NATIONAL RESEARCH COUNCIL OF ITALY
The Italian Geodynamics Project

SOUTHERN ITALY NOVEMBER 23, 1980 EARTHQUAKE

Pubblicazione N. 503

7 ECEE

Athens, September 1982

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INTRODUCTION

The Italian Geodynamics Project has been approved in 1976 by the Italian Government. This was one of several projects elaborated by the National Research Council and finalized to improve and coordinate researches in various fields, all considered of very high socio-economic priority.

The Project includes the following 6 Subprojects:

- seismic networks
- seismic risk and earthquake engineering
- surveillance of active volcanoes and volcanic risk
- Paleography, paleotectonics and ore deposits
- Structural model of Italy
- Neotectonics.

As a whole, about 1000 researchers and 300 technicans cooperate to the Project. They form about 200 research units belonging to almost all Italian public research institutions (Universities, National Research Council, other public research centers).

Immediately after the November 23, 1980 earthquake, a considerable part of the researchers working in the Project devoted themselves to post-earthquake emergency activities. The initial program included the following items.

- Geology. Seismic sources and focal mechanisms. Surface effects.
- Seismology. Source parameters for the main shock and for the afterschoks sequence.
- Macroseismic effects. Isosists, attenuation laws, macroseismic focal parameters.
- Engineering. Technical support to emergency decisions of local Authorities. Survey of buildings behaviour.

In the meantime, Government Authorities asked the responsibles of the Project to organize the necessary scientific support to Central Government decisions. The main topics were: total damage, distribution of damage among different cities and villages, revision of the seismic map of the 3 Regions (Campania, Basilicata, Puglia) where damage occurred, emergency microzoning for reconstruction purpose.

An ad hoc working group prepared a form and an instruction manual for damage evaluation. There the working group organized an intensive course for 600 engineers and architects who were at that time in military service. With the guide of the researchers of the working group those 600 engineers and architects carried out an accurate damage evaluation in a sample made of 41 cities.

Another working group prepared the requested seismic map for Campania, Basilicata and Puglia. The same working group prepared also a critical review of the seismic map of all Italy, leading to a proposal of new map which has been accepted by the Ministry of Public Works.

A third working group organized an emergency microzonation program covering 38 cities. The main goal of the program consisted of making available to local and regional Authorities a number of seismic safety elements to be considered in planning for reconstruction.

In the frame of the Geodynamics Project, further studies and data collections have been carried out in connection with the November 23, 1980 earthquake. This report illustrates all the studies that may be interesting for the scientific community, except data regarding strong motion records (1); the report is divided into the following sections:

1. Geology. The main features of the November 23, 1980 earthquake are presented with reference to a general geologic study and with emphasis on the neotectonic evolution of the area.
2. Seismology. Preliminary anlysis of some focal parameters, which characterize the main event and the aftershocks sequence. Cumulative strain release curve of the aftershocks sequence. Epicenter distribution of aftershocks in the period November 23, 1980 - April 30, 1981.
3. Macroseismic survey. Historical seismicity of the area, from December 5, 1456 to July 23, 1930. Organization of the macroseismic survey after the November 23, 1980 event. Analysis of some anomalous attenuation zones. Macroseismic evaluation of focal parameters.
4. Emergency microzonation. Main results of the study for each investigated site. Organization of the intervention. Content of the final reports. Examples and discussion.
5. Damage evaluation. Elaboration of the data regarding 36.000 buildings. Damage Probability Matrices for the most common types of buildings. M.S.K.-76 Intensity derived on a statistical basis. Damage Probability Matrix versus M.S.K. Intensity scale.
6. Structural features of buildings. Description of the most common types of buildings in the zone, with particular emphasis on the cities with less than 10.000 inhabitants.
7. Behaviour of aseismic r/c buildings. Description of the behaviour of the r/c buildings designed according to aseismic italian standards in one of more hit towns during the November 23, 1980 earthquake: Sant'Angelo dei Lombardi.

G. Grandori

(1) Data regarding strong-motion records of the November 23, 1980 earthquake recorded in the 21 stations of the strong-motion network in Southern Italy have been reported in a separate publication: "Accelerometric recordings of the main quake and relating processing". Editor - ENEA - ENEL - Commission on seismic problems associated with the installation of nuclear plants.

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Section 1. GEOLOGICAL STRUCTURE OF THE REGION AND SURFACE EFFECTS OF THE SHOCK

by

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The Southern Apennines are part of a mountain chain constituted by décollement nappes piled up between Early Miocene and middle Pliocene times. The regional strike of the tectonic structures is NW-SE and the direction of the nappe transport is towards the Adriatic Sea. Three first-order structural units may be distinguished from the Adriatic to the Tyrrhenian seas: the Apulia foreland, the Molise-Bradano forethrough and the Apenninic chain (fig.1).

The Apulia foreland is constituted by a thick (around 6000 metres) sequence of slightly deformed Mesozoic and Tertiary shallow-water carbonates. We can distinguish the Murge-Salento region which represents a stable aseismic area and the Gargano promontory which is affected by a moderate seismicity due to block movements (prevalently strike-slip motions) along marginal faults. Deep seismic soundings revealed a typical continental crust 30-35 Km thick and a sharp Moho discontinuity (GIESE and MORELLI, 1975). A lithospheric thickness of 100-120 kilometres has been extimated by surface wave analysis (CALCAGNILE and PANZA 1979). The whole region is characterized by positive values of the Bouguer anomalies.

The Molise-Bradano forethrough forms an elongate narrow basin filled by a thick (more than 6000 metres) sequence of Pliocene-Quaternary terrigenous deposits. The front of the Apennines overthrust the western part of the basin during middle Pliocene times, so that the Lower Pliocene

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original depocenter is presently buried beneath allochthonous sheets. Drilling results indicate that the amount of the horizontal displacement is higher than 30 kilometres. The Molise-Bradano forethrough is characterized by negative Bouguer gravity anomalies. The minimal values are reached in the Taranto Gulf, where seismic reflection profiles allow to recognize that the base of the Pliocene (that is the top of the Murge-Salento carbonate platform) lies 6500-7000 metres below s.l. under the Apenninic nappes. The latter, in turn, are stratigraphically covered by U. Pliocene-Quaternary neo-authochtonous deposits which locally may reach some thousand metres in thickness (e.g. S.Arcangelo basin; Sibari basin). North of Potenza, at the inner margin of the Bradano through, Vulture Mt. rises up, a Quaternary volcano very likely growth on a knot of NW-SE and NE-SW trending faults which dissected the Apulia basament.

The Apenninic chain is constituted by a pile of nappes consisting of Mesozoic-Tertiary sedimentary rocks which include shallow-water carbonates, basinal pelagic deposits and flysch sequences. Palinspastic restorations (SCANDONE et Al. 1974) allow to calculate some hundred kilometres of total shortening; such a severe deformation is not expressed either in the crustal roots of the Apennines which do not exceede 40 Kilometres or in the altitude of the mountain chain slightly exceeding 2000 metres; along the Tyrrhenian margin of the Apennines, moreover, the Moho discontinuity lies at a deepth of only 20-25 Kilometres. The discrepancy has been explained admitting that crustal thinning along the south-western side of the Apennines occurred during the opening of the Tyrrhenian Sea. The latter has been interpreted as a young oceanic basin generated by a counterclockwise rotation of the Italian peninsula in Middle-Late Miocene times (SCANDONE,1979).

The Southern Tyrrhenian sea is characterized by the occurrence of deep focus earthquakes related to the presence in the asthenosphere of a lithospheric body which represents the remnant of a larger subducted slab (GASPARINI et Al.,1982). Intermediate earthquakes have been recordered along the Tyrrhenian side of the chain. The Southern Apennines are affected by destructive shallow events with epicentral areas pratically coinres in the bed rock and of ground cracks in the soil. In order to survey a large territory in a short time, the team was divided in small working groups operating in different areas or having different tasks.

In the examined area four principal lithologic groups crop out:

- thick bedded dolomites and limestones of Mesozoic age constituting in this sector of the Apennines the lower nappes of the tectonic edifice;
- terrigenous deposits, consisting of sandstones, paraconglomerates and subordinate marls with olistostromes of chaotic clays including lithic blocks. These deposits belong to a Lower-Middle Miocene wildflysch which unconformably overlie the carbonate thrust sheets;
- chaotic varicoulored clays supporting large masses of basinal marls and limestones of Cretaceous-Lower Miocene age;
- Pliocene clays, sands and conglomerates.

The structural edifice has been dissected by vertical faults chiefly striking N 70° W; only in the Sele Valley the principal faults approach tne N-S direction.

A small group of geologists spent several days visiting most of the faults mapped as active faults in recent time (APRILE et AL.,1979), particularly those which border the carbonate massifs. Hundreds of fault surfaces have been examined, but no traces of new displacements have been discovered.Moreover, no traces of fracturing related to the main event have been discovered in the bedrock, also when the latter was constituted by Pleistocene deposits crossed by very recent joint systems. Several cracks, on the contrary, have been found in the soil and in the roadways, as well as in Quaternary unconsolidated colluvial deposits. Locally (e.g. Senerchia; S.Gregorio Magno) colluvial deposits resting on and against fault surfaces appear down-shifted with vertical displacements of several decimetres. In such cases, the fresh fault surface is exposed, simulating reactivation phenomena. The non-existence of reactivation phenomena is demonstrated by the fact that along the same fault surface no displacement was observed in the bedrock, when this was exposed. In conclusion, all major structures which appear as signs of tectonic activity along faults are compaction by vibrating during the main shock. The minor structures, ciding with the divide of the mountain chain. The maximal isoseismals de lineate elongate narrow ellipses which follow the strike of the regional tectonic structures (see SCARPA and SLEJKO, this report). The focal mechanisms reveal fault planes trending NW-SE and horizontal T axes oriented normally to the strike of the Apennines. Dip-slip and strike-slip mo tions have been determined (GASPARINI et Al., 1982).

The Apenninic region is closely dissected by several systems of faults, the most prominent being developed along the Tyrrhenian side of the mountain chain. The vertical displacements may reach here some thousand metres, with subsidence rates approaching 0.3 cm/y in the coastal plain during Early Quaternary times.

No considerable historical seismicity is reported along the Tyrrhenian side of the Apennines, in spite of the striking evidences of neotectonic activity. As we said before, the large Apenninic earthquakes occur along the divide of the mountain chain. This fact may be explained admitting a migration of the NW-SE fault system from the Tyrrhenian border towards the Adriatic one in Pliocene-Quaternary times.

The average rate can be estimated around 4 cm/y. Such kinematic trend is in good agreement with a documented time-space migration of the Apenninic divide, showing that the boundary between down-faulted blocks and uplifted blocks migrated in time from the inner side to the outer side of the tectonic edifice. We believe that this process is a consequence of a still active rifting related to the anticlockwise rotation of the italian peninsula and to the opening of the Tyrrhenian Sea.

Three days after the catastrophic event a team of thirteen geologist operating in the Italian Geodynamics Project reached the epicentral area for structural investigations (CARMIGNANI et Al., 1981). The aim was to control whether displacements related to the earthquake occurred along the Quaternary faults or new faults had been generated, as well as to col ect data suitable for structural analysis such as measuraments of fractuon the contrary, result to be more interesting because less influenced by local geological and morphological conditions. More than 3000 elements have been measured and divided according to the azimuth (strike of the fracture), dimensions (length of the fracture and amount of the displacement) and tipology (fissures; direct, reverse and strike-slip "microfaults"). Structures obviously related to collapse phenomena have been discarded a priori. Computer analysis has been executed, mainly consisting of : azimuth distribution of the crack systems in the whole region and their frequency in the different areas; correlation between azimuth systems and morphology in order to eliminate residual structures related to gravity phenomena; regional distribution of the fractures expressed by the average number of cracks/km along the roads.

We observed a good correlation between the frequency of the fractures and the distribution of the isosismals; this correlation suggests the possibility to use the future also this parameter in order to evaluate the macroseismic intensity.

The azimuth distribution of the ground cracks over the whole investigated area is shown in fig. 2. We made several tests of significance on the different systems and only the N60°W and the N20°E peaks appear surely representative of structures not related to geometrical or morphological local conditions. Along the direction N60°W compression and tension cracks have been recognized; the same fracture often shows to have undergone alternatively dilation and contraction. Along the N20°E direction, on the contrary, we found only tension cracks. The system N60°W has been attributed to a preferred direction of seismic wave propagation; the second one has been interpreted as an extensional system forming with the previous one an angle of about 90°. The direction N60°W pratically coincides with the strike of the regional structures and approach the most probable surface defined by the fault-plane solution, as well as the ropture surface suggested by the aftershock distribution (see SCARPA and SLEJKO, this report). We cannot discriminate, therefore, how much the pattern of the crack field is due to the geometry of the tectonic structures and how much it is influenced by the geometry of the seismic source and by the focal parametres.

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