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A new view of Italian seismicity using 20 years of instrumental recordings

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Abstract

In this paper, we show the seismicity of the past 20 years that occurred in Italy and surrounding regions. Hypocentral locations have been obtained by using P- and S-wave arrival times from the INGV national and several regional permanent seismic networks. More than 48,000 events, selected from an original data set of about 99,780, are used to reconstruct the most complete seismic picture of the Italian region so far. The seismicity distribution allows inference on seismotectonics of this complex region of subduction versus continental collision. Our results clearly reveal the geometry of the Adria and the Ionian subduction and a continuous normal fault belt in the upper crust, following the Apennines mountain range. The depth of the seismogenic layer is computed from the cut-off of seismicity at depth and shows large variations along and across the seismic active regions. Earthquakes are generated by the different velocity of slab retreat and the subsequent asthenospheric upwelling.

Keywords: Italian seismicity; Seismotectonics; Adria lithosphere geometry; Slab geometry

1. Introduction

The tectonics of Italy is controlled by the relative motions between Africa and Eurasia plates, accommodated by a puzzle of tectonic units developed during the subduction and collision of the Alpine and Apennine belts (Dercourt et al., 1986; Malinverno and Ryan, 1986; Doglioni et al., 1994; Patacca et al., 1990). Tomographic images show that the initially continuous Apennines subduction has been segmented into different arcs, due to the nature of the subducting material (Lucente et al., 1999; Piromallo and Morelli, 2003; Margheriti et al., 2003) in agreement with geologic reconstruction (Patacca and Scandone, 1987). Seismological data and recent geodetic studies reveal that the Apennines are undergoing a NE-trending extension, with seismic deformation rates higher in the southern Apennines (Anderson and Jackson, 1987; Westaway, 1992; Pondrelli et al., 2002; Hunstad et al., 2002). At present, the convergence between Africa and Eurasia is accommodated by a complex deformation of the

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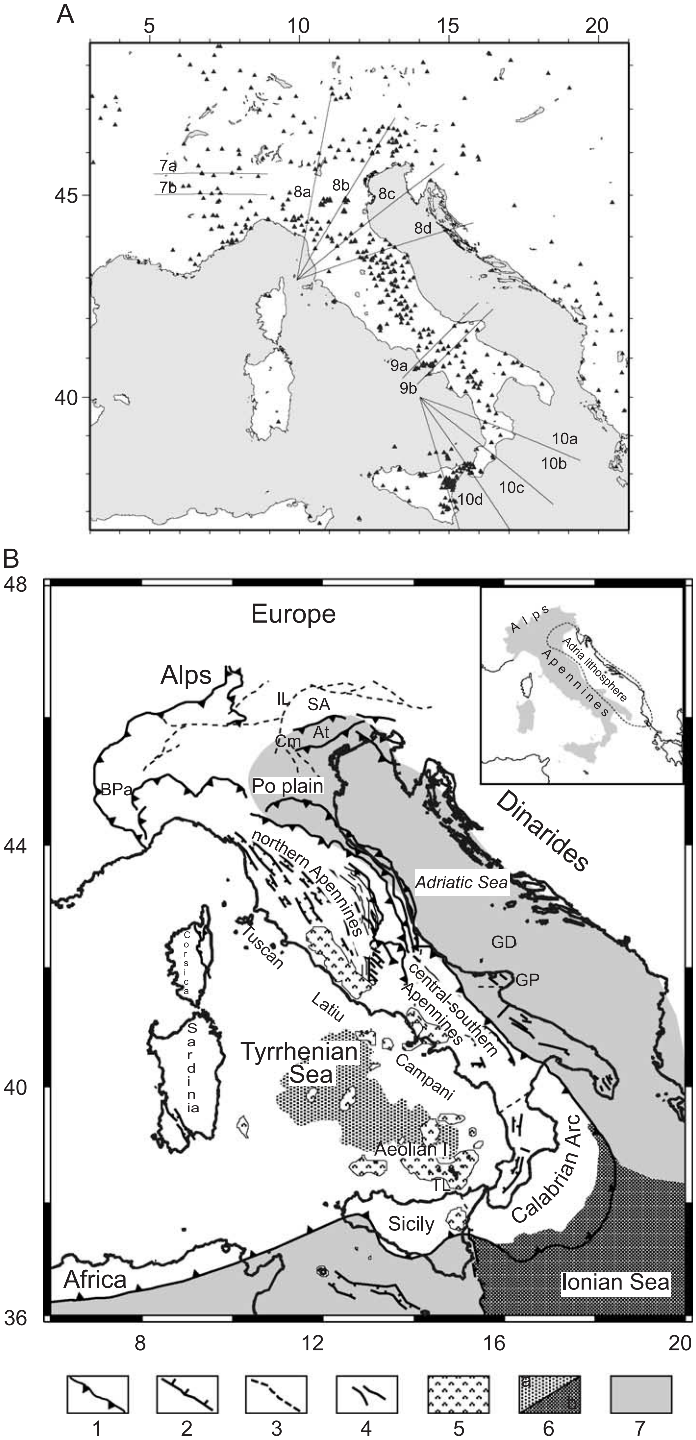

Fig. 1. (a) Distribution of permanent seismic stations used in this study and managed by different Italian and European Institutions. The traces of vertical sections of Figs. 7–10 are shown in the map. (b) Structural sketch of the Italian region, including the main geographical and tectonic references, modified from Margheriti et al. (2003).

Alps and Apennine systems due to the fragmentation of the west-dipping slab (Royden et al., 1987). Contemporaneously to a compression in the external front of the Apennines, extension developed within the mountain range accommodated by moderate and large normal faulting earthquakes along the Apennines (Pantosti et al., 1996; Montone et al., 1999; Pondrelli et al., 2002, among many others).

In this work, we have analysed the past 20 years of seismicity recorded by the several permanent seismic networks that operated in Italy and surrounding countries. We compute a complete picture of earthquake occurrence, yielding new constraints for the understanding of seismotectonics. P- and S-wave arrival times from previously computed seismic catalogue[1] (CSTI working group, 2001) along with new associations of P- and S-wave arrivals from all possible networks for earthquakes in the period 1997–2002 were used to relocate more than 73,500 earthquakes with an homogeneous procedure, adapting and optimizing location parameters.

2. Earthquake catalogue and location procedure

The first step of this study was the creation of a catalogue of P- and S-wave arrival times for the period 1997–2002, including data from the INGV national network and several regional networks (Fig. 1). All the arrival times were associated, based on those by individual networks and propagation times for P-wave, and carefully re-analysed to find possible errors or inconsistencies. Our final data set consists of about 791,000 and 616,000 P-wave arrivals recorded at 467 and 411 stations for the periods 1981–1996 and 1997–2002, respectively, and 609,013 S-wave arrivals for the whole period. We have computed the magnitude for about 86% of the 99,780 events by using the duration of earthquakes contained in the bulletins, as estimated by the national and regional network analysts.

To simplify the process of earthquake location for such a huge data set, we preferred the use of an optimized 1D velocity model and a unique Vp/Vs value equal to 1.8 (Fig. 2), selected considering the available information on the regional structure (Kissling, 1993; Scarascia et al., 1994; Di Stefano et al., 1999). The validity of our choice is demonstrated by the fact that the simple 1D velocity model yields a very good match of arrival times after earthquake location.

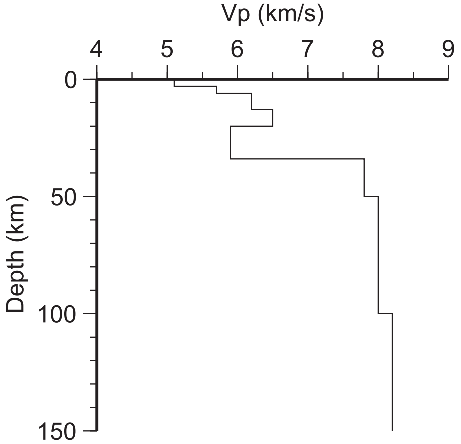

Fig. 2. P-wave velocity model used for the earthquake location, derived from the available information on the deep structure. The main feature is a velocity inversion in the lower crust (Vp=5.6 km/s, while Vp is higher than 6.0 km/s in the uppermost crust).

In locating events, we had to satisfy two opposite cases: (1) earthquakes falling in areas with a dense distribution of seismic stations (i.e., central-northern Apennine) and (2) events in areas where the closer stations are located at distance larger than 80 km (i.e., the southern Tyrrhenian). To obtain the best possible location, we cautiously selected the location weighting parameters. The availability of high quality P- and S-wave arrivals from dense temporary networks allowed us to finely tune the location parameters until similar locations were obtained, using local and regional data separately. We performed several trials, by varying the distance and residual weights. For case 1, we used sharp weighting parameters to enhance the information at close stations. For case 2, we used smooth weighting parameters to locate events recorded only at a few and distant seismic stations. Our choice of final location for both procedures is based on the final rms residual. P-wave residuals after the 1D location are very small (Fig. 3), more than 90% is less than 1 s, confirming the validity of the simple 1D model. S-wave residuals are higher, because most of the S-wave arrivals were read on vertical seismograms. Therefore, we decided to down-weight the S-wave data. Location rms are on average less than 0.6 s and formal hypocentral errors are smaller than 2–4 km for most of the events. The

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[1] The seismic catalogue can be retrieved on the web.

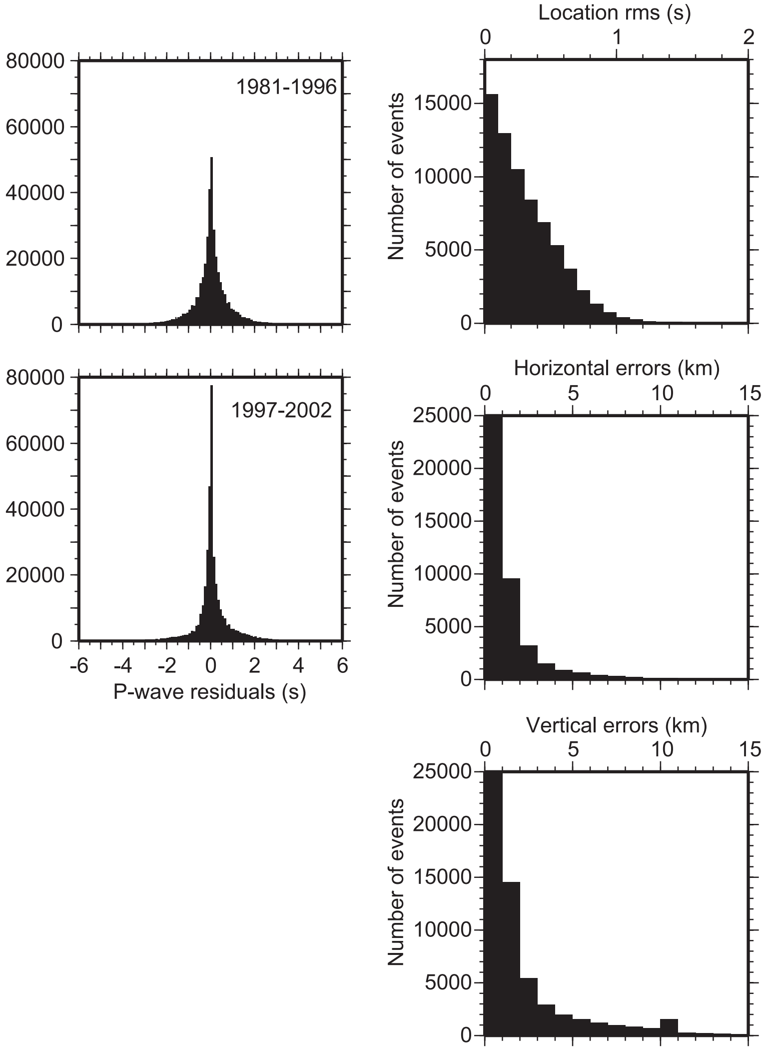

Fig. 3. On the left, histograms of P-wave residuals showing the improvement of location for the 1997–2002 with respect to the 1981–1996 period. Most of the residuals are less than 1 s, showing the first-order goodness of the used velocity model. On the right, final location rms, horizontal and vertical errors for the locations of the whole data set. Formal location errors are less than 2 and 4 km for horizontal and vertical coordinates, respectively.

majority of upper crustal events have location rms smaller than 0.2–0.4 s and errors less than 2 km (Fig. 3). Higher location rms values and errors are observed for the deep earthquakes and for events with an azimuthal gap larger than 180°, located mostly around the Italian peninsula. The comparison between 1D and 3D locations (improved by using local data) shows that the hypocentral depth of upper crustal events is less constrained with bulletin data. Most of the hypocentral improvements is due to the availability of high-quality readings at close stations of dense temporary networks. To improve earthquake locations in the future, the use of accurate 3D velocity models is a key, but only along with higher quality, re-analysed P- and S-wave arrivals.

3. Italian seismicity

Fig. 4 shows the distribution of about 45,000 earthquakes which have a location rms smaller than

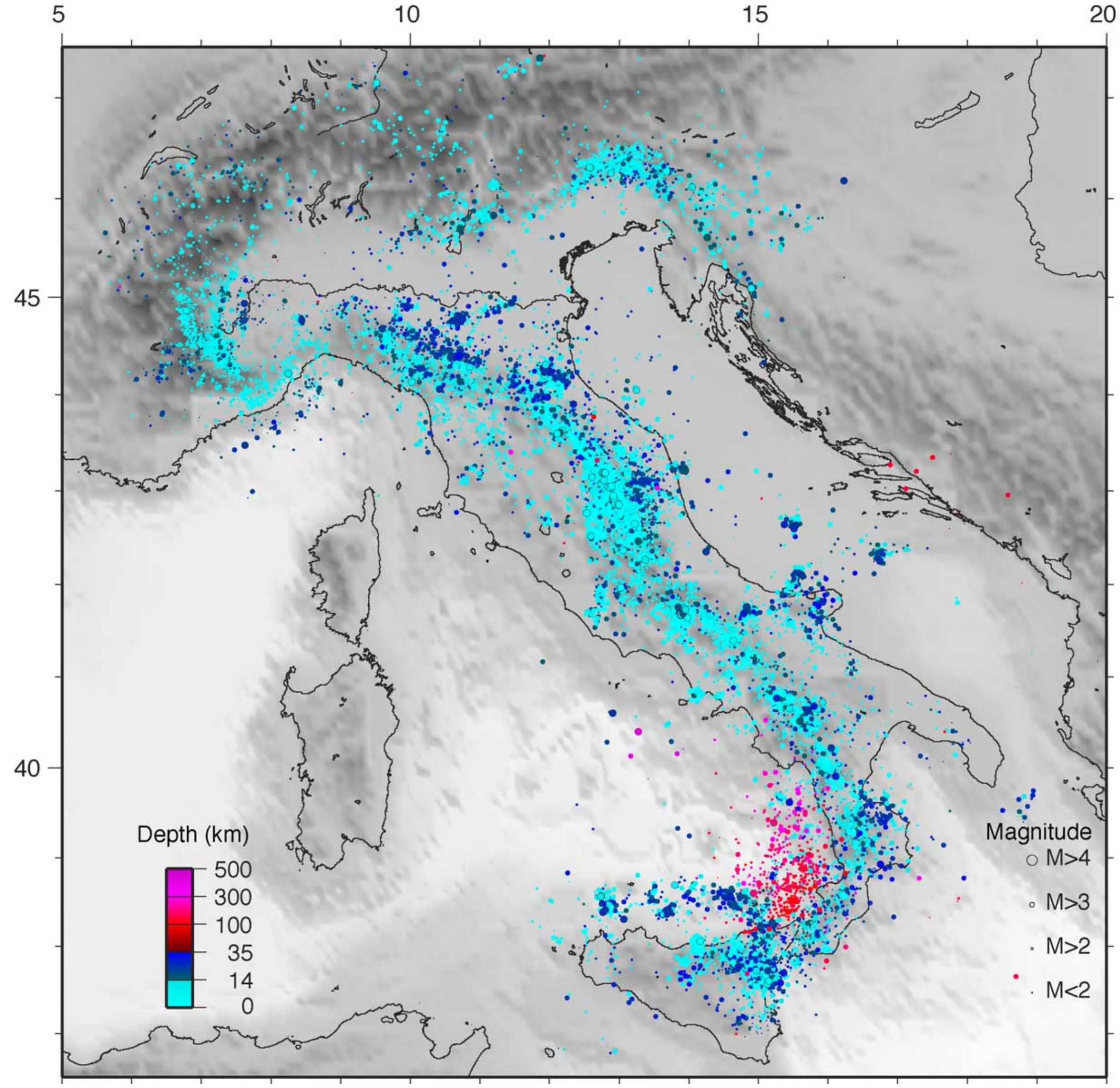

Fig. 4. Hypocentral distribution of the about 45,000 selected events. Colour scale, continuously varying, indicates the depth of events (blue colours for the crustal seismicity and red colours for the mantle seismicity). The different size of circles is given by the magnitude scale indicated on the lower right corner.

0.8 s, epicentral errors less than 4 km (6–10 km for deep earthquakes) and an azimuthal gap less than 180° and 240° for shallow crustal and deep events, respectively. The main features revealed by the instrumental seismicity are:

- a continuous belt of upper crustal seismicity beneath the Apennines,
- a continuous region of deep crustal events to the east of the upper crustal seismic belt (Fig. 5a),
- subcrustal earthquakes beneath the northern Apennines, the Calabrian arc, and sporadically in the Alps (Fig. 5b).

We discuss separately the main seismic regions. Vertical sections are drown across the main seismogenic

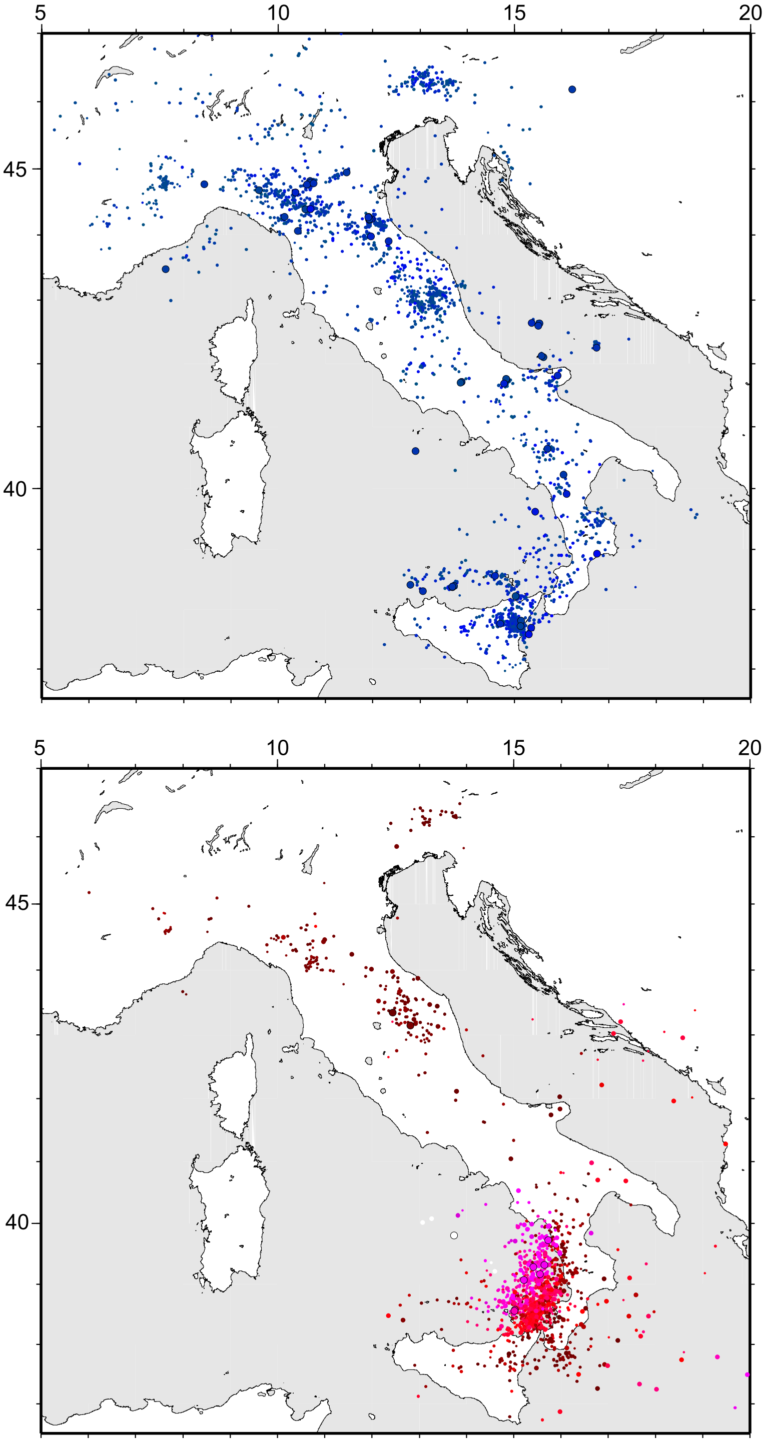

Fig. 5. Epicentral distribution of deep crustal (a) and sub-crustal (b) earthquakes. The deep-crustal seismicity delineates the limits of the Adria lithosphere. Sub-crustal seismicity is confined in the northern Apennines, identifying a broad NW-trending structure, and in the Calabrian arc.

regions, considering only earthquakes with hypocentral errors less than 2 km (6–10 km for deep earthquakes). To discuss the cinematic within the seismic regions, focal mechanisms of large magnitude events (M>4.5) from the Harvard CMT catalogue and regional Centroid Moment Tensors (Pondrelli et al., 2002) are shown in Fig. 6.

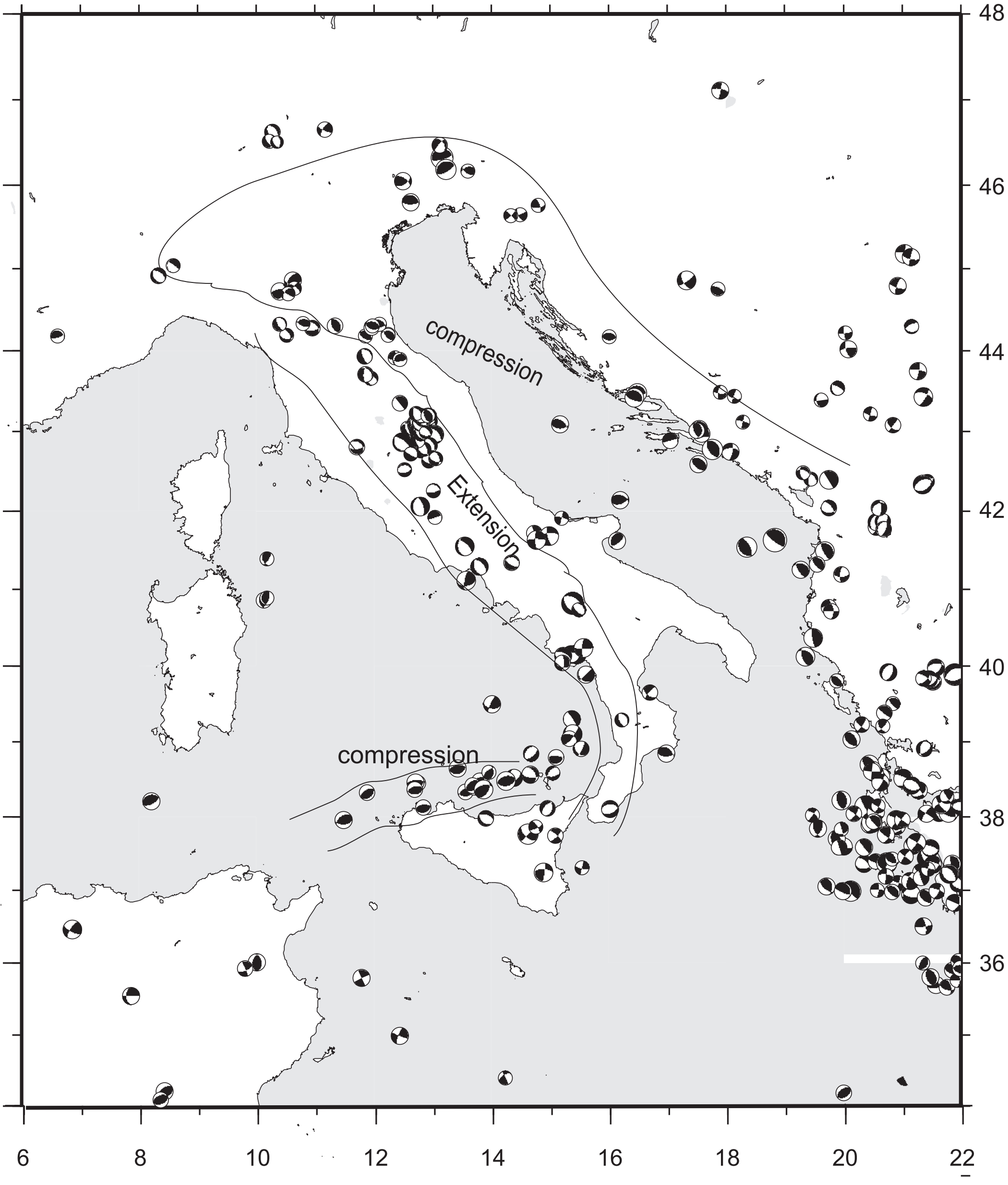

Fig. 6. CMT (Harvard) and RCMT (Pondrelli et al., 2002) solutions for the M>4.5 seismicity since 1976. The extension along the Apennines belt and the compression around the Adria lithosphere and in the northern Sicily offshore are evident.

3.1. The Alps

The seismicity is abundant and clustered in the eastern and western Alps, while it is sparse in the central Alps (Fig. 4), probably reflecting the density of seismic stations. In the western Alps, we note two main arc-like strips of events with M_d usually smaller than 3.0 that follow the mountain range, namely the Briançonnais and Piemontais arcs (Fig. 7). A radial extension characterizes the present day tectonics of the inner belt, suggesting complex mechanisms of slab retreat or break off (Sue et al., 1999; Sue and Tricart, 2002). Along the main strips, regions with few and sparse events identify seismic gaps, where future earthquakes are more likely to occur (i.e., the Pelvoux massive, the Lepontine dome).

In the eastern Alps, the shallow crustal seismicity is located on several south-verging ramps developed within the Adriatic Mesozoic cover (Adriatic thrust fault system, Fig. 8c). Subparallel faults broad the active region at the intersection between the Alpine and Dinaric structures. The southernmost active thrust is located at the foothill. Large thrust earthquakes are caused by a N–S trending compression (Fig. 6, see also Slejko et al., 1989; Bressan et al., 1998, among many other). The deep crustal seismicity indicates the northeastward flexure of the Adria plate beneath the Dinarides belt, indented in the south-dipping European subducting lithosphere and a possible over thrusting of Adria along a S–SW-verging ramp (Fig. 8c). To the west, the border of the Adria lithosphere is poorly defined by seismicity. Along the Adriatic thrust fault system, regions with scarce background seismicity define possible seismic gaps (i.e., the Cansiglio and Montello westernmost segments of the Adriatic thrust fault system, see Fig. 1b). To the east, the seismicity clusters on N–NW trending

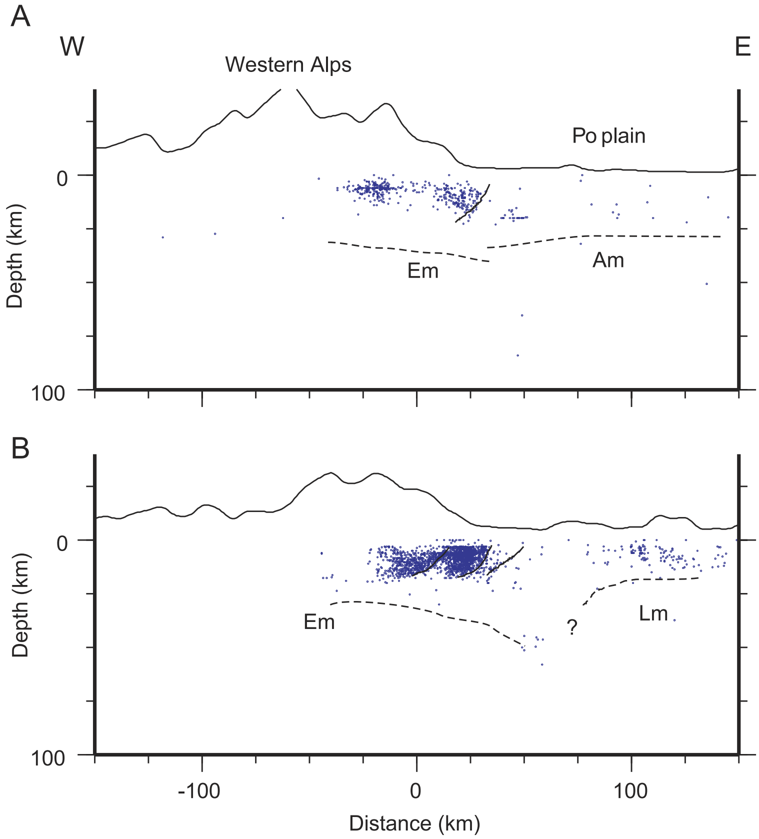

Fig. 7. E–W vertical sections of seismicity across the western Alps. Events falling ±20 km from the section are plotted. The geometry of the European and Ligurian Moho taken from available seismic reflection data is shown.

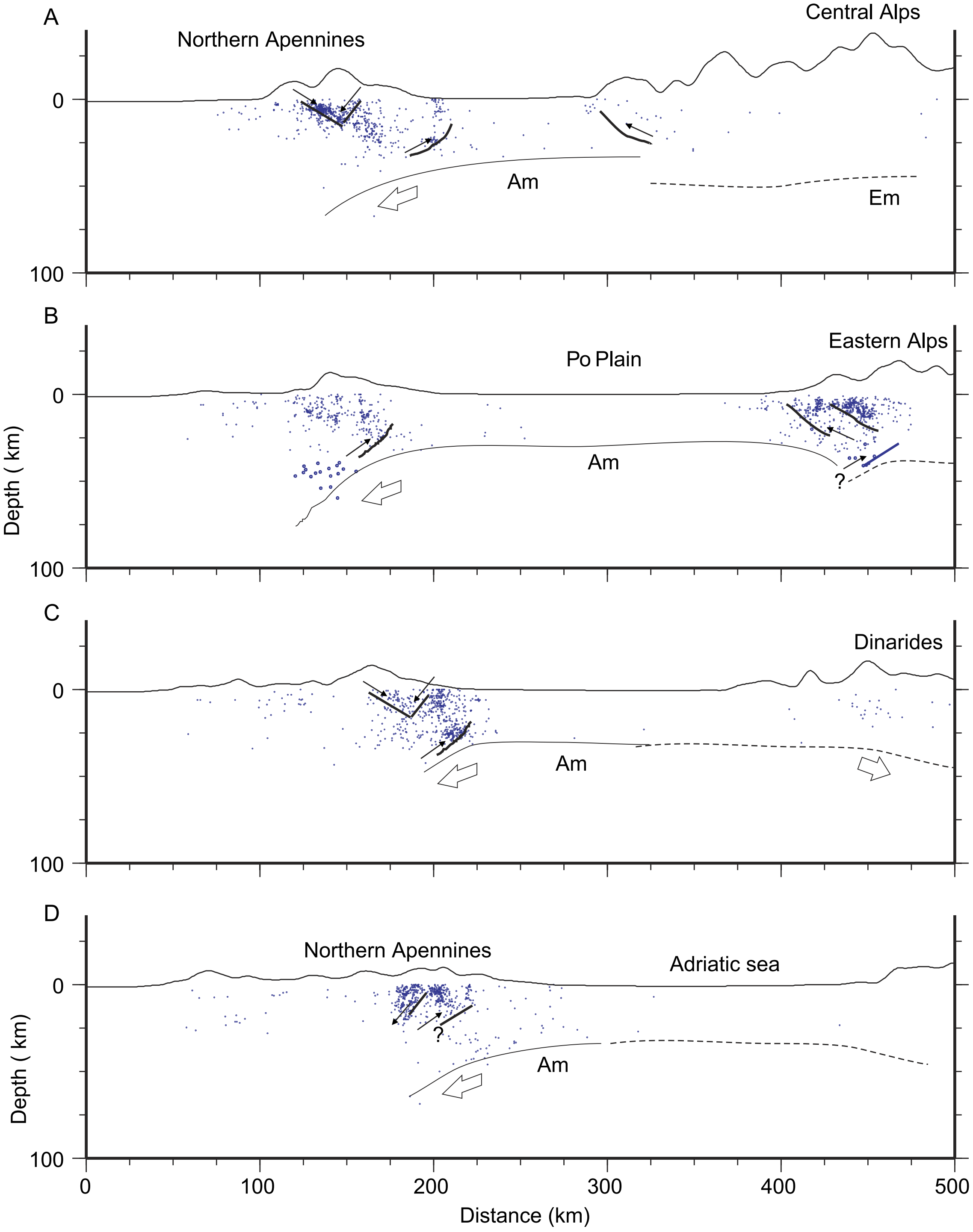

Fig. 8. Vertical sections of seismicity across the northern Apennines arc. Events falling ±20 km from the section are plotted. The lines indicate the geometry of the Adriatic and European Moho, as suggested by seismic reflection data and earthquake hypocenters. The bold lines show a simplified sketch of the main faults in the crust.

faults in the northern part of the Dinarides. Strike slip mechanisms, such as the M_L 5.6 Bovec earthquake, accommodate a transpression of Adria.

3.2. The Apennines upper crustal seismic belt

The main feature is an arc-like belt of seismicity in the upper crust that follows the mountain range (Fig. 4). From north to south, the upper crustal seismicity shows a rotation from NW-trending alignments in the north to NNE-trending in Calabria, paralleling the rotation of the Apenninic and Calabrian arcs. In the northern and southern Apennines, the NW-striking segments are confined within the upper 6–8 and 12–15 km of depth, respectively. The largest events show normal faulting mechanisms (Fig. 6), consistent with the regional NE-trending extension (Westaway, 1992; Montone et al., 1999). The limit between the flexure of Adria and the extensional belt is sharp, well defined by the depth variations of hypocenters (Figs. 5 and 8).

In the southern Apennines, the upper crustal seismic belt is narrow (30–50 km). Large earthquakes originate on ~20–40 km NW-elongated normal faults (Pantosti and Valensise, 1990; Amato et al., 1992; Pantosti et al., 1996; Galadini, 1999; Piccardi et al., 1999 among many others), that cut the entire upper crust (down to 12–15 km depth, Fig. 9). Background seismicity mostly occurs at the borders of the silent fault segments. An active NE-trending extension has been observed by focal mechanisms and borehole breakouts (Montone et al., 1999). Normal fault earthquakes occur mostly beneath the mountain belt (Fig. 6), following a rotation from NW-trending in southern Apennines to NE-trending in Calabria and in the Messina strait (Pino et al., 2000).

3.3. The Adria–Ionian subducting lithosphere

One of the most intriguing results is the diffuse occurrence of deep crustal and subcrustal earthquakes

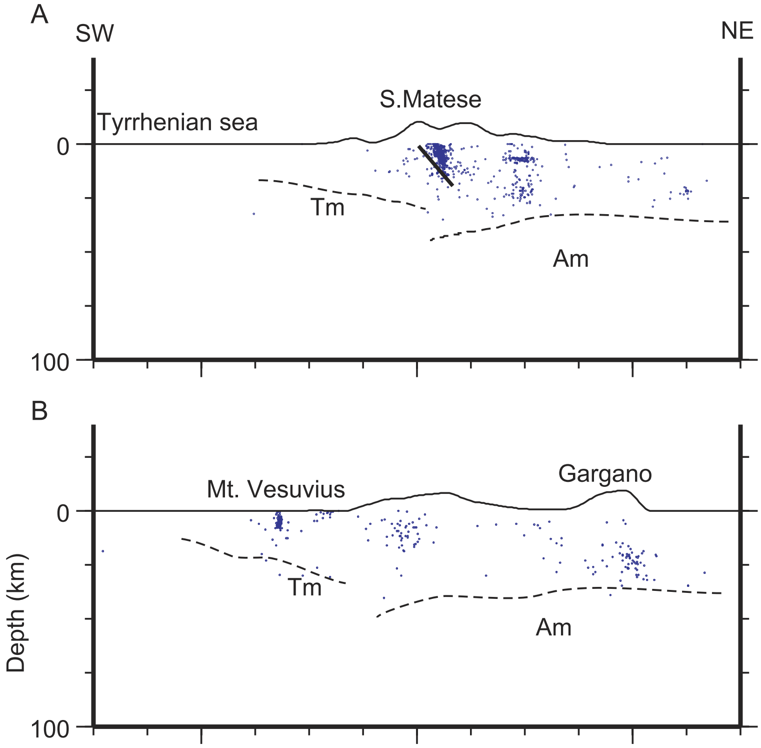

Fig. 9. SW–NE vertical sections of seismicity across the southern Apennines (a, b). Events falling ±15 km from the section are plotted. The lines indicate the geometry of the Adriatic and Tyrrhenian Moho, hypothesized based on the few available information, and a simplification of the main faults in the crust (bold lines).

that shows the location and geometry of the Adria lithosphere, flexured beneath the Alps and Apennines (Fig. 5a,b). The northern limit of Adria is well defined by the deep crustal seismicity occurring beneath the eastern, central and western Alps. In the northern and central Apennines, from the Po plain down to the Gargano promontory, the arc-like belt of deep crustal seismicity follows the mountain range and defines almost continuously the flexure of Adria beneath the belt. Hypocentral depths are typically between 12 and 25 km. The largest events (Parma M=5.7, 1973; Parma M_L 5.1, 1983; Reggio Emilia, 1996 M_L 5.4, and Forlì, 2000 M_L 4.5, Selvaggi et al., 2001) indicate a mechanism of compression on thrust faults buried beneath the Po plain that parallel the curvature of the arc. A E–NE elongation of seismicity on subparallel faults connects the Apulian foreland to the Dinarides (Fig. 4), in correspondence with the variation of lithospheric thickness (Panza, 1984). In the Gargano Promontory, a E–NE-striking strip of events is present and the largest events occurred in past years indicate an active compression (Figs. 4 and 6). Far to the south,

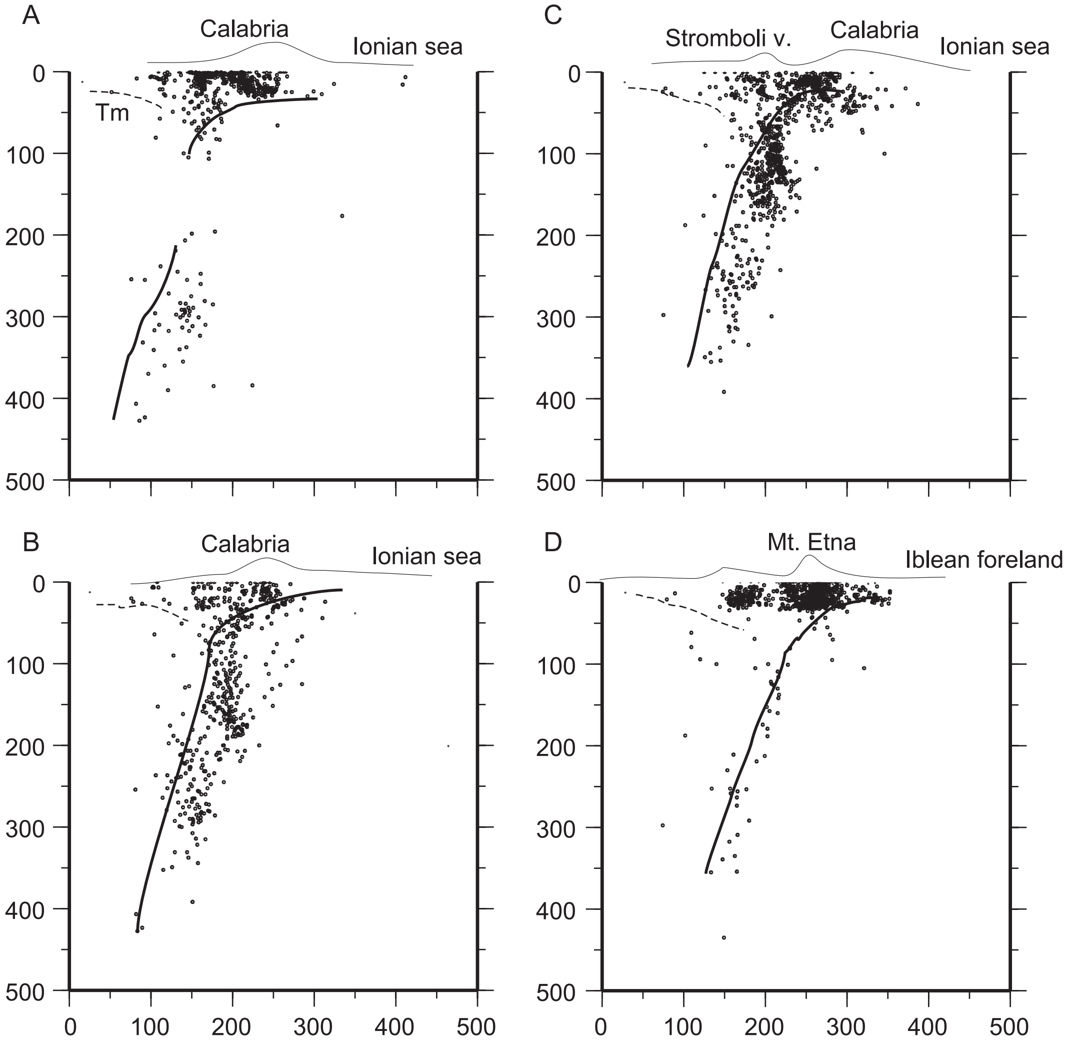

Fig. 10. Vertical sections across the Ionian slab. Events falling ±30 km from the section are plotted. Section d is located to the west of the Tindari–Letojanni fault and crosses Mt. Etna volcano and the Iblean foreland. The lines indicate the geometry of speculated the Tyrrhenian Moho (dashed) and the Ionian slab from deep earthquakes (solid).

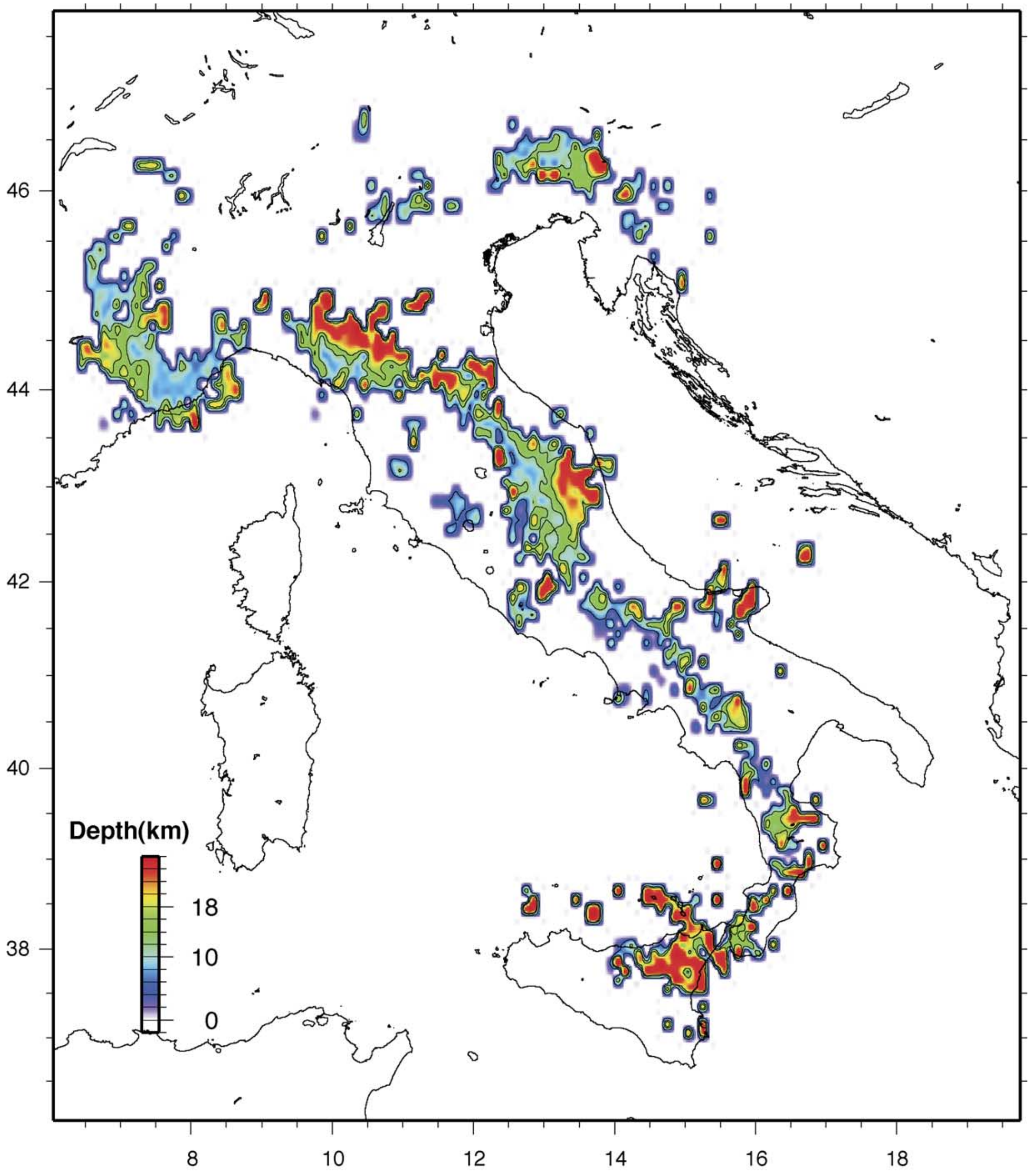

Fig. 11. Depth of the seismogenic layer computed by the cut-off of seismicity. Note the extreme lateral variation of the brittle layer thickness given by the complexity of the deep structure.

there is not a clear signature showing seismic deformation across the Adria continental and the Ionian oceanic lithosphere border. In the southern Apennines, deep crustal seismicity occurs mostly on E–W trending strike slip faults in the metamorphic basement of Adria (Potenza 1990–1991, Molise 2002 earthquakes).

The subcrustal seismicity dies out to the south of 43° of latitude and delineates the Adria lithosphere descending in the uppermost mantle (Figs. 5 and 8). In the southern Apennines, the subcrustal seismicity is absent.

In the Calabrian arc, deep earthquakes define the 70° NW-dipping Benioff plane (Fig. 10). Laterally, the seismically active portion of the slab is not longer than 250 km, less than its vertical extent, resulting in one of the smallest seismic signature of slab in the world. In the southern part (Fig. 10b and c), the distribution of hypocenters is continuous while a gap of seismicity is observed between 100 and 200 km depth to the north, where the Benioff plane rotates (Fig. 10a). To the west, deep seismicity sharply decreases across the NNW-trending Tindari–Letojanni (TL) fault imaged as a NNW-elongated strip of events. The few deep events to the west probably indicate a relic portion of the slab (Figs. 5 and 10d).

To the west of the TL fault, we observe an E–W elongated seismic belt located in the Tyrrhenian offshore of Sicily (Fig. 4). This belt consists of several, almost parallel, E–W and NNE-trending faults with focal mechanisms that indicate a N–S compression (Fig. 6).

4. The depth of the seismogenic layer

We used hypocenter locations of about 48,000 selected events to derive a map of the seismogenic layer beneath the study region. Hypocentral locations from local networks operating in geothermal and volcanic areas along the Tyrrhenian coast, about 3000 events, are added to obtain more reliable results in those areas. We computed the 75% of seismicity cut-off every 0.1° of latitude and longitude, using only earthquakes located within the crust. The chosen cut-off is reliable to establish the vertical extent of the seismogenic layer. Results in Fig. 11 clearly show that the depth of the seismogenic layer strongly varies and follows the tectonics of the area. In the Apennines, the depth increases from 4–6 km beneath the Tyrrhenian coast to 6–8 and 12–14 km beneath the normal fault belt in the northern and southern Apennines (down to the Calabrian arc), respectively. Results are very attractive for the northern Apennines normal fault seismic belt. Here, an eastward deepening of the layer from 6–8 to 10–12 km depth is defined in agreement with local studies (Chiaraluce et al., 2003; Piccinini et al., 2003). Further to the east, and in the external area of the Apennines system, the depth of the seismogenic layer increases to more than 20 km, following the flexure of the Adria and Ionian lithosphere. Along the northern Apennines chain axis, the belt of deep crustal seismicity is locally displaced.

In the western Alps, we find that the depth is around 10 km, except a western sector and the easternmost strip, where the depth reaches 12–14 km. In the eastern Alps, we observe a central area where the seismogenic layer is shallow (6–8 km), while its depth increases northward (12 km) along the dipping of the main active thrusts, and both southward and eastward in the Dinarides (z>16 km), where the Adria lithosphere is flexured.

In Sicily, the seismogenic layer is deeper, down to 20 km depth, beneath the offshore compressional belt, the TL fault system and beneath Mt. Etna. Some few spots with shallow depth seismicity are visible. The deepening of the seismogenic layer is consistent with studies from local networks.

5. Discussions

Earthquake distribution allows us to make inference on the seismotectonics of Italy (Fig. 12). The main observed features agree with results obtained by the analysis of seismometric data and focal mechanisms at a local scale (Selvaggi and Amato, 1992; Chiarabba and Amato, 1997; Eva et al., 1997; Bressan et al., 1998; Sue et al., 1999; Selvaggi et al., 2001; Chiaraluce et al., 2003, among many others) and with geologic information (Meletti et al., 2000, and references therein).

5.1. The shallow crustal normal faulting belt

The inner normal fault belt develops within the eastward thrust Meso-Cenozoic cover. The faulting

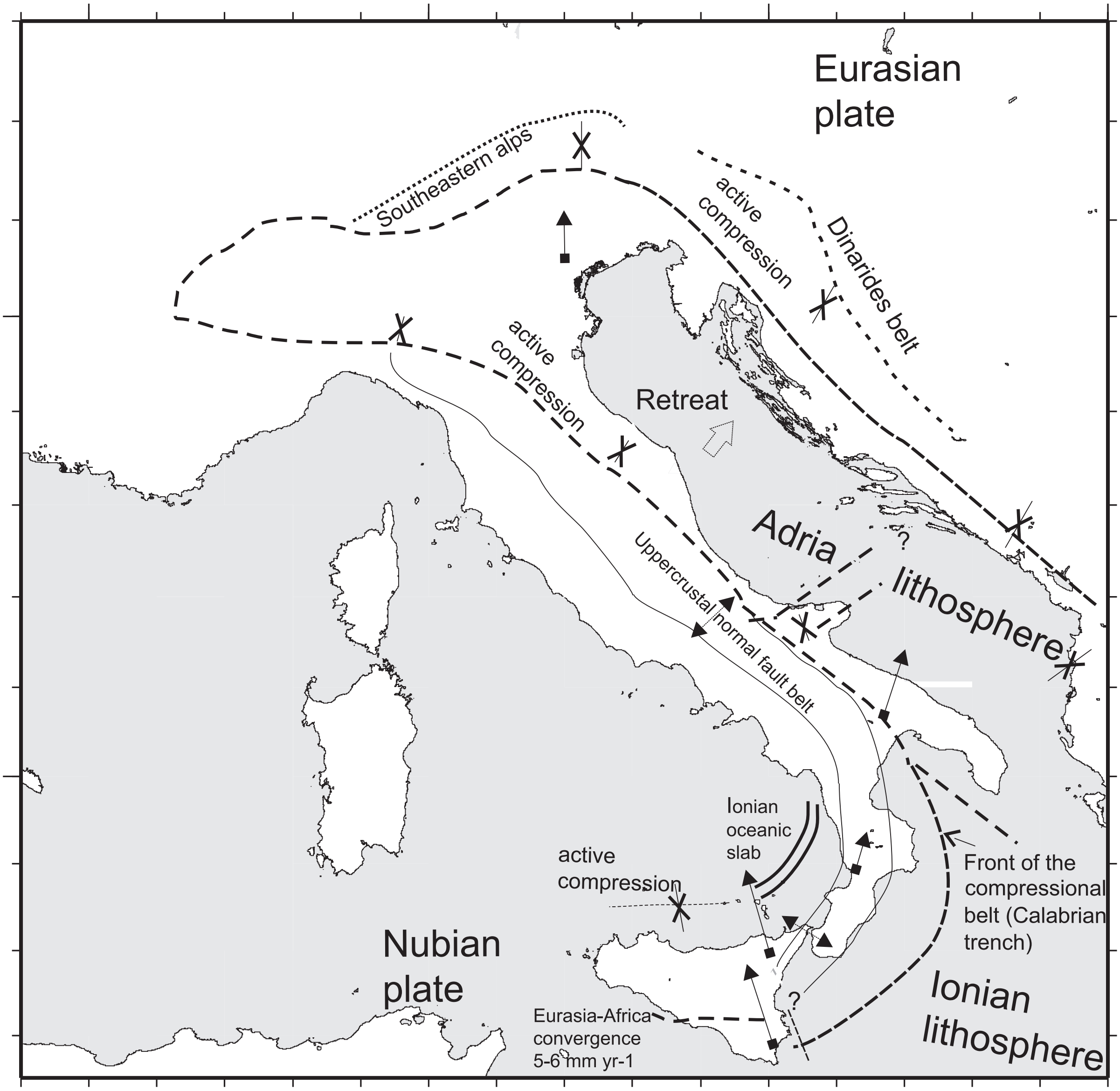

Fig. 12. Tectonic scheme summarizing seismological data (this study) and available cinematic constraints (Devoti et al., 2002; Hollenstein et al., 2003; Battaglia et al., 2004). Arrows are simplified directions of GPS sites relative to a stable European plate.

mechanisms indicated by surface geology, focal mechanisms and borehole breakouts (Westaway, 1992; Montone et al., 1999) show a clear NE-trending extension active in the whole Apenninic belt. Strongest earthquakes have larger magnitude in the southern than in the northern Apennines. The thickness of the seismogenic layer differs along the normal fault belt (Fig. 11), and it is probably controlled by the heterogeneous crustal structure, inherited from the former compression. In the northern Apennines, the presence of low angle east-dipping detachments observed by geology and seismology (Barchi et al., 1998; Boncio and Lavecchia, 2000; Mirabella and Pucci, 2002; Piccinini et al., 2003) may explain the shallowing of the seismogenic layer and the resulting thin-skinned tectonics. Conversely, a thick rigid Apulian limestone platform is present beneath the eastward thrust Meso-Cenozoic units of the southern Apennines (Improta et al., 2000), doubling the depth of the brittle seismogenic layer. Seismic occurrence suggests that the pre-existing structure, developed during the Plio-Pleistocene compression and the mountain building, controls the thickness of the seismogenic layer and the thin- or thick-skinned tectonics.

Background seismicity mostly develops at the border of the main NW-trending fault segments. The different magnitude observed for large events indicates that the lateral extent of faults changes from about 10 km to more than 40 km in the northern and southern Apennines, respectively. Thus silent segments, with poor background seismicity, are larger and more easily identified in the southern Apennines. The lateral continuity of faults may be controlled by the different thickness of the seismogenic layer and by the pre-existing structure. We hypothesize that most of the fault segments where large earthquakes are expected in the future are presently locked and characterized by scarce background seismicity.

5.2. The Adria microplate?

The existence of the Adria microplate was proposed considering the distribution of extensional earthquakes in the Apennines and compressional events in the eastern Alps and in the Dinarides (Anderson and Jackson, 1987). This deformation has been interpreted as due to the rotation of a rigid microplate with an Euleran pole located in the western Alps. Based on seismic deformation of historical events, Adria was supposed to be neither a rigid rotating microplate nor a rigid promontory (Westaway, 1992). Recent geodetic data suggest that Adria is a microplate separated from the Eurasia and Nubian plates, while its southern limit is ambiguously defined (Calais et al., 2002; McClusky et al., 2003; Battaglia et al., 2004). Calais et al. (2002) proposed that the Adria microplate is divided from Nubia by the Gargano Dubrovnik fault (GDF). Tomographic models of the upper mantle show that the Adria lithosphere, south of the GDF, is continuously connected with the Ionian slab (Di Stefano et al., 1999). The seismicity in the Gargano offshore, occurring along a broad NE-trending fault system that comprises the GDF and subparallel faults, along with the change from inverse to strike slip mechanisms for earthquakes in the Adria lithosphere are evidences for a structural limit that separates two regions of Adria that behave differently. Seismicity in the Adriatic Sea can be explained as due to either an independent rotation of two microplates, or, more likely, an intraplate deformation caused by the different retreat and rotation of the Adria lithosphere. In any case, we find no evidence for a seismically active plate margin between the southern part of Adria and the Ionian lithosphere.

The origin of deep crustal seismicity is not easy to be understood. Earthquakes occur within the metamorphic basement or at the contact with the upper Mesozoic cover of the Adria continental lithosphere. A possible explanation is that the differential rotation of Adria is accommodated by pre-existing discontinuities of the continental lithosphere.

5.3. Seismic slabs

Subcrustal earthquakes have been already observed by previous studies (Anderson and Jackson, 1987; Giardini and Velona’, 1990; Selvaggi and Amato, 1992; Selvaggi and Chiarabba, 1995). Here we better and more completely describe the lateral and vertical extent of the seismic slab. Subcrustal earthquakes are limited to the northern Apennines and the Calabrian arcs, with hypocenters down to 100 and 500 km depth, respectively. The two arcs are separated by the southern Apennines where subcrustal events are absent and the compression was active until middle Pleistocene and is probably, at present, significantly slowed (Doglioni et al., 1994) or terminated (Meletti et al., 2000). We find no seismological evidences for an active compression. The deep features revealed by seismicity are consistent with the Adria lithosphere separated into regions with different retreat and deformation.

In the northern Apennines, subcrustal earthquakes are related to the flexure of the Adria continental lithosphere. Cinematics of deep events is still undefined. The largest event occurred in the past years (Mw5.3, 1998 Gualdo Tadino earthquake) shows a trans-tensional focal mechanism and a down-dip extension. This mechanism is consistent with the stretching of the subducting continental lithosphere. Deep crustal events have inverse focal mechanisms suggesting that the compression in the accretionary wedge and in the subducting lithosphere is still active.

The deep seismicity of the Calabrian arc defines a 70° dipping Benioff plane, laterally continuous only for 200 km. Frepoli et al. (1996) and Selvaggi (2001) found that almost the entire slab is in down dip compression, suggesting that the slab pull is not significant. Recent geodetic data show that the Calabrian and southern Apenninic units do not retreat toward the trench (Devoti et al., 2002; Hollenstein et al., 2003), but they may not indicate the actual motion between the subducting and the overriding plates. The absence of a significant slab pull by focal mechanisms is consistent with the absence of retreat by geodetic data, and requires a more complicated model.

5.4. The Sicilian compressional structure

The northern Sicily offshore compressional structure is strikingly revealed by past years seismicity. The E–W-elongated fault system consists of several subparallel NNE-trending and E–W segments that accommodate the compression between the Nubian and European plates. The compression inverts pre-existing extensional structures in the Sicilian offshore developed during the Cenozoic. The deformation between the two plates is shifted 150 km northward with respect to the former front of the compressional belt and the African (Iblean) foreland. This observation is consistent with the few deep events occurring to the west of the TL fault indicative of a relic slab.

6. Conclusions

Past years seismicity shows the signature of a complex system of continental collision and subduction. In our interpretation, seismotectonics is controlled by the northeastward retreat of the Adria–Ionian lithosphere. The retreat is hampered by the indentation of the Adria plate in the Alpine structure. The resulting rotation generates compression and transpression in the eastern Alps and in the Dinarides with a climax at their intersection. The limit of the Adria plate is defined by seismicity. The several subparallel faults in the Adriatic offshore may indicate an intraplate deformation of Adria caused by different retreat and rotation. The slab retreat, either of continental or oceanic lithosphere, produced an upwelling of the asthenosphere in the Tyrrhenian region and originates the uplift and the extensional tectonics of the Apennines. At present, the retreat of the Ionian and southern Adria lithosphere is still not evident and this ambiguity probably depends on the lack of information on earthquake cinematics and deformation in the Calabrian trench.

The compression between the Nubian and Euroasiatic plates and the deformation produced by the rotation of Adria are re-activating pre-existing structures, creating a complex tectonic settings.

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