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The seismic sequence of Potenza (May 1990)

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Abstract
A microearthquake digital network has been installed after the Potenza earthquake (May 5, 1990, $M_L = 5.2$). The seismic network allowed the detection of more than 200 events from May 7 to 16, with magnitude ranging from 0.6 to 3.1.
The overall seismicity pattern is comprised in a prominent East-West zone of epicenters which extends for about 20 km, with hypocentral depths mainly concentrated between 15 and 25 km. These depths are unusual compared to those of similar seismic sequences occurred in the Central and Southern Apennines. However, the use of several velocity models and V_P/V_S values shows unrelevant changes in hypocentral locations. Synthetic tests were performed to evaluate the network resolution. The focal mechanism of the mainshock shows a N70E T axis, approximately lying on the horizontal plane.
An interesting feature is that Potenza aftershocks are clustered close to the South-East edge of the 1980 Irpinia fault. The differences found in some aspects of these two seismic sequences reflect the complex distribution of the stress release in Southern Apennines.

1. Historical seismicity and geological outline

The first earthquake reported in the Italian Seismological Historical Catalogue for the Potenza area, occurred in 300 a.C. near the Vulture volcanic complex (I = VIII-IX MCS). Many earthquakes, with intensities ranging from VI to X MCS, stroke the area surrounding Potenza in the last 400 years. The strongest occurred in 1561 (Vallo Di Diano, X MCS), 1694 (Irpinia, X MCS), 1857 (Basilicata, X MCS), 1930 (Irpinia, X MCS), 1980 (Irpinia, X MCS). The 1694 and 1980 earthquakes have been the most powerful felt in Potenza (VIII MCS) with many damages and casualties. Two events with magnitudes greater than 4.0 occurred near Potenza in the past decade: on February 2, 1983 ($M_D = 4.2$) and July 23, 1986 ($M_D = 4.0$).

The structural complexity of the geological units outcropping in Potenza area has been extensively studied by many Authors in order to define the tectonic setting (Selli, 1962; Accordi, 1966; D'Argenio, 1973; Ogniben *et al.*, 1975). From westside to eastside, the Southern Apennines are composed by different limestone platforms spaced by siliceous basins. These structural units have been subjected to a complex tectonic evolution following the compressive phases of the Apenninic orogeny with strong crustal shortening. This led to develop the Apenninic Chain as a progressive climbing towards eastside of the different units.During Plio-Pleistocene a neotectonic distensive phase caused the regional raising and fragmentation of the brittle limestone platform (Ogniben *et al.*, 1975).

The Potenza region is characterized by the outcropping of Pliocenic sediments (Unità di Argenio) trasgressive over the *lagonegrese-molisano* flysch.

2. The main shock

On May 5, 1990 at 7:21 GMT an earthquake occurred in the Potenza region was recorded by the Italian National Seismological Network and located about 3 km North of Potenza at 40.64 N and 15.86 E. The depth was fixed at 15 km because of the poor resolution on the depth parameter due to the relevant distance between the national network stations (40 km).

The local magnitude (M_L = 5.2) has been calculated by the Villasalto (Sardinia) VBB seismic station. The moment magnitude, M_W, has been estimated 5.8. The earthquake was intensively felt in Avigliano, Pietragalla and Cancellara (villages close to Potenza) with VII MCS intensity (Tertulliani *et al.*, 1990).

The focal mechanism (fig. 1) calculated by using 24 clear first motions from the ING seismological network and from a local network installed near Benevento (Iannaccone *et al.*, 1990) shows a strike slip solution with a N70E *T* axis and a N163E *P* axis. A layered linear gradient velocity model with the V_P/V_S ratio equal to 1.75 has been used to obtain the focal solution.

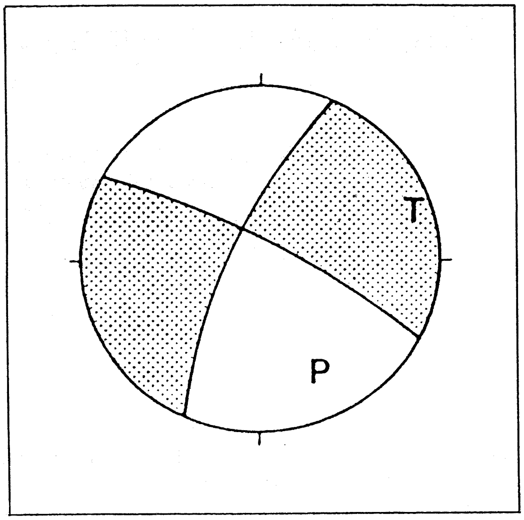

Fig. 1. The Potenza earthquake fault plane solution (May 5, 1990 at 7:21 GMT, M_L = 5.2); the best fit obtained from the distribution of 24 first motions shows a strike slip solution with *T* axis at N70E.

3. Network installation and data analysis

Two days after the main shock a microearthquake network was installed in the epicentral area and operated for two weeks. The network was equipped with 2 three-component and 4 vertical-component remote digital stations. Data were sent via radio links to a central acquisition unit mounted on a special truck, located 15 km North of Potenza.

More than 200 aftershocks were located in real time and their magnitudes evaluated. Figure 2 shows the waveforms of an aftershock recorded by the network.

Moreover, in order to extend the network configuration towards S-W, data have been completed with those recorded by two seismometric stations of the ING national network within 70 km from the epicentral area. The aftershocks have been then relocated by the Hypoinverse code (Klein, 1989), selecting the events with more than 8 *P* or *S* phases.

The hypocentral locations have been computed using a laterally homogeneous layered model inferred from a geological profile (Mostardini and Merlini, 1986) near the epicentral region. Table I shows the *P* velocity for each layer; the selected V_P/V_S ratio is 1.75. Such a value agrees with that found by Deschamps and King (1984) for the Irpina region.

The epicentral map (fig. 3a)) depicts an overall seismicity pattern comprised in a prominent East-West striking zone of epicenters which extend for about 20 km with a small dispersion at the border of the network. The hypocentral depths (fig. 3b), 3c)) are mainly concentrated between 15 and 25 km.

In fig. 3 the main shock location, computed by the Centralized National Seismological Network, is reported.

The histograms in fig. 4 give information about the location quality. The hypocentral errors keep mainly between 1.0 and 2.0 km, the root mean squares (RMS) are generally not greater than 0.15 s.

The fault plane solution of the main shock, the hypocentral depths of the aftershocks and the lack of aftershocks in the first 10 km of the crust are the most peculiar features of this sequence. These seem to misfit previous studies about aftershock sequences occurred in the Central and Southern Apennines. In fact, strong earthquakes

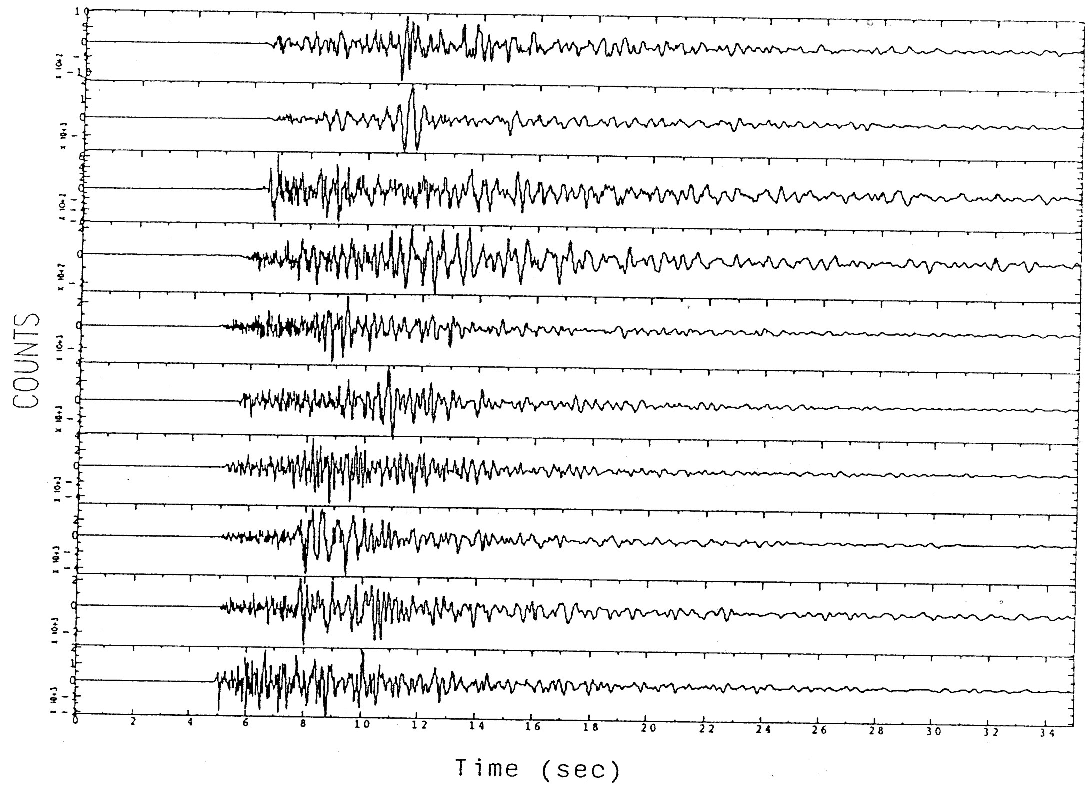

Fig. 2. Aftershock waveforms recorded by the ING portable network stations on May 9, 1990 at 20:01 (GMT) (M_D=2.9). The upper and the lower three waveforms are respectively the E-W, N-S, and vertical components of the two seismometric stations equipped with a three-component sensor.

Table I.

V_P (km/s)	Top (km)
3.0	0.0
4.5	3.5
5.7	6.0
6.5	10.0
7.5	25.0

in this area generally show a dip slip mechanism along a focal plane lying in the Apennine direction and the aftershock depths are not deeper than 15 km (Deschamps and King, 1984; Deschamps *et al.*, 1984; Gasparini *et al.*, 1985; Haessler *et al.*, 1988).

These observations suggested to perform some tests to verify the accuracy of the locations and to evaluate the influence due to the velocity model and the network geometry.

4. Synthetic location tests

Synthetic data-bases were produced using suitable crustal models of the region (table II.).

Figure 5 shows the histograms of the number of events *versus* the hypocentral depth. A layered linear gradient and a half-space velocity model have been used to locate the aftershocks; the V_P/V_S ratio has been increased up to 1.90, in order to take into account the effect of the large thickness of the sedimentary layers observed in the area (more than 2 km) on the S-wave velocity.

For each velocity model we have calculated

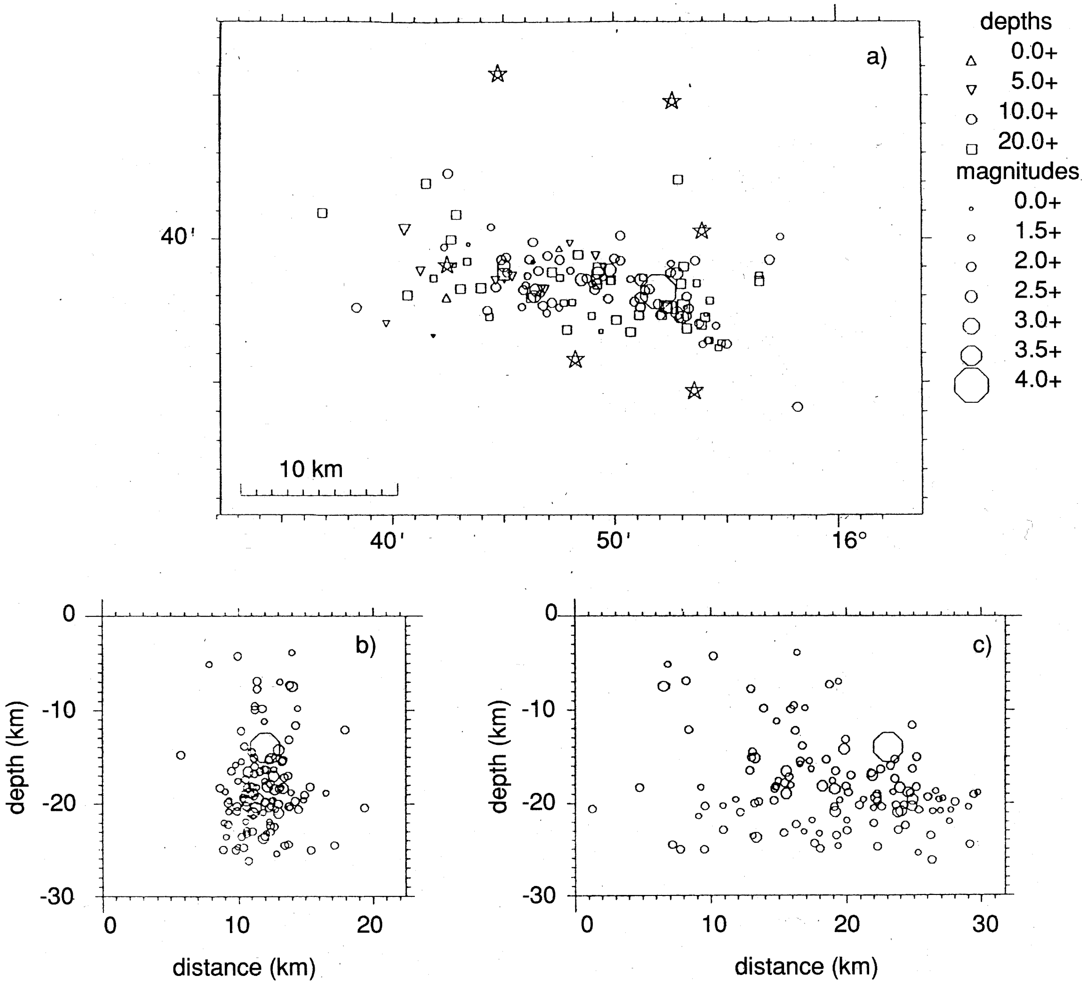

Fig. 3. a) Aftershocks epicentral map. Symbols are proportional to the magnitudes, stars are the seismic stations. The main shock (big open circle) has been superimposed on the map; b) N-S section; c) E-W section.

Table II.

Homogeneous model		Linear gradient model		Halfspace model	
V_P (km/s)	h (km)	V_P (km/s)	h (km)	V_P (km/s)	h (km)
3.0	0.0	3.0	0.0	6.0	0.0
4.5	3.5	4.5	3.5	8.5	35.0
5.7	6.0	5.7	6.0		
6.5	10.0	6.5	10.0		
7.5	35.0	8.5	35.0		
V_P/V_S=1.9		V_P/V_S=1.8		V_P/V_S=1.8	

the theoretical travel times at the seismic stations. These values have been modified by adding random errors from a Gaussian distribution with standard deviation equal to the average of the residuals previously found using the true database. The synthetic arrival times have been used as input for the relocations. The results (fig. 6) agree with the location obtained from observed arrival times: the major part of the epicenters move not more than a few hundreds metres; there is a good fit for the depth parameter too.

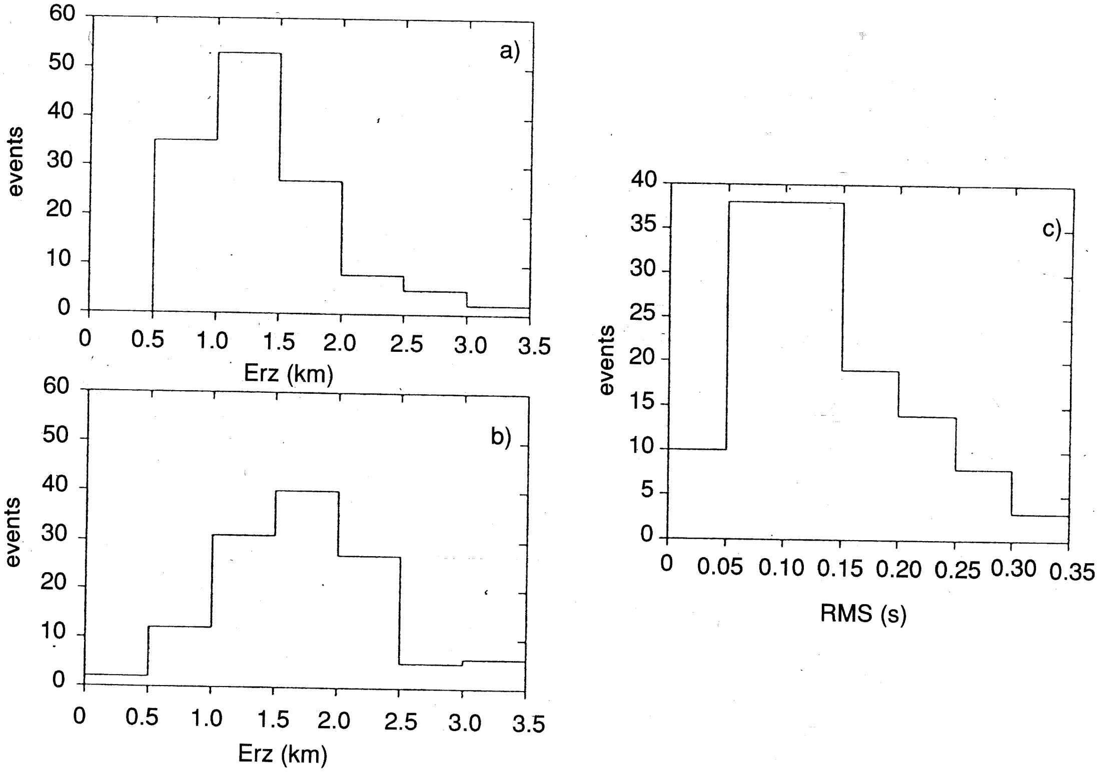

Fig. 4 Number of events *versus* hypocentral error: a) number of events *versus* epicentral error, b) number of events *versus* the error on depth, c) number of events *versus* RMS.

5. Conclusion

The Mobile Seismological Network, deployed just after the May 5, 1990 Potenza earthquake allowed to record more than 200 events, magnitude ranging from 0.6 to 3.1. The hypocentral depths of these events, verified by several tests, are unusual compared to those of previous sequences occurred in Central and Southern Apennines.

The aftershock area is generally considered as the upper limit of fault length. In this case, the epicenter distribution covers an area of about (20 km) in length (fig. 3).

The moderate magnitude of the Potenza earthquake should involve a rupture area not greater than 10 km^2. The remarkable difference between the two values suggests that the aftershock distribution reflects a structural discontinuity, wider than the mainshock rupture area, where the stress release is favorite.

An interesting feature raises comparing the aftershock distributions of the Potenza and Irpinia earthquake (November 23, 1980, $M_L = 6.9$) (Westaway and Jackson, 1987; Bernard and Zollo, 1989; Amato *et al.*, 1989; Pantosti and Valensise, 1990). The epicenters of the Potenza sequence are clustered close to the south-east edge of the 1980 Irpinia fault (fig. 7). This could be regarded as a possible evidence of the interaction between adjacent fault segments. Moreover, the remarkable differences found for these two seismic sequences (focal depths, direction of alignment of epicenters, and fault plane solutions) reflect the complex distribution of the stress release in Southern Apennine. On the other hand, it can be observed that the *T* axes of the focal solutions for Irpinia and Potenza earthquakes lay in a horizontal plane with roughly the same direction.

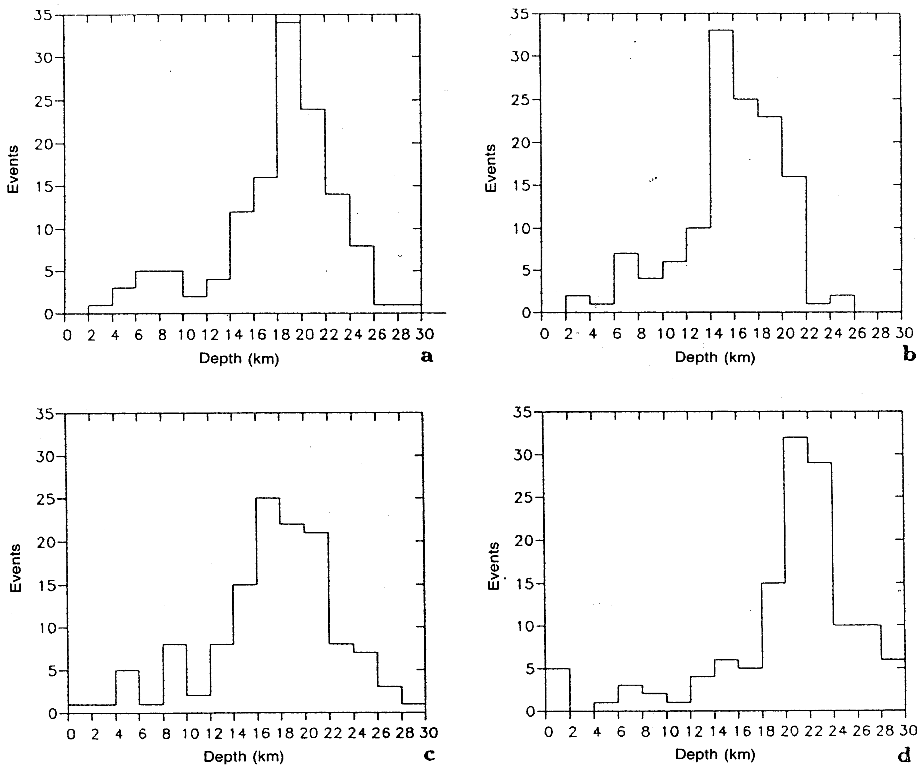

Fig. 5. Number of events *versus* depth for three crustal models used to locate the aftershocks: a) homogeneous layered model derived from a geological profile (Mostardini and Merlini, 1986), $V_P/V_S = 1.75$; b) homogeneous layered model, $V_P/V_S = 1.9$; c) linear gradient layered model; d) half-space model. See tables I and II for layer thickness and *P*-wave velocity.

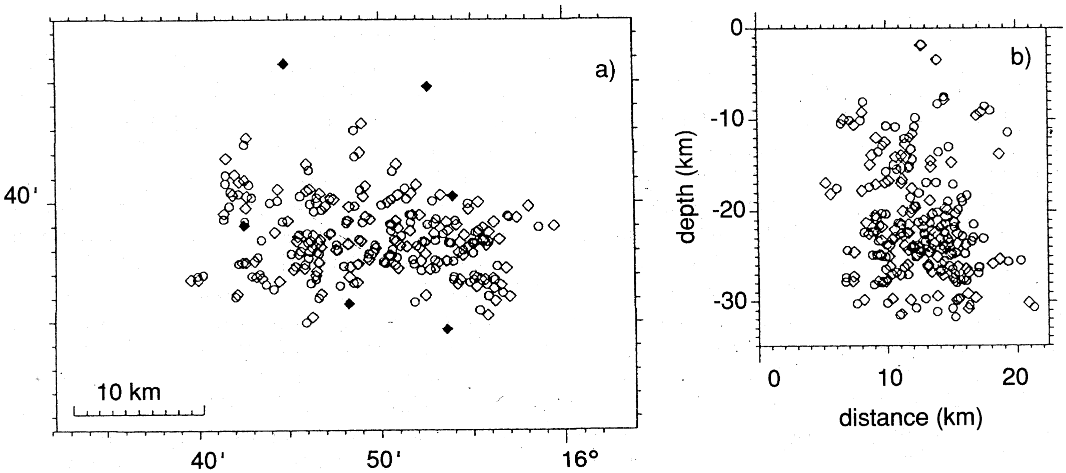

Fig. 6. Example from the synthetic tests: a) epicentral map of the aftershocks (open circles) and the relocations (open diamonds) computed using theoretical travel times, black diamonds are the seismic stations operating during the survey, b) transverse section.

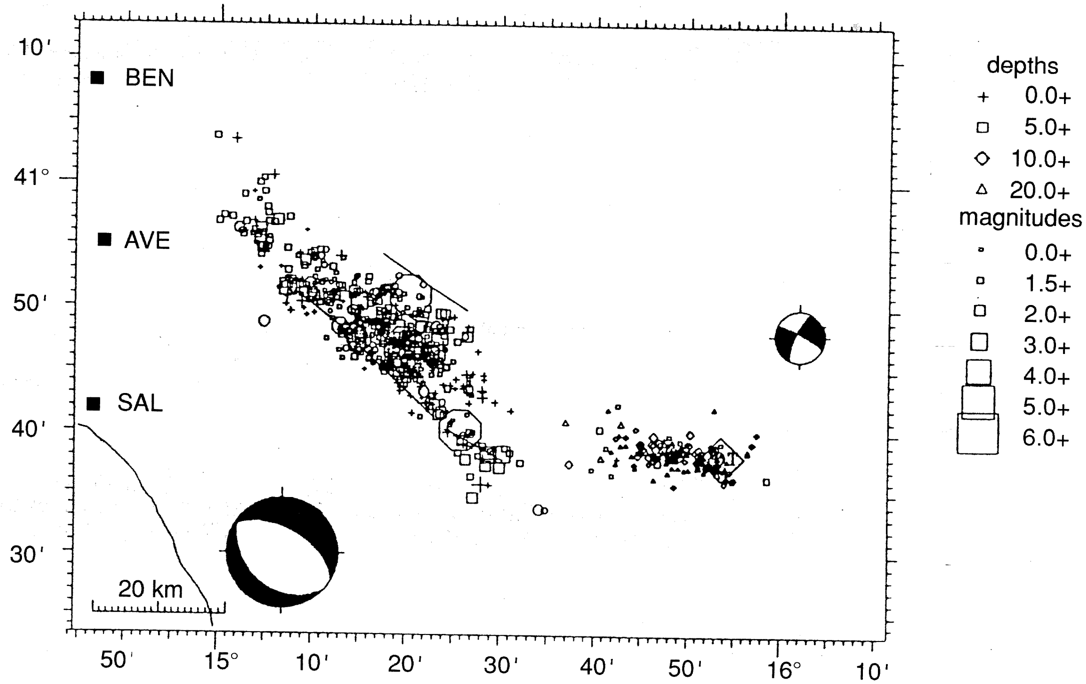

Fig. 7. Epicentral map of the Irpina (1980, M_L=6.9) and Potenza (1990, M_L=5.2) aftershocks. The fault plane solutions for both the main shocks are also shown.

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