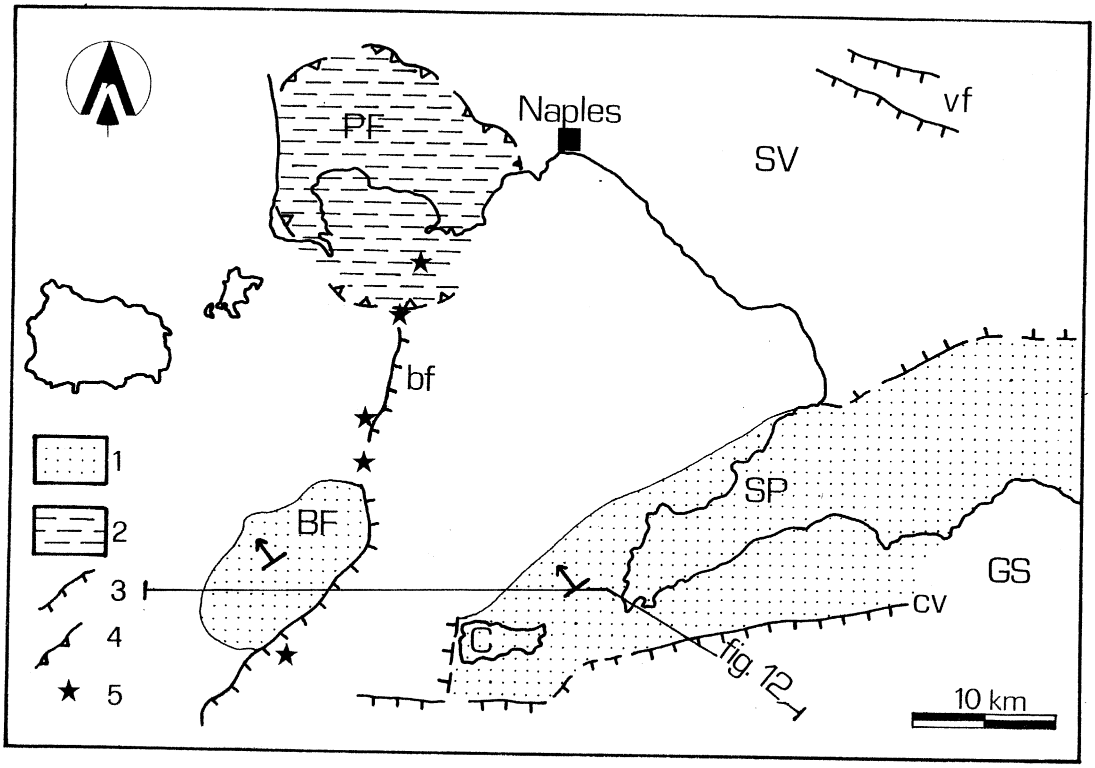


Fig. 11. Structural sketch map of the Gulf of Naples: 1 = outcropping carbonatic basement (arrows indicate the dipping); 2 = Phlegraean Fields caldera, where the shallow magmatic chamber is thought to be located; 3 = normal fault; 4 = border of the Phlegraean Fields caldera; 5 = submarine volcanoes (after Fusi *et al.*, 1991); PF = Phlegraean Fields; SV = Somma-Vesuvius; SP = Sorrentina Peninsula; GS = Gulf of Salerno; C = Capri; BF = Banco di Fuori; bf = Banco di Fuori fault; vf = vesuvian faults; cv = Capri-Vulture fault.

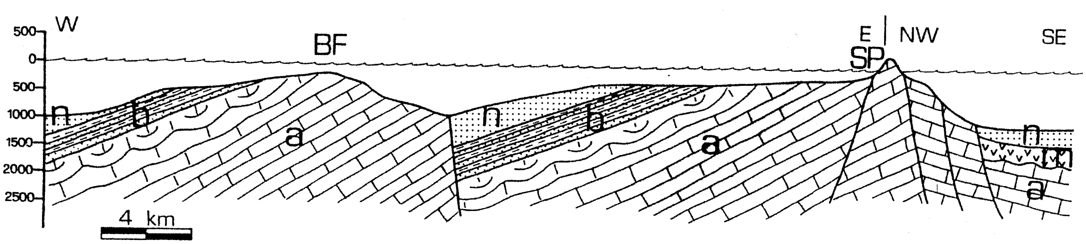


Fig. 12. Cross section of a sector of the Gulf of Naples (location in fig. 11), showing the horst and graben structure: BF = Banco di Fuori; SP = Sorrentina Peninsula; a = acoustic basement; b = Miocene arenites; m = Messianian clastic unit; the other letters indicate Plio-Quaternary sedimentary seismic units (for their explanation see Fusi *et al.*, 1991).

«basement» cannot be recognized in air gun profiles with penetration of about 2 s. It is the author's opinion that the interpretation of the carbonatic «basement» in the Phlegraean area by (Finetti and Morelli, 1974) is exaggerated; in the multichannel seismic reflection profiles of this area, in fact, it is difficult to recognise the reflector corresponding to the top of the carbonatic basement. Furthermore, in the Phlegraean Fields the carbonatic basement was not recovered even in a 2800 m deep borehole (Rosi and Sbrana, 1987).

To explain the absence of the carbonatic basement both in seismic profiles and in wells, the presence of an important tectonic feature can be inferred offsetting the basement by several thousand metres below the Gulf of Pozzuoli (fig. 13). No evidence of this tectonic feature was found in the seismic survey here presented, probably due to the scarce penetration of seismics. However, the working hypothesis suggested on the basis of the data available is that an east-west fault located south of the Island of Ischia could be responsible for the dislocation of the carbonatic «basement». This tectonic feature could be concentric with respect to the Phlegraean Fields shallow magmatic chamber.

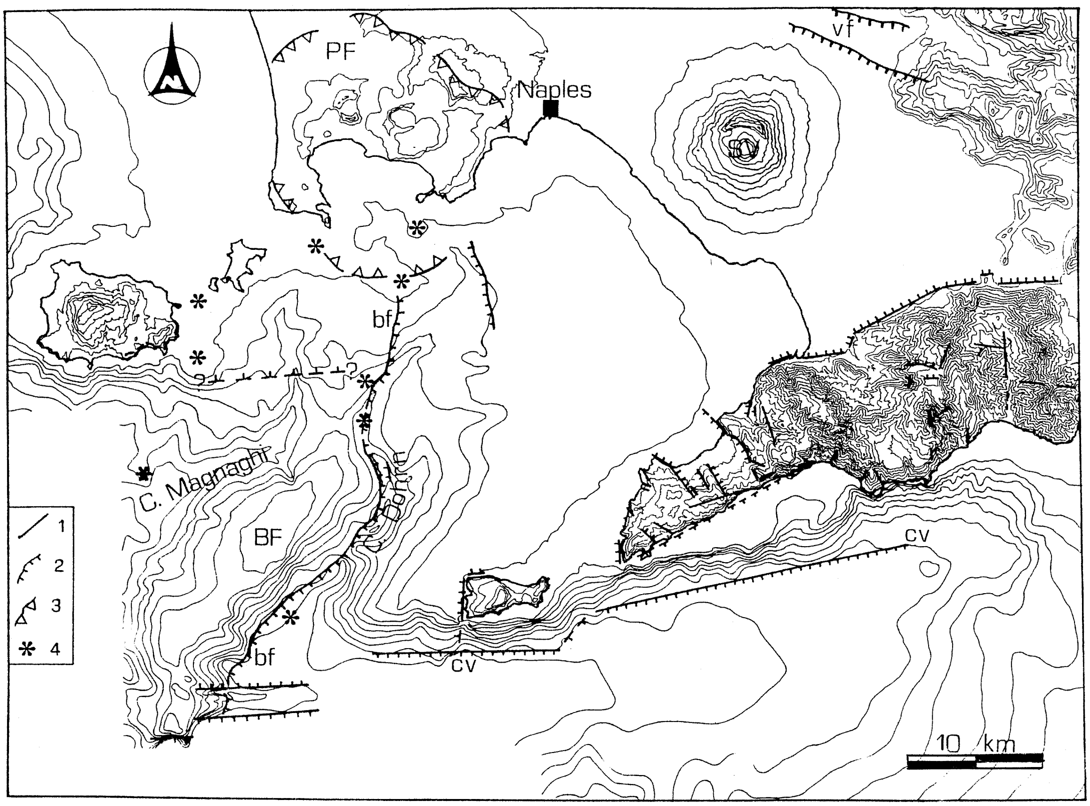


Fig. 13. Morphostructural map of the mainland and marine sectors (isobaths and isoipleths every 100 m): 1 = lineaments after aerial photographs; 2 = normal fault; 3 = border of the Phlegraean Fields caldera; 4 = submarine volcanoes (after Fusi *et al.*, 1991); PF = Phlegraean Fields; SV = Somma-Vesuvius; BF = Banco di Fuori; bf = Banco di Fuori fault; vf = vesuvian faults; cv = Capri-Vulture fault; ? = hypothetic fault, lowering the carbonatic «basement» toward the Phlegraean Fields.

4.3. *Mount Somma-Vesuvius area*

The isochrone map in the area of Mount Somma-Vesuvius shows that the carbonatic «basement» sinks from E to W, that is from the carbonatic hills around the Campanian Plain below Mount Somma-Vesuvius (fig. 10a,b); this regular sinking matches the monoclinal structure identified in the Gulf of Naples. Some structures are superimposed on this monocline: 1) in the north-western area, a depression of about 1.70 s is present (fig. 10a), which is related to the Acerra graben (Cassano and La Torre, 1987; Scandone *et al.*, 1991;); 2) in the south-eastern area the isochrones tilt in an east-west direction (fig. 10a), identifying the Pompei graben (Cassano and La Torre, 1987); 3) an important fault, composed of two steps and trending N110° can be seen in the northern area of fig. 10a («v» in fig. 11); the throw of this fault is of about 0.80 s, corresponding to about 800 m. Further south the carbonatic «basement» is much deeper, as testified by Trecase 1 well (AGIP), the only one available in the study area, where Mesozoic gray dolomites were recovered at 1889 m depth (Balducci *et al.*, 1976). The isochrone map shown in fig. 10a,b. is supported by the map of resistive basement obtained through geoelectrical surveying data (Cassano and La Torre, 1987).

The seismic reflection profiles below Mount Somma-Vesuvius show that the extensional tectonics is very recent, as all the sedimentary sequences are affected by normal faults (figs. 7 and 8). On the basis of a mesostructural survey on the Sorrentina Peninsula it has been demonstrated that an anticlockwise rotation of the axis of extension from east-west to north-south occurred since Pliocene (Fusi and Garduno, 1992). The E-W extension has been related to the opening of the Tyrrhenian Sea (Fusi and Garduno, 1992), while the more recent north-south extension has been tentatively related to a local radial extension due to the uprising of the asthenosphere in the area of Phlegraean Fields (Fusi and Garduno, 1992). Assuming this hypothesis, both the east-west and the north-south systems of normal faults can be considered active.

Although in the area of Mount Somma-Vesuvius the relationship between the east-west system of normal faults and the volcano is not clear, it can be inferred that this important system is the main route of uprising of the magma. These faults have a radial trend with respect to the active volcanic area of the Gulf of Naples (Phlegraean Fields and Mount Somma-Vesuvius).

5. Conclusions

The general structure of the carbonatic «basement» in the Gulf of Naples is a monocline dipping toward north-west, that is toward the Phlegraean Fields, with an angle of about 10° (fig. 11). This monocline is dissected by some normal faults with a regional relevance, which cause a horst and graben-like structure (fig. 12): 1) the Capri-Vulture fault, trending N70° (fig. 11), which causes the abrupt sinking of the carbonatic «basement» south of the Sorrento Peninsula (figs. 9a,b) and separates the Gulf of Naples from the Gulf of Salerno, which completely lacks volcanism; this fault plays no role in magma uprising; 2) the N110° vesuvian faults (fig. 11), which cause the abrupt sinking of the carbonatic basement below Mount Somma-Vesuvius (fig. 10a,b); these faults, arranged radially with respect to the active volcanic area of Somma-Vesuvius and Phlegraean Fields, are interpreted as important ways of uprising for the magma; 4) the Banco di Fuori fault, bordering the submarine carbonatic horst of Banco di Fuori and trending N10° (fig. 11) and along which five submarine volcanoes are aligned (Fusi *et al.*, 1991); this fault, which is a preferential way of magma uprising, is arranged radially with respect to the shallow magmatic chamber of Phlegraean Fields.

The structural setting of the carbonatic basement in the Gulf of Naples is related to the extension of the Tyrrhenian Sea (Malinverno and Ryan, 1985), which caused a horst and graben-like structure. The trending of the Banco di Fuori fault is analogous to that of the Central Fault of the Tyrrhenian Sea (Rehault *et al.*, 1987); on the other side the east-west system of faults, such as the vesuvian faults and the Capri-Vulture fault can be related to a local north-south extension (Fusi and Garduno, 1992), due to the presence of a shallow magmatic chamber in the Phlegraean Fields area (Dvorak and Mastrolorenzo, 1991; Cortini *et al.*, 1991). Both system of faults can be considered active assuming the hypothesis of a local radial extension connnected to the uprising of the asthenosphere in the area of Phlegraean Fields. Only the Banco di Fuori fault and the vesuvian faults, directly connected with the Phlegraean area and arranged radially with respect to it, represent a preferential uprising route for magma.

An important tectonic feature, probably located south of the Island of Ischia and concentric with respect to the Phlegraean Fields caldera, is hypothesized to explain the absence of the carbonatic basement in the Phlegraean area, both in seismic reflection profiles with 2 s penetration and in 2800 m deep wells.

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