Important earthquakes in Southern Appennines, Italy

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Abstract

How the soil reacts when it's subjected to an earthquake is a fact that cannot be omitted in planning. The research of these phenomena lets to locate seismogenetic areas and to define the different structural elements that feature regional and local environment.

Besides it lets to find out attenuation law to be utilized in risk's maps, and gives clear proofs of the different soil's behaviour even in a restrict area that must be known for more detailed microzoning testing.

The Osservatorio Vesuviano (Naples - Italy) in collaboration with the Gruppo Nazionale Difesa dei Terremoti is working to define the historical and contemporaneous earthquakes' effects.

1. The XIX century events in southern Italy

The Osservatorio Vesuviano in strict collaboration with the Gruppo Nazionale per la Difesa dai Terremoti (CNR) furnished a macroseismic study of the XIX century events occurred in the Apennines Chain of Southern Italy.

The list of these earthquakes is reported in tab. 1; among these the most violents are the 1805 and the 1857 events that were object of an accurate historical reconstruction.

The earthquakes in Tab. 1 occurred in the Two Sicily Kingdom ruled by Borboni dinasty which were kings of Naples since XVIII century to 1860 exept for two brief periods: the Neaplitan Republic (1799) and French Period (1806-1815). It is interesting to note how in this period of time changes the approch to disaster. In fact, for the 1805 event, Mr. Giannoccoli, an accusing officier, was named the only responsable to king and was sent to epicentral area invested with full governmental powers.

On the contrary, for the 1857, were utilized legal autorities, like piramidal sequence: Minister of Interior, Regional (Intendents) and Local (Maiors) autorities.

Tab. 1 - The XIX century events.

EARTHQUAKES	EPICENTRAL ZONE
26. 07. 1805	*FROSOLONE*
01. 02. 1826	*TITO*
02. 01. 1831	*RIVELLO*
20. 11. 1836	*LAGONEGRO*
14. 08. 1851	*VULTURE*
09. 04. 1853	*CAPOSELE*
16. 12. 1857	*MONTEMURRO*

All the documents of this period stay in the Record Offices placed in real, temporal sequence.

For the 1857 earthquake, it has been possible to distinguish a 3 minutes large foreshoc (Fig. 1a) that occurred in northern part of the epicentral area (Fig. 1b), and then the main shock that caused 2000 deads in Montemurro village only.

Many superficial effects were recognized too. For the 1805 earthquake, that occurred on the east of Matese Mountains, there were numerous evidences of these kind (Fig. 2a, 2b).

Two of them will reported:

- near Morconi village, at Taverna vecchia, a horse post, appared "un arabesco come prodotto da innumerevoli talpe" (an arabesque caused by many moles), the actual "mole's traks" judged like superficial evidence of the seismogenetic fault.
- around S. Giorgio la Molara took place a spectacular ones: "....una voragine apertasi nel tenimento di S. Giorgio Molara ..... per la lunghezza di passi (*) 1922 e per la larghezza di passi 800 ...." ("a chasm occurred in the fields near S. Giorgio la Molara .... with a length of 1922 steps (*) and breadth of 800 steps") (*) 1 passo=1 step=195,15 cm The contemporary map in Fig. 3 was drawn by engineer.

2. *Attenuation of earthquake intensities in southern Italy*

Isoseismal maps of the largest earthquakes recorded in the Apennine Chain of Southern Italy show that the areas within the high intensity isoseisms are noticeably elongated along the direction of the chain.

This trend is illustrated, for exemple, by the M.C.S. IX isoseisms plotted in Fig. 4.

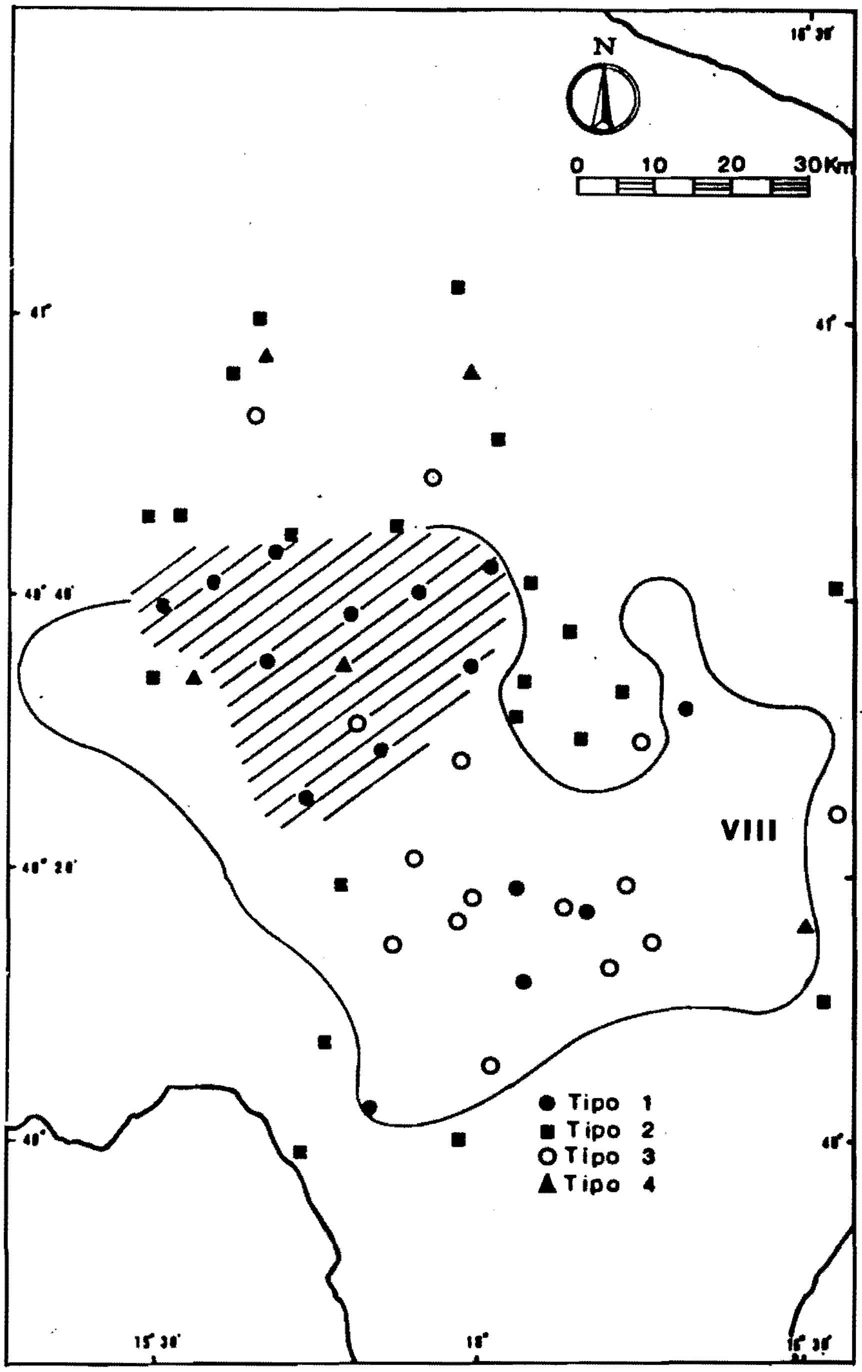
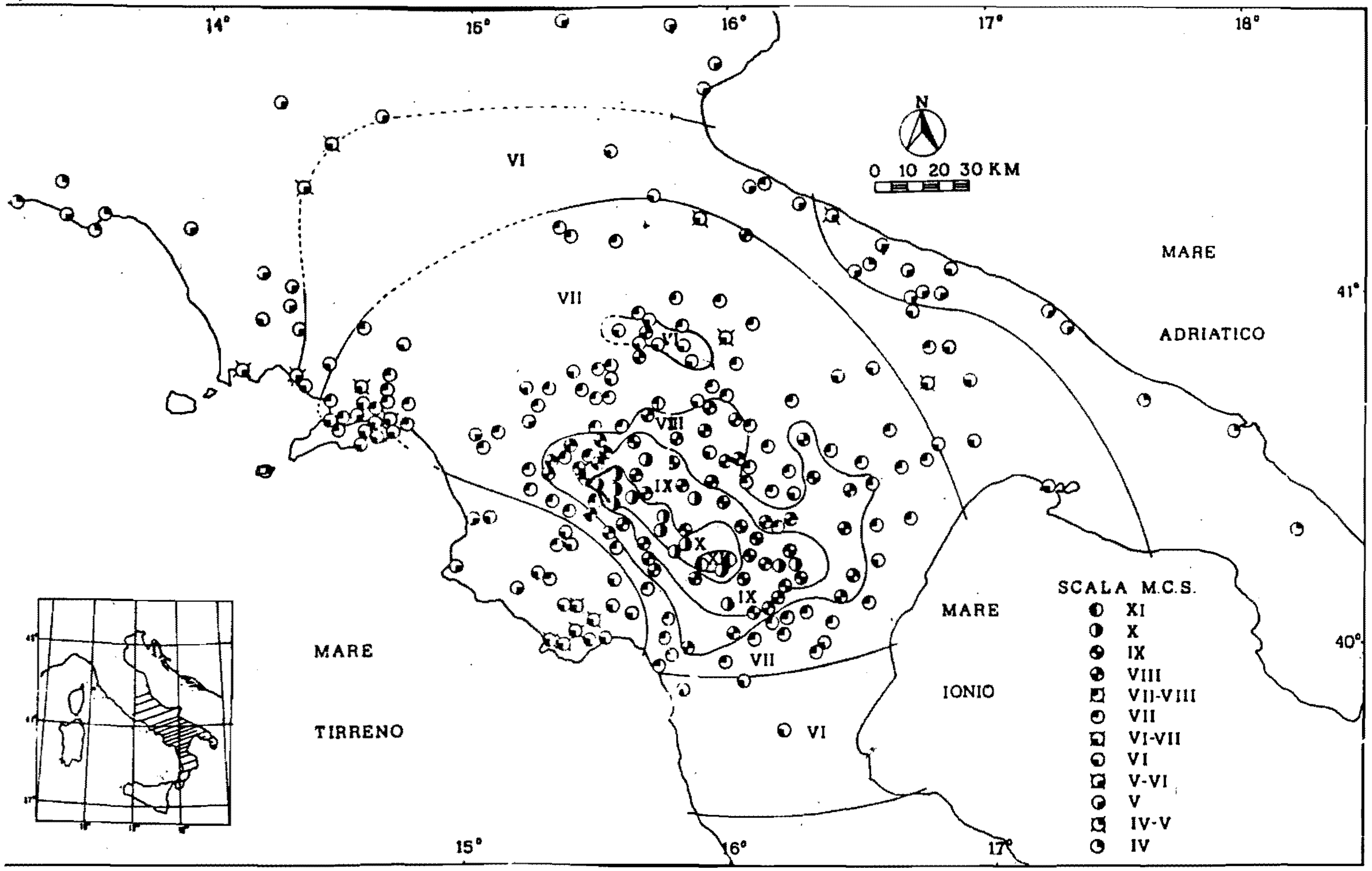


Fig. 1/A - Area of foreshock of 1857 event.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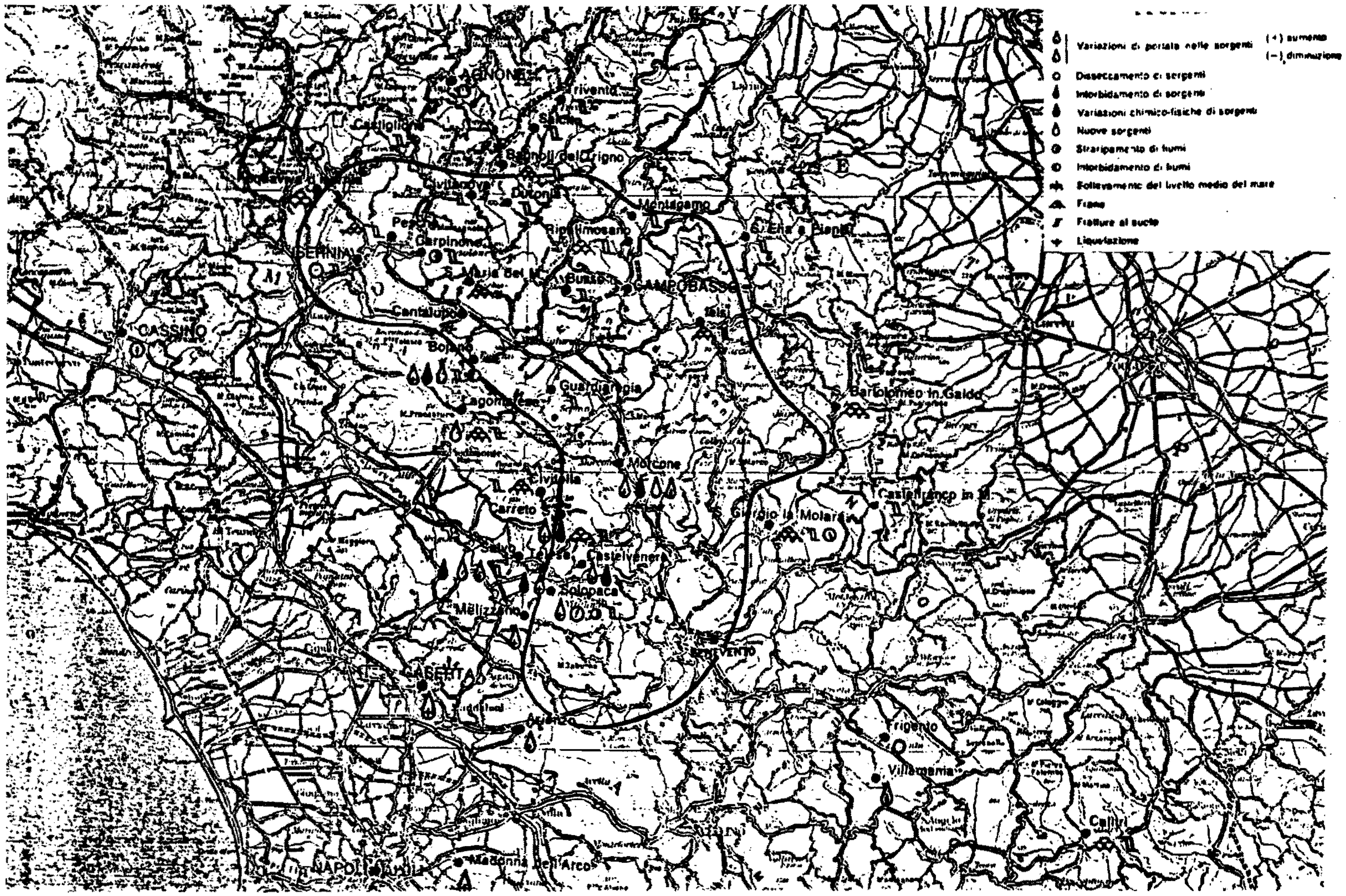
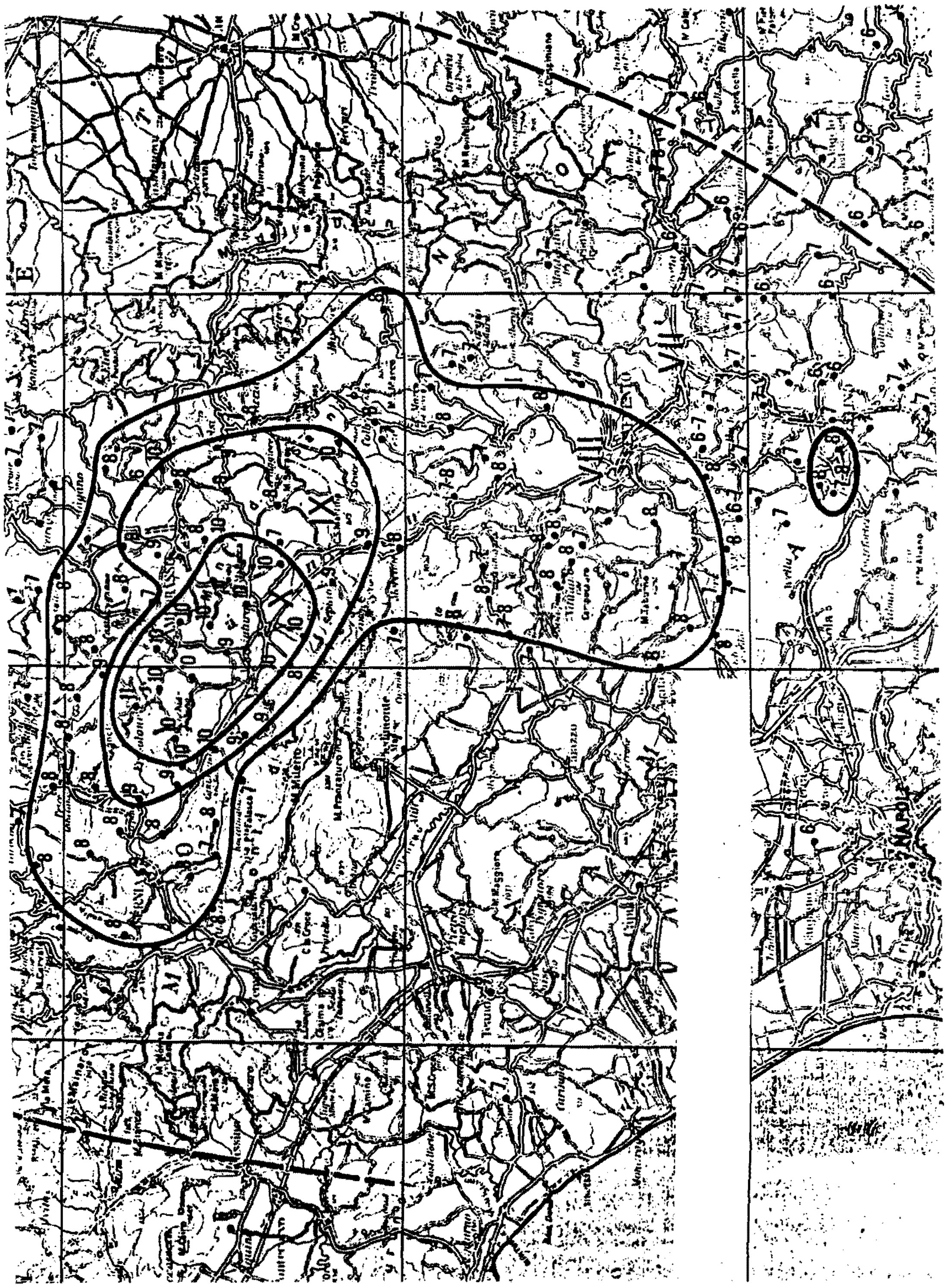


Fig. 2/A - Ground and water effects of 1805 earthquake.



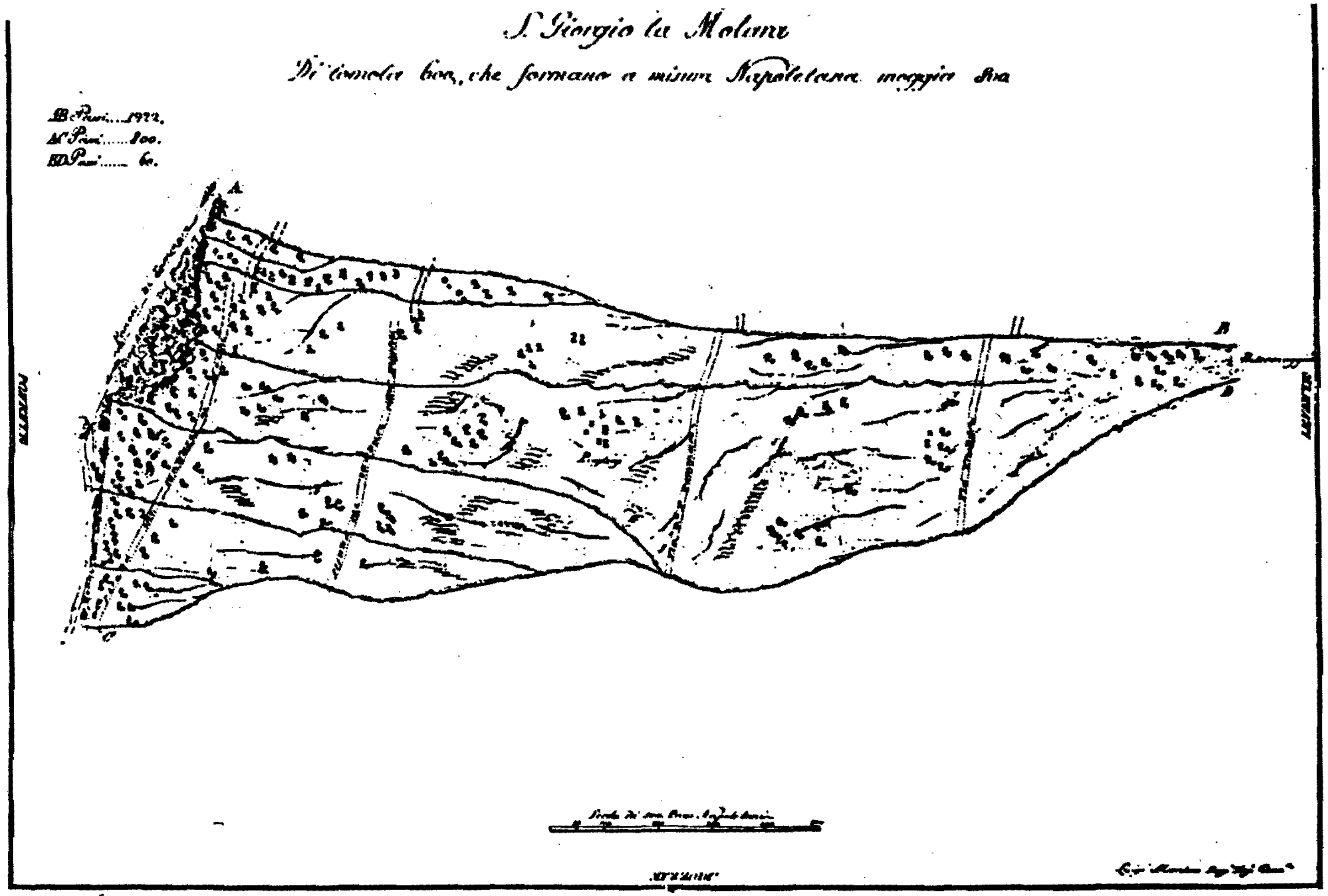


Fig. 3 - Map of a chams occurred in the fields near S. Giorgio la Molara.

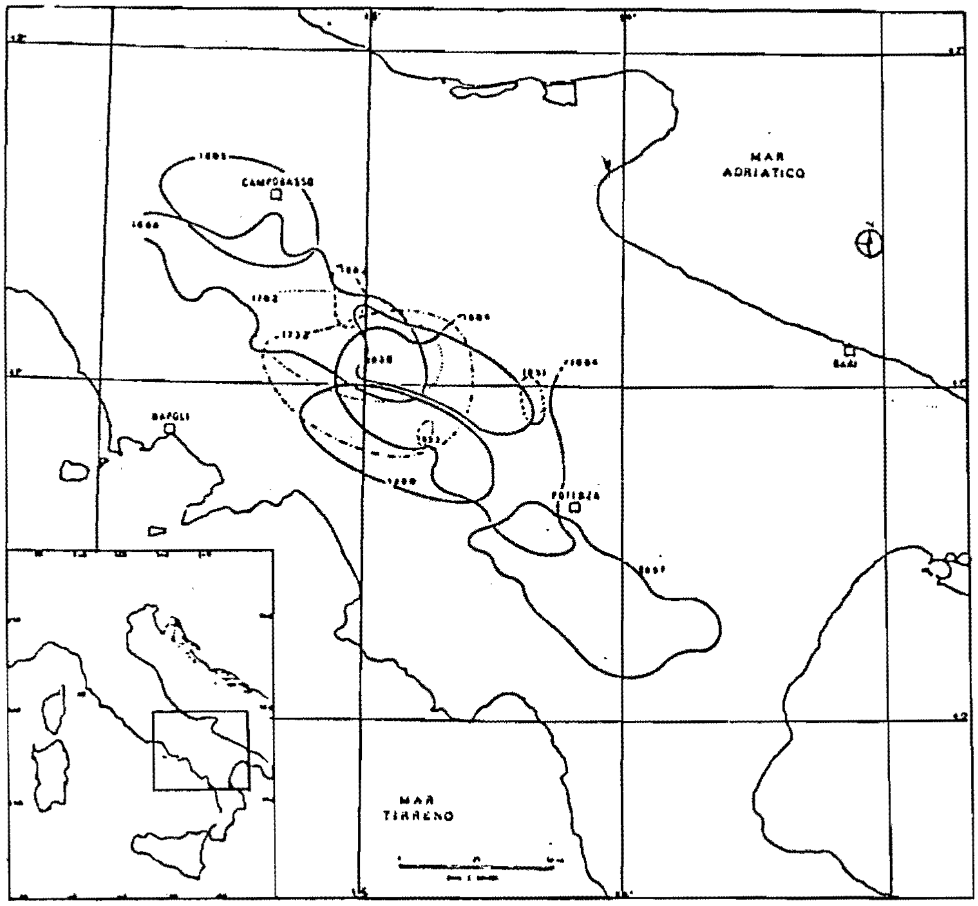


Fig. 4 - Map of the MCS IX isoseismals for the earthquakes of 5 June 1688, 8 September 1694, 14 March 1702, 29 november 1732, 26 July 1805, 14 August 1851, 9 April 1853, 16 December 1857, 23 July 1930, 21 August 1962, 23 November 1980.

For seismic risk and emergency analysis, it is usually assumed that the intensity distribution has no azimuthal dependence. However, since the isoseisms do show a general elongation along a direction of 135C N, it has been possible to obtain attenuation relations in direction of (R1) and in direction perpendicular to (R2) the axis of the Apennine Chain following Chandra's procedure (CHANDRA, 1979) and assuming a costant focal depth, h, of 10 km (BRANNO ET AL., 1986).

The following relation were obtained:

$$I(R2) - Io = 2.46 - .05R2 - 2.46 \log(R2+10) \quad S2 = .09 \qquad (1)$$

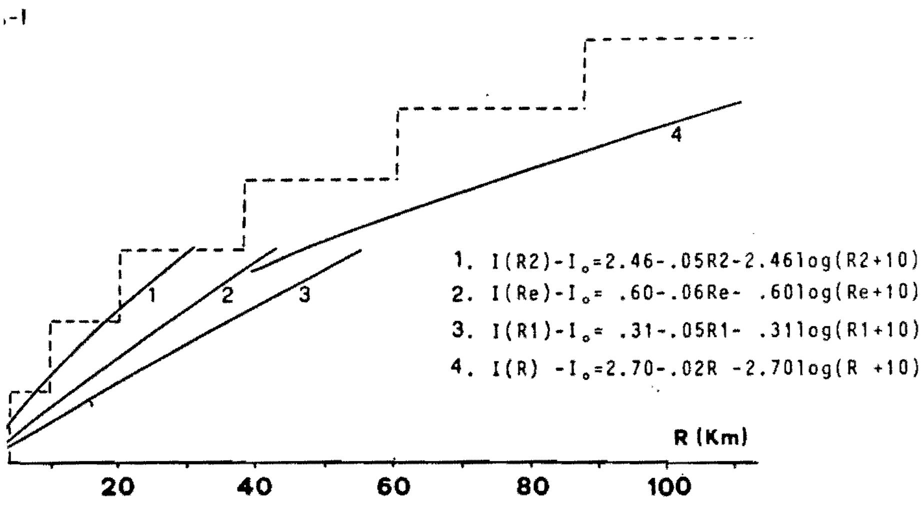
$$I(Re) - Io = .60 - .06Re - .60 \log(Re+10) \quad S2 = .03 \qquad (2)$$

$$I(R1) - Io = .31 - .05R1 - .31 \log(R1+10) \quad S2 = .03 \qquad (3)$$

$$I(R) - Io = 2.70 - .O2R - 2.70 \log(R+10) \quad S2 = .02 \qquad (4)$$

Re are the radii of equal-area-circle by using near and far-field or only near a respectively.

The attenuation relations corrisponding to Equation (1), (2), (3) and (4) plotted in Fig. 5 with, for comparison, the relation used (hatched line) for "shakeability map" of Italy (PETRINI ET AL., 1979).



5 - *The attenuation of earthquake intensity with distance from the epicentre. The solid lines the relations used in this paper; the hatched line shows the relation used for "Shakebility map" of Italy.*

valuation of earthquake magnitudes

For to evaluate the manitude of ancient earthquakes, the relation take into account the equal area damaging rather than epicentral nsity only, are to prefer.

An attempt of this kind for italian area has been made (BRANNO ET 1986), by using isosesmal maps for recent and well-studied earthquakes the empirical relation of the form (SHEBALIN, 1972):

$$Ii= bM-v\log (R^2+h^2)^{1/2}+c \qquad (5)$$

An example of the magnitudes evaluated (M) is Tab. 2; are also ented the macroseismic magnitudes calculated according to Karnik, MK G.-C.N.R., 1985), and the M1 I.N.G. Seismological Bullettin, for parison.

However, caution must be exercised for different areas applications.

These kinds of relations represent a first-approximation level and do ake into account either:

-the errors associated with each variable; or
- the regional setting of the area of interest; for example in Italy, the NW-SE tectonic trend of the Mainland peninsula with different structures, such as the foreland, foredeep, Apennine Chain and backdeep, running parallel with the Appennine Chain from the Adriatic to the Tyrrenian Sea.

Furthermore, the nature of the seismic energy distribution will have been significantly influenced by local, as well as regional, structural conditions. The relative effects of these two factors are difficult to evaluate and, indeed, it is only with the detailed analysis of recent earthquakes that it has been possible to separate regional from local contributions, some examples are shown in Fig. 6.

Tab. 2 - Evaluation of earthquake Magnitudes: MK (macroseismic magnitude calculated according to Karnik); ML (local magnitude from I.N.G. Seismologic Bullettin); M (macrosismic magnitude calculate according to (5) relation).

EARTHQUAKE	ML	MK	M
05.06.1688		6.6	6.9
08.09.1694		6.1	7.0
14.03.1702		6.1	6.6
29.11.1732		6.1	6.7
26.07.1805		6.5	6.5
14.08.1851		6.1	5.7
09.04.1853		5.6	5.2
16.12.1857		7.0	6.7
23.07.1930	6.5	7.0	6.5
21.08.1962	6.0	6.5	6.2
06.05.1976	6.1		6.2
19.09.1979	5.5		5.4
23.11.1980	6.5		6.5

4. Southern appennines seismogenetic map

In Fig. 7 are plotted the rupture lengths for the earthquakes in Fig. 4 in according to Magnitude-Rupture lenght proposed by BONILLA ET AL. (1984).

The direction of segments is just like the direction of maximum elongation of isosisms.

There is to note that no segment (Fig. 7) falls again on another one: it is probable to find about it analysing events proceding the 1688 earthquake (a few are in Fig. 7, dashed circle), for which it isn't possible, up to now, to determine a preferential elongation.

Resides, in the seismogenetic belt considered it is possible to observe that:
- the bulk of seismic energy is relased in the central part;
- the width of the belt is determined by 1694-1930-1980 earthquake succession;
- the migration of seismic activity is generally random, 1688-1702-1732-1910-1930 earthquakes succession;

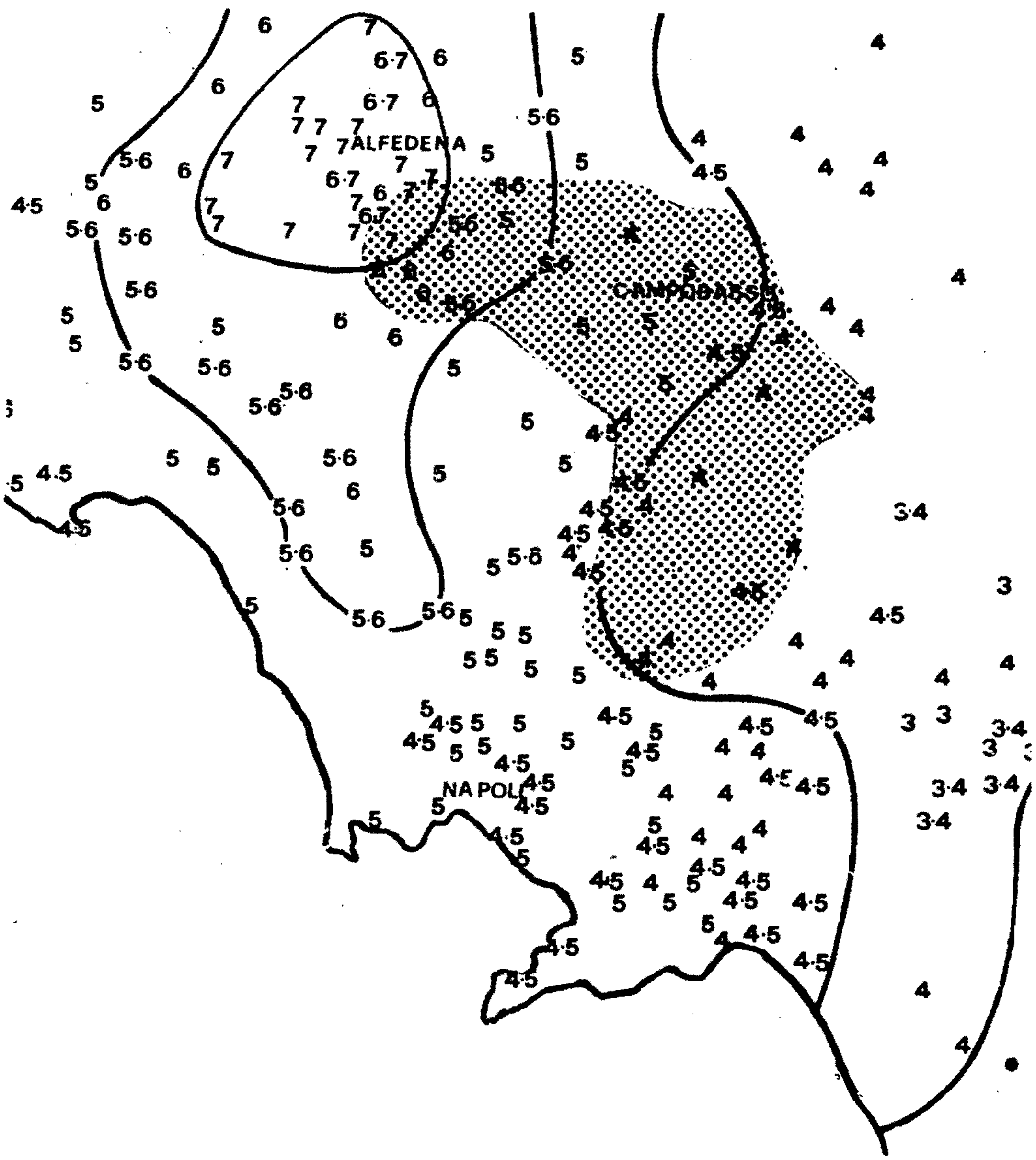


Fig. 6 - Comparison between the May 7, 1984 earthquake (solid line) and VII degree area (dotted line) of July 26, 1805 earthquake. It show attenuation values of intensity around Mt. Matese and good propagation in the direction of Campania plane.

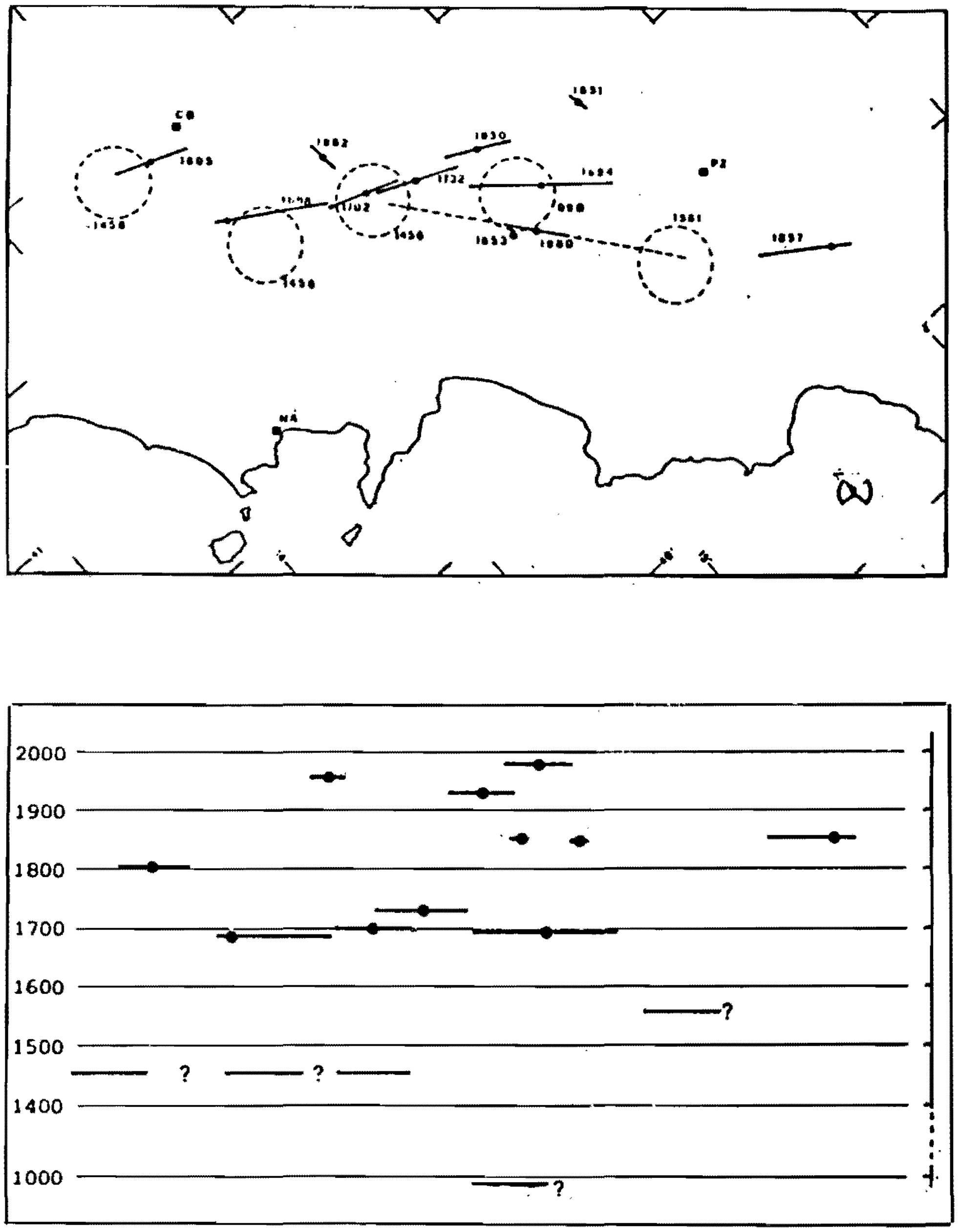


Fig. 7 - (a) Plot of the rupture lengths (solid lines) for the earthquakes shown in Fig. 4. The dashed line shows the length of the aftershocks-area for the November 23, 1980 earthquake. The dashed circle show the epicentral areas of 990, 1456 and 1561 earthquakes.

(b) The distribution of earthquake locations with time, showing also the associated rupture lengths. The rupture were calculated from the relation of Bonilla (1984).

- there are, in a brod sense, seismic gaps on the other sides of the 1805 and 1957 earthquake, NW and SE rispectively.

5. Conclusion

The revision of largest earthquakes recorded in Southern Apennine has allowed to find mutual peculiarity such as isoseism elongations in according to the axial direction of the chain, and to obtain new attenuation relations of intensity with a simmetry different of circular shape, which let to define better the seismic risk of Southern italian peninsula.

The valutation of the ancient earthquake magnitude, comparing the shaked areas with those of the recent events, it is to prefer to the epicentral intensity-magnitude evaluation. Particularly the 1694 earthquake, the largest analysed event, shows a 7.0 rather 6.1 (C.N.R.-P.F.G., 1985) magnitude.

The headlines shown above should be completed by the careful revision of the great historical events occurred before that of 1688 and by a detailed analysis of recent earthquakes for exhaustive comparison.

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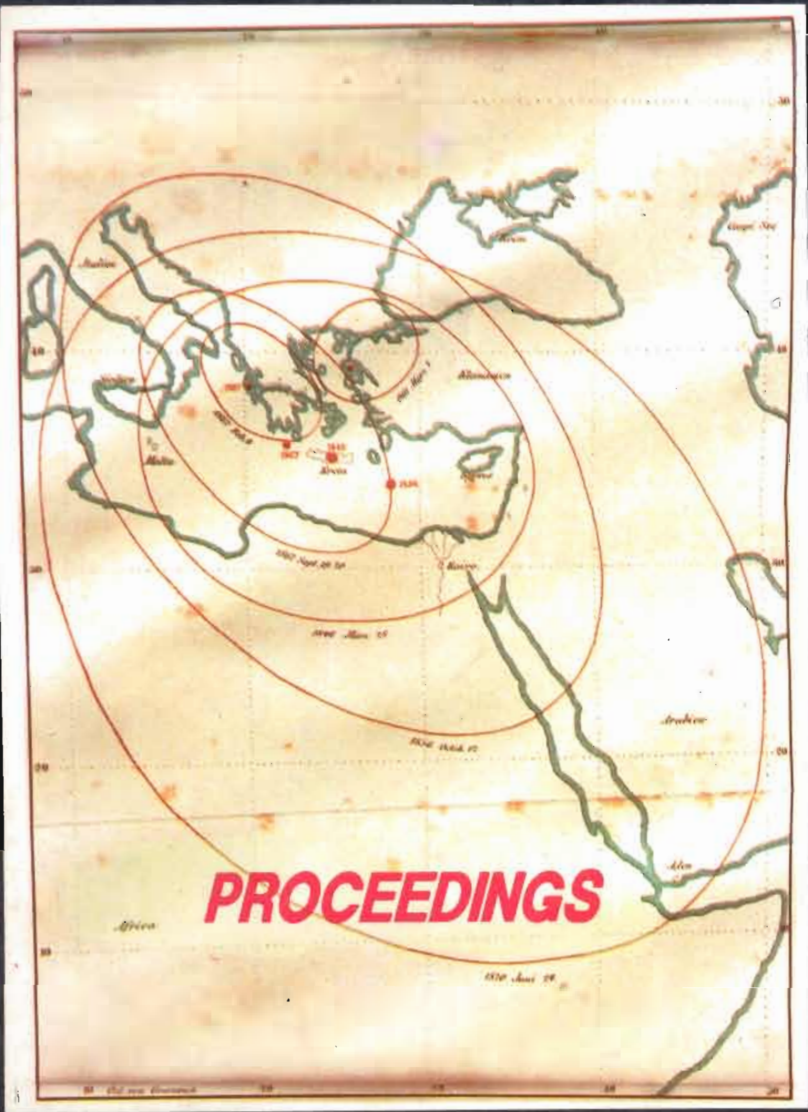

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