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EARTHQUAKE IN CAMPANIA-BASILICATA, ITALY
NOVEMBER 23, 1980

A RECONNAISSANCE REPORT

by
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COMMITTEE ON NATURAL DISASTERS
(1980)

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OVERVIEW

On November 23, 1980, south-central Italy was struck by a disastrous earthquake that affected the regions of Campania and Basilicata and the provinces of Naples, Salerno, Avellino, and Potenza. The magnitude 6.8 earthquake, which was centered about 100 km east of Naples, caused severe damage, even though it was of moderate intensity. It killed approximately 3,000 people, injured about 9,000, and left more than 100,000 homeless. Two weeks later, more than 1,500 were still missing. The heavily damaged area covered more than 10,000 sq km.

Immediately after the disaster, the National Research Council's Committee on Natural Disasters and the Earthquake Engineering Research Institute organized a joint team to conduct field studies and to report their observations on the response of the populace, structures, lifeline facilities, and geotechnical features to the earthquake effects. The team members were James Stratta, structural engineer and team leader; Luis Escalante, lifeline facilities engineer; Ellis Krinitzsky, geotechnical engineer; and Ugo Morelli, social scientist.

The team arrived in Rome on December 3, 1980. After conferring with staff officers at the U.S. Embassy, with engineers from the Comitato Nazionale Energia Nucleare (CNEN), and with officials in the Ministry of the Interior, the team proceeded to Naples, from which field studies of the devastated areas were made each day for the following week. A reconnaissance flight by helicopter was first made over the damaged area. Trips were then made by automobile to cities and villages, to make the detailed observations described here.

On completing the field studies, the team members returned to Rome to discuss their observations with the U.S. Embassy members and with the Italian engineers at CNEN. The observations in this report are based on the information the authors obtained as of that time.

Observations

Although the shocks were of moderate intensity, damage to housing and injuries to occupants were severe for a number of reasons:

- The earthquake produced multiple strong shocks in the first few minutes.

- Seismic zoning in this area reflects only the areas damaged in recent earthquakes and not seismicity that may be anticipated based on the historic seismicity of Italy.
- In this region, older homes are mostly unreinforced rubble-stone masonry wall buildings with little seismic resistance that had been subjected to frequent shaking from previous earthquakes.
- Much of the newer multiple dwelling housing construction is reinforced concrete frame with infill masonry walls--also weak with respect to seismic loads.
- Many of the villages in this mountainous region were located on high ridges and were accessible only by one or two winding narrow mountain roads. Debris from destroyed masonry buildings in the villages above often completely blocked these access roads, delaying rescue efforts in the high mountain villages.

Lifeline facilities--electric power, water, telephone, and roadway systems--were slightly to severely damaged. Much of the damage to three of these--power, telephone, and roadway systems--was caused by building failures and the movement of building debris down slopes in the mountain villages.

The Italian government responded promptly and organized, under the natural disaster act of 1970, a network of operations centers to direct rescue and recovery activities. Rescue forces from many sources and the Italian Red Cross recovered and cared for the victims. Temporary housing was provided in tents, trailers, railroad cars, prefabricated buildings, school houses, and requisitioned hotel rooms. Field hospitals and temporary feeding centers were established. Lifesaving operations in the immediate post-disaster period were particularly difficult because heavy equipment suitable for moving debris was not available soon enough in the many places where it was needed.

The study team concluded, inter alia, that:

- The multiple shock data for this earthquake, together with some information on multiple shocks from other earthquakes, may be useful in specifying earthquake ground motions for future designs.
- Seismic zoning for building code requirements should reflect the anticipated seismicity of an area.
- Buildings should be designed and constructed to account for the influence of nonstructural elements such as infill walls.
- To save more lives of survivors, better preparation is needed; for example, planning for emergency response, training of personnel, planning for use of heavy equipment to move debris, and improvement in techniques for rescuing people trapped in debris.

SEISMOLOGICAL AND GEOTECHNICAL ASPECTS

The Earthquake

The Campania-Basilicata, Italy, earthquake of November 23, 1980, occurred at 18 h 34 m 53.0 s Greenwich time. The local time was 19 h 34 m 53.0 s. The epicenter was at latitude 40° 46'N and longitude 15° 18'E. Magnitudes were reported as follows:

Strasbourg..................M_S = 7.0
Trieste.....................M_S = 6.8
Pasadena....................M_S = 6.9
Berkeley....................M_S = 7.2; m_b = 6.7
U.S. Geological Survey......M_S = 6.8; m_b = 6.1

The CNEN has reported a preliminary M_S = 7.0, with a focal depth of 18 km. The focal depth estimated by the U.S. Geological Survey is 10 km.

An intensity map, with the epicenter of the main event, is shown in Figure 1a. These intensities are those of the Mercalli-Cancani-Sieberg scale (MCS) used in Italy. (The MCS scale was used in its general sense without reference to the type of construction. Its use is consonant with that for historic earthquakes in this region. The Intensity X boundary includes areas of lesser intensity and may be modified when more detailed studies are made. See Appendix A for an abbreviated version of the scale.)

The area of severest shaking, MCS X, was bounded by Sant' Angelo dei Lombardi, Calitri, Pescopagano, and Calabritto, but the damage reached as far east as Potenza, north to Ariano Irpino, west to Naples, and south to Capaccio (the area shown here as MCS VII - IX). There were also pockets of substantial damage outside this area.

The earthquake triggered strong-motion instruments at the following locations: Arienzo, Auletta, Bagnoli Irpino, Benevento, Bisaccia, Bovino, Brienza, Calitri, Centrale Nucleare Garigliano (two records), Gioia Sannitica, Lauria (Caldo), Mercato San Sescerino, Roccamonfina, Rionera in Vulture, San Giorgio La Molara, San Senero, Sturno, Torre del Greco, Tricarico, and Vieste (see locations on Figure 1b). The strong-motion records, all produced on kinemetrics SMA-1 instruments,

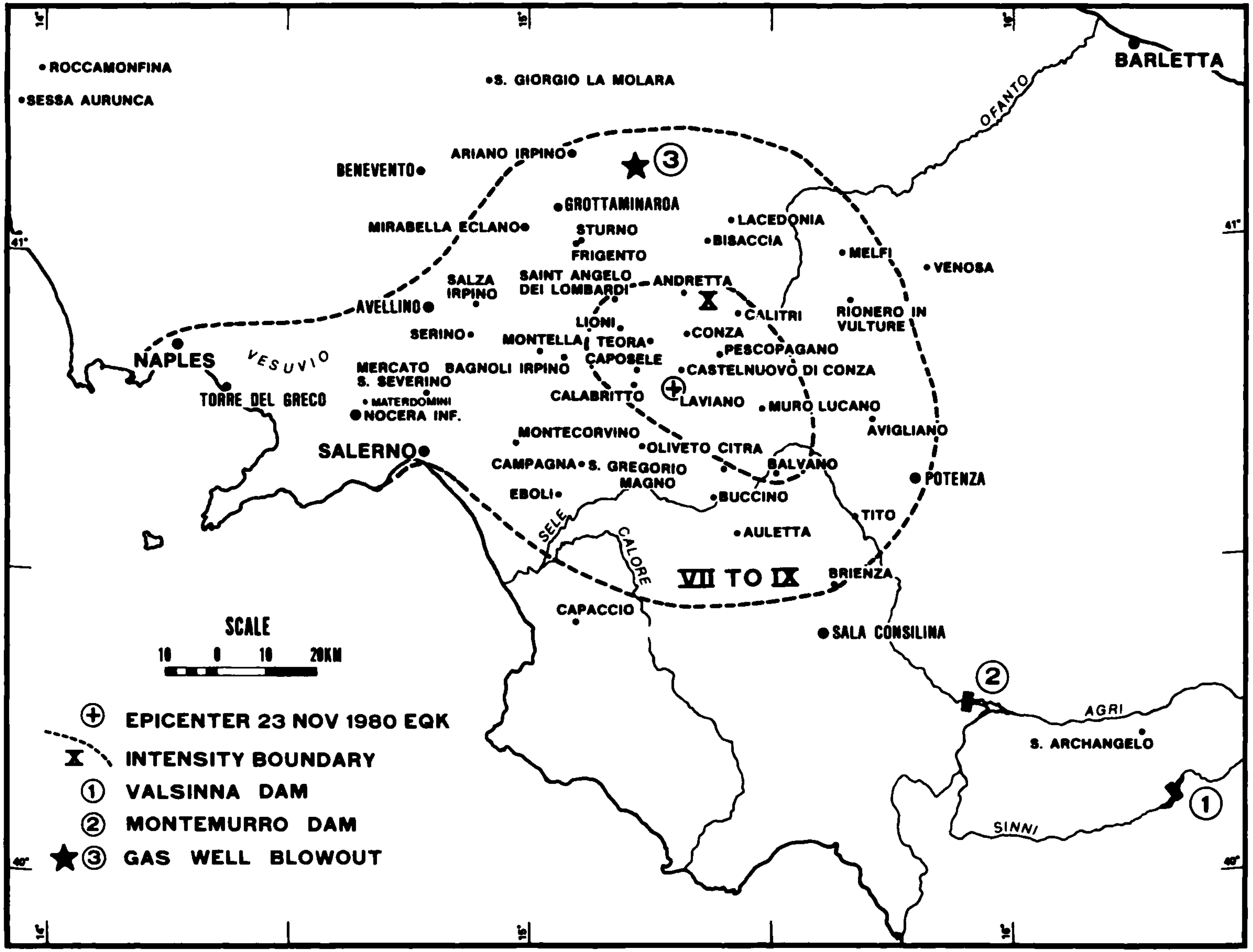

Figure 1a. Location map and intensity pattern of earthquake in Italy, 23 November 1980.

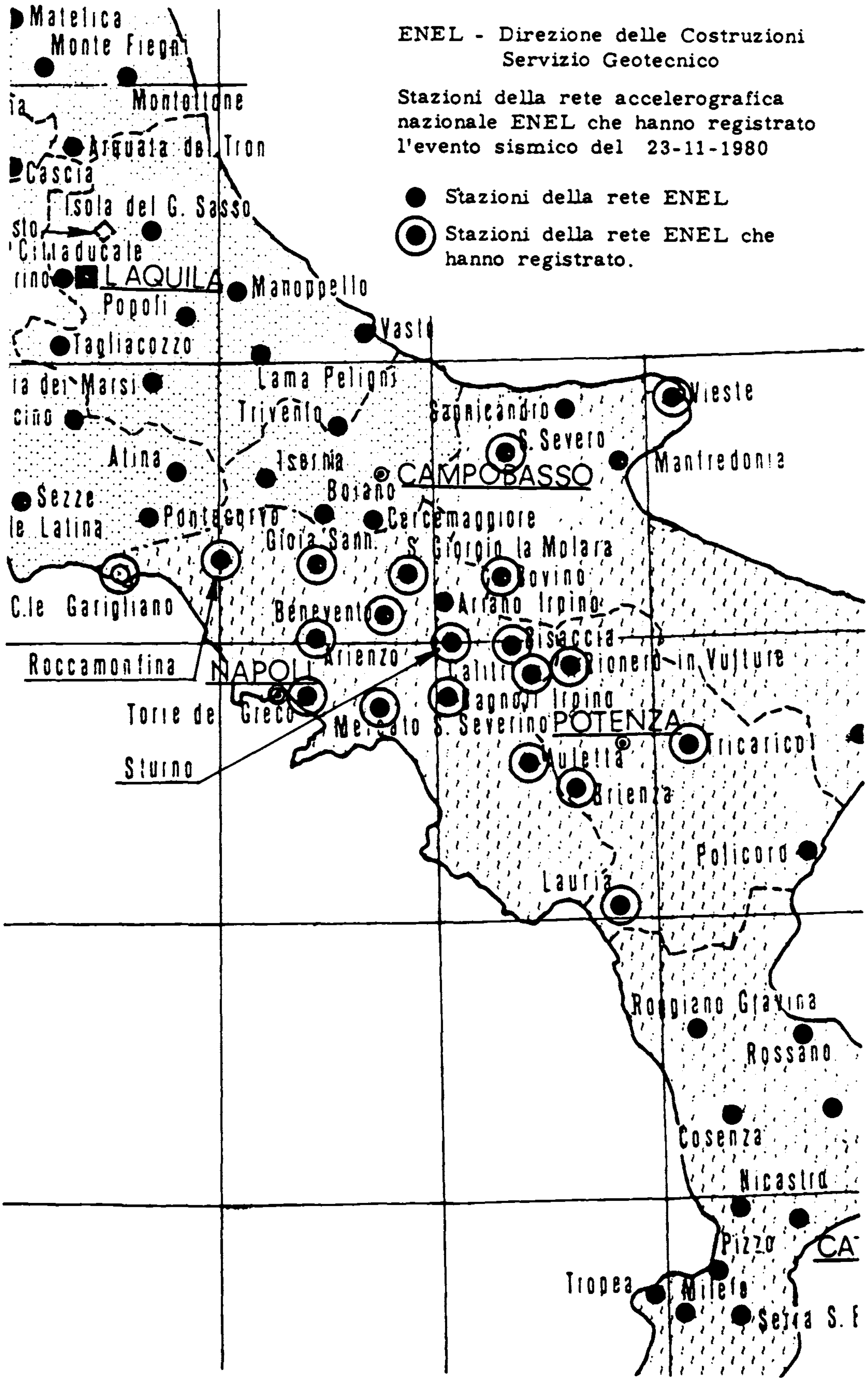

Figure 1b. Locations of strong motion instruments (closed dots) and instruments triggered by the earthquake (circled dots). Map by CNEN-ENEL (1980).

show that there were from three to five shocks within less than 2-1/2 minutes. The first was the most severe. Apparently there was no buildup of premonitory shocks. The second shock was less severe, and later events were even less so. The strongest recorded motion was 0.35 g at Sturno, for the main shock (Table 1).

The severest motions were recorded at Sturno, Calitri, Brienza, and Bagnoli Irpino. Peak motions at these stations range from a little more than 0.1 g to 0.35 g, with bracketed durations (greater than 0.05 g) of from 5 to 27 seconds for the main shock, and a total of 146 seconds for all five shocks at Sturno. The amount of damage in relation to the first and succeeding shocks was not established and may prove difficult to ascertain. Portions of the strong-motion records at Sturno and Calitri are shown in Figures 2a and 2b. At Calitri (Table 1), the second shock had motions as severe as the first, indicating possibly that Calitri is closer to the source of the second shock than Sturno. A further complication in the record at Calitri is a landslide that occurred at the edge of the town. Its movement may be reflected in the strong-motion record; however, no interpretation has yet been made.

Geological Setting

The earthquake was centered in a mountainous region where there is a predominance of Tertiary volcanic rocks, principally from the Miocene age, and crystalline igneous rocks of greater age. Mount Vulture, 15 km east of the area and with an Intensity X shaking, is a dormant volcano. In the western part of the disaster area, there are large expanses of young, effusive, igneous rocks resulting from recent volcanism. West of this area is Mount Vesuvius.

The topography of the area is rugged. Valley bottoms have an elevation of 500 m and mountain peaks on the southwest reach 1500 m. The epicenter at Laviano (Figure 3) is along a linear trend, NW to SE, formed by the northeast slopes of the adjacent mountains. Another lineation, from Teora southward, is suggested by the rivers and valley bottoms. These lineations may be structurally controlled, but none can be positively identified as being related to the causative fault of this earthquake.

No surface fault ruptures were identified during the reconnaissance. Flight crews making helicopter runs reported that they saw cracks in the earth down the slope from the town of Laviano. After visiting this site, the team judged the cracks to be erosion effects in colluvial or earth-slide materials that were not related to the earthquake. The valleys have colluvium and alluvial fill which may obscure evidence of fault effects.

Historic Seismicity

The catalogue of Italian earthquakes (Carrozzo, 1972), lists an earthquake for June 7, 1910, that occurred at latitude 40° 32'N,

Table 1. Preliminary Estimates of Peak Motions for the Earthquake.

Instrumentation Station	No. of Shocks on First Record and No. of Seconds from First to Last	Motion Components	First Shock Peak Accel. g	First Shock Duration (>.05g) sec	Second Shock Peak Accel. g	Second Shock Duration (>.05g) sec
Bagnoli Irpino	3 - 115	N-S	0.125	5.3	*	3.0
		V	0.083	6.0	*	---
		E-W	0.166	7.5	*	3.0
Bisaccia	3 - 76	N-S	0.079	4.2	*	6.0
		V	0.039	---	*	---
		E-W	0.075	2.4	*	6.0
Brienza	5 - *	N-S	0.162	9.0	*	*
		V	0.111	8.5	*	*
		E-W	0.131	10.9	*	*
Calitri	5 - 140	N-S	0.100	24.0	0.14	17
		V	0.158	20.0	0.158	17
		E-W	0.118	27.0	0.158	17
Mercato San Severino	3 - *	N-S	0.092	10.7	*	*
		V	---	---	*	*
		E-W	0.139	14.0	*	*
Sturno	5 - 146	N-S	0.17	13.0	*	9.5
		V	0.22	12.0	*	---
		E-W	0.35	15.0	*	9.5

*Not estimated

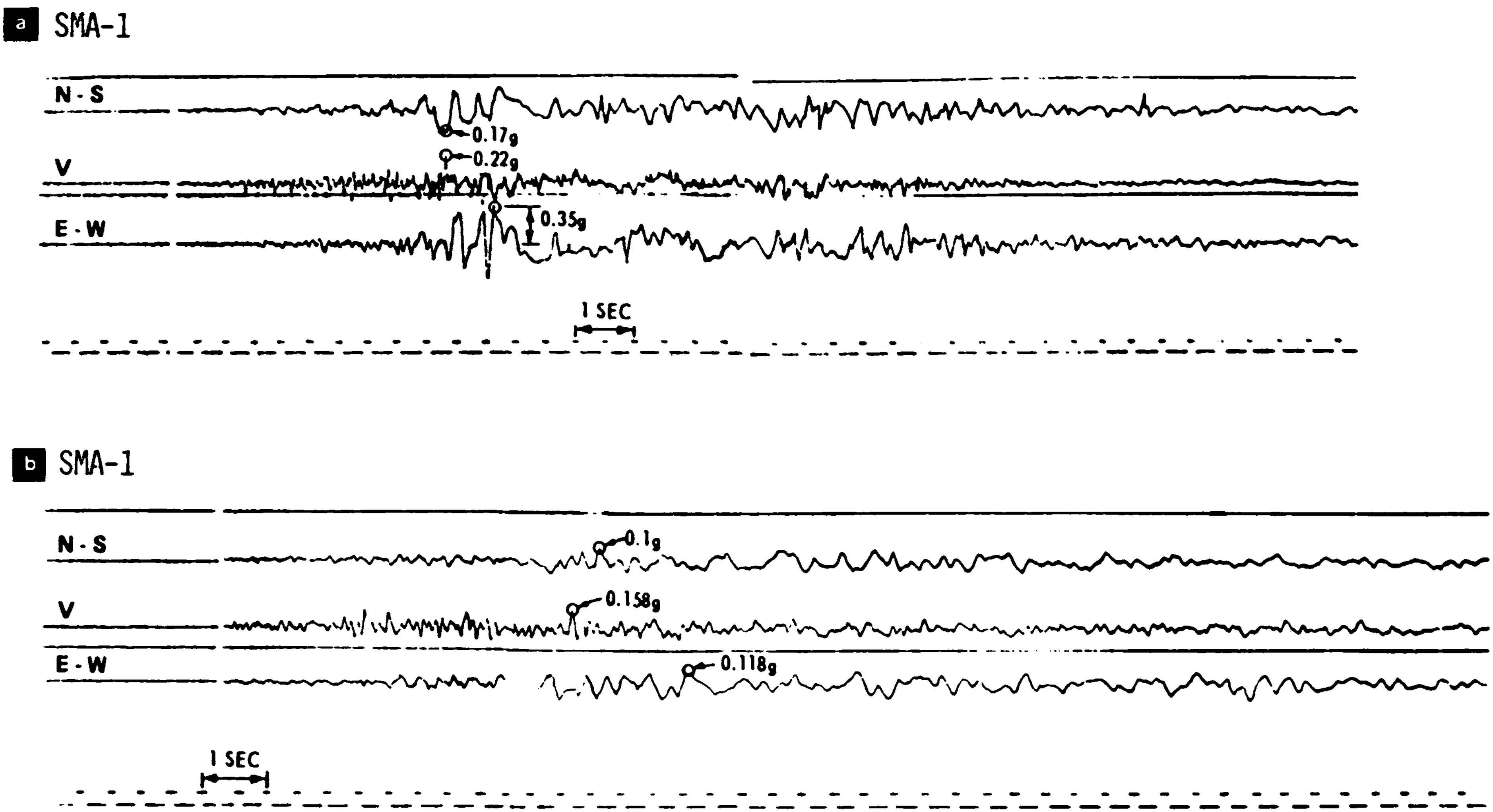

Figure 2. Strong motion during main shock: (a) Recorded at Sturno
(b) Recorded at Calitri.

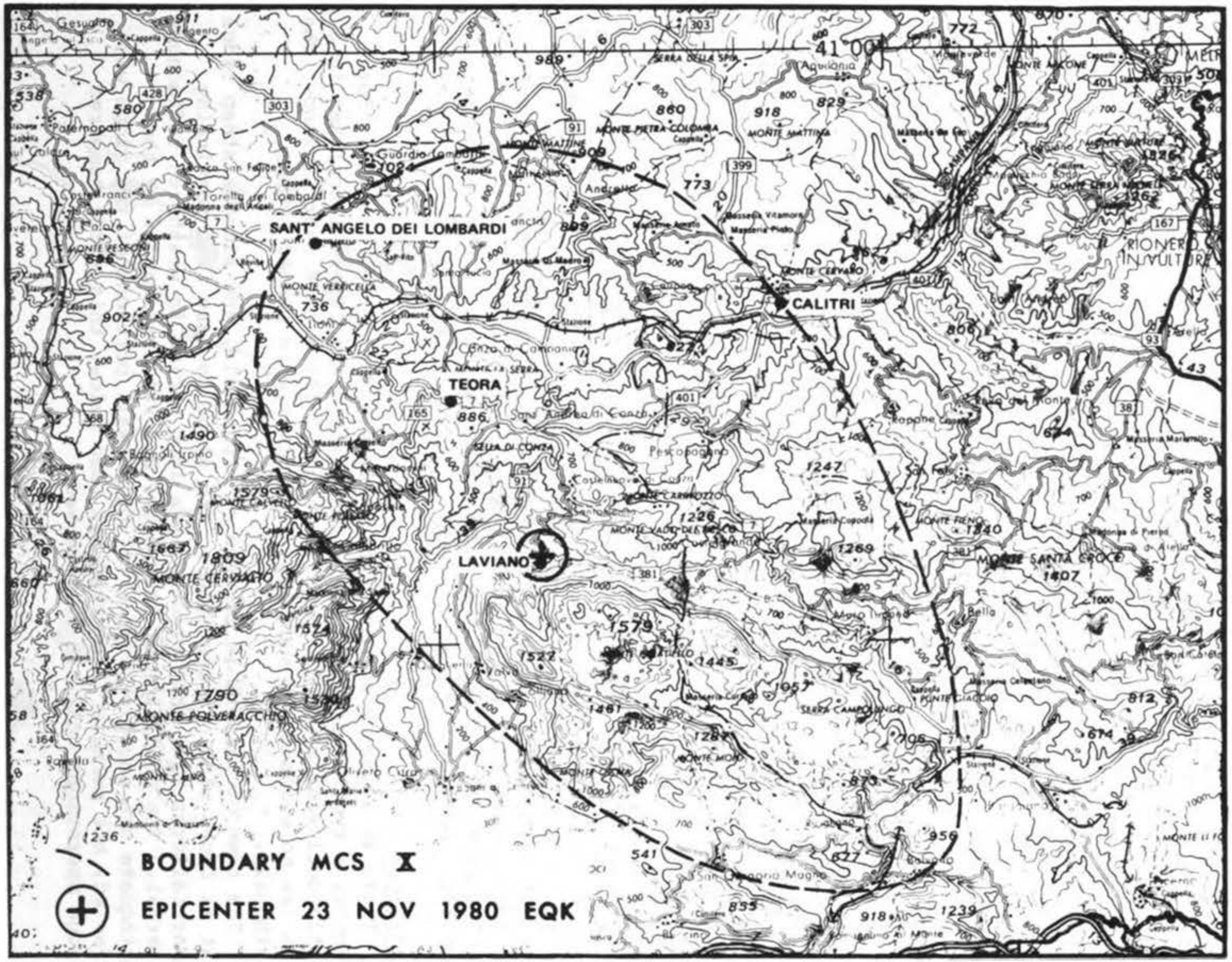

Figure 3. Topography in the area of severest shaking.

longitude 15°16'E, a location very close to the present event. It was M_L = 5.9, with an MCS Intensity X. It was preceded by a felt shock on June 7 and followed by shocks on July 8, Intensity IV, and July 31, Intensity VI.

The most severe historic earthquake in the vicinity was recorded on September 8, 1694, at latitude 40°N, longitude 15°E. It was an interpreted M = 6, Intensity X.

Maps of historic seismicity in Italy (Giorgetti and Iaccarino, 1973a; see Figures 4a and 4b) show that all but the most severe earthquakes have been distributed evenly throughout the area shown, both in size and spatial distribution. Iaccarino (1973a, b, c) counts a total of 2,130 events between the years 1 and 1972. Of these, he interprets 60 as Intensity X, with 20 more that were greater than X. The most severe earthquakes, X and greater, are situated along the mountainous spine of the country and away from the coasts. The November 23, 1980, earthquake fully matched the trend of these historic, severe earthquakes. For a composite of the intensities recorded between 1500 and 1972, see Figure 5 (Iaccarino, 1973b). The Intensity X of the present earthquake occurred within the Intensity X zone on the map.

Seismic zoning in Italy (Iaccarino, 1973a) is shown in Figure 6. The seismic zones are shown as Category 1 and Category 2.

Accessory Earthquake Effects

In this case, the principal accessory event was the blowout of a gas well 10 days before the earthquake, near Ariano Irpino, about 25 km from the epicenter and within the areas of severe shaking. A flame-like red glow was also reported sighted near Campagna, in the evening during the earthquake, but this report could not be confirmed.

The team did not check the numerous hot springs in the region for anomalous behavior.

Landslides

There is evidence of many shallow landslides in this region. For example, a typical situation in which there are multiple landslides in a gentle colluvial slope is shown in Figure 7 for a site near Laviano. The team saw no evidence of such landslides that were caused by the earthquake.

The town of Calitri is perched on a pinnacle, and along a steep ridge that is faced with a steep slope. The slope is bare from continuing shear failures that took place over a long period in weathered tuffaceous material. The condition of this slope and failures caused by the earthquake are shown in Figure 8. Only small portions of the slope were affected, but because it blocked the road below, this slide hampered rescue operations until it was removed.

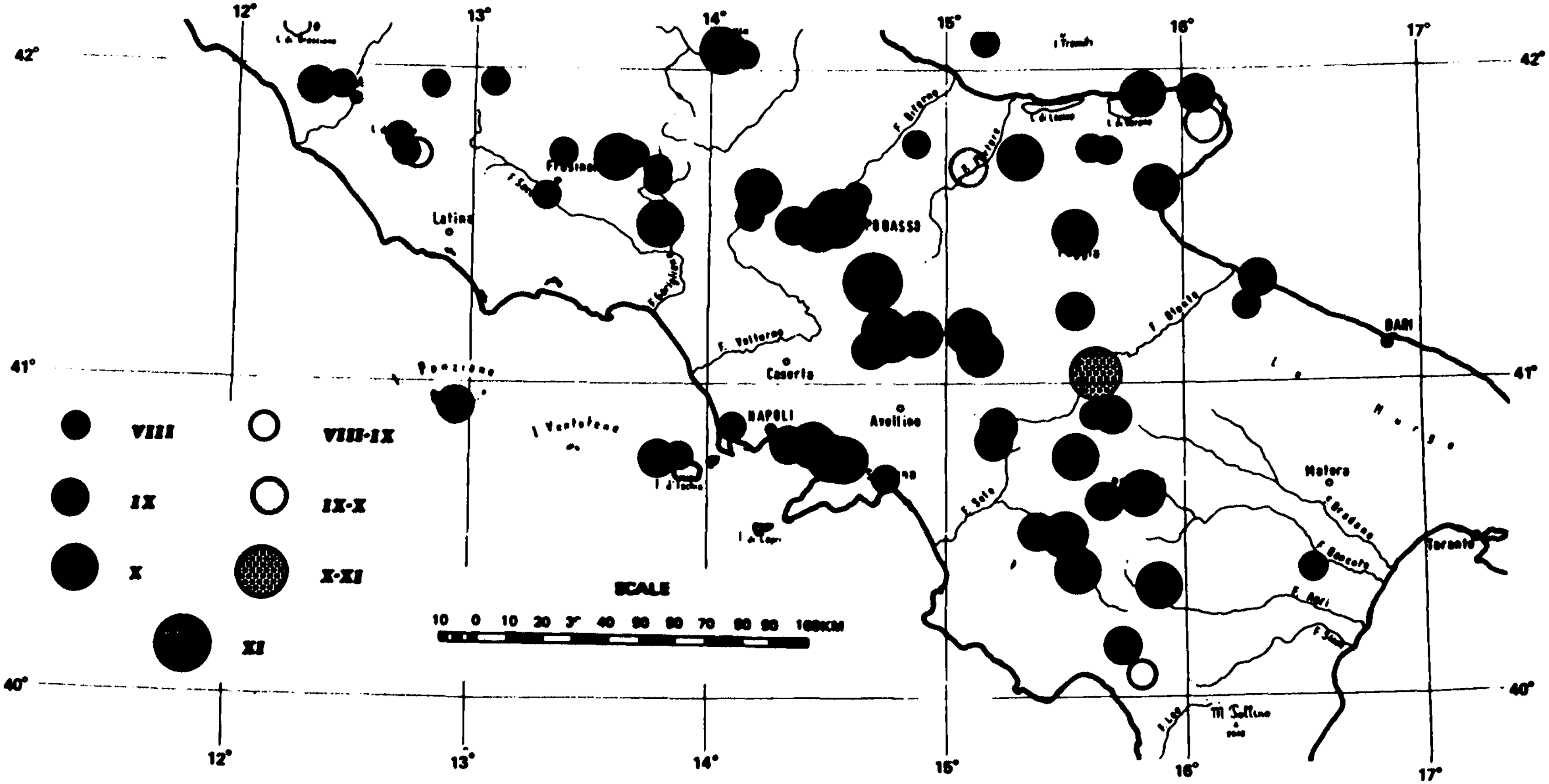

Figure 4. Seismic events in Italy: (a) 0 to 1893, MCS intensities VIII to XI.

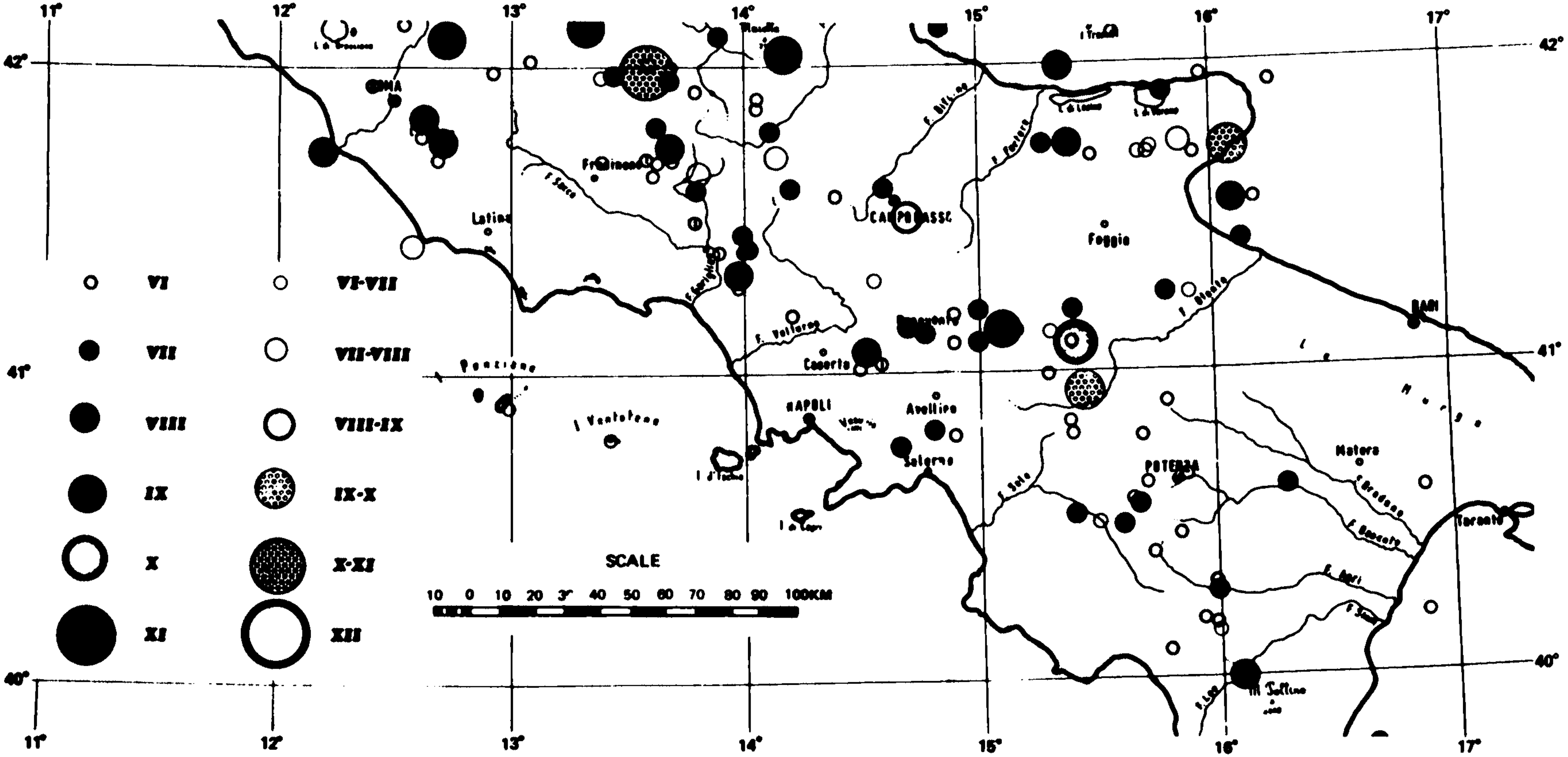

Figure 4 (cont'd). Seismic events in Italy: (b) 1893 to 1972, MCS intensities VIII to XI.

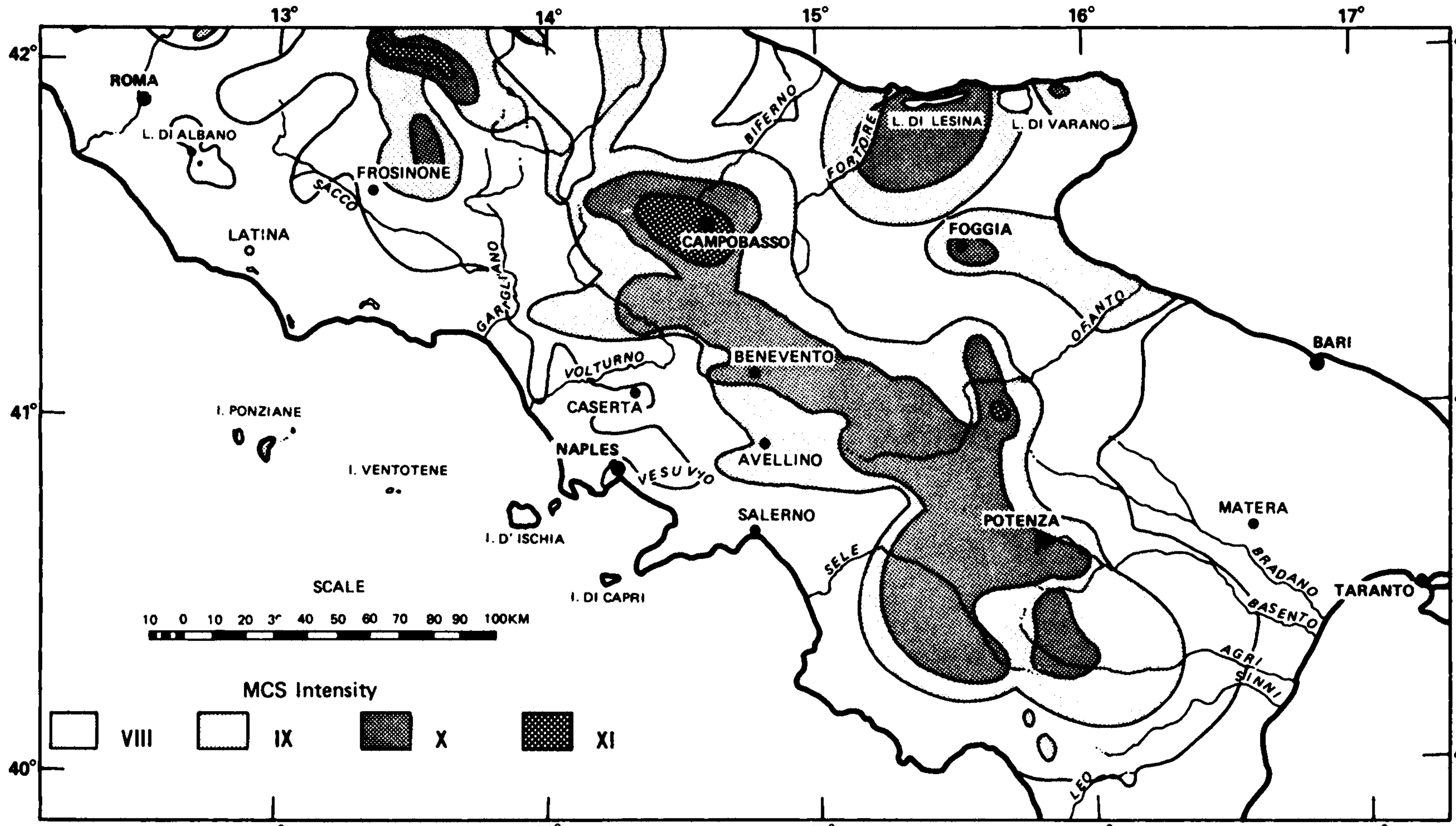

Figure 5. Seismicity in Italy: 1500-1972.

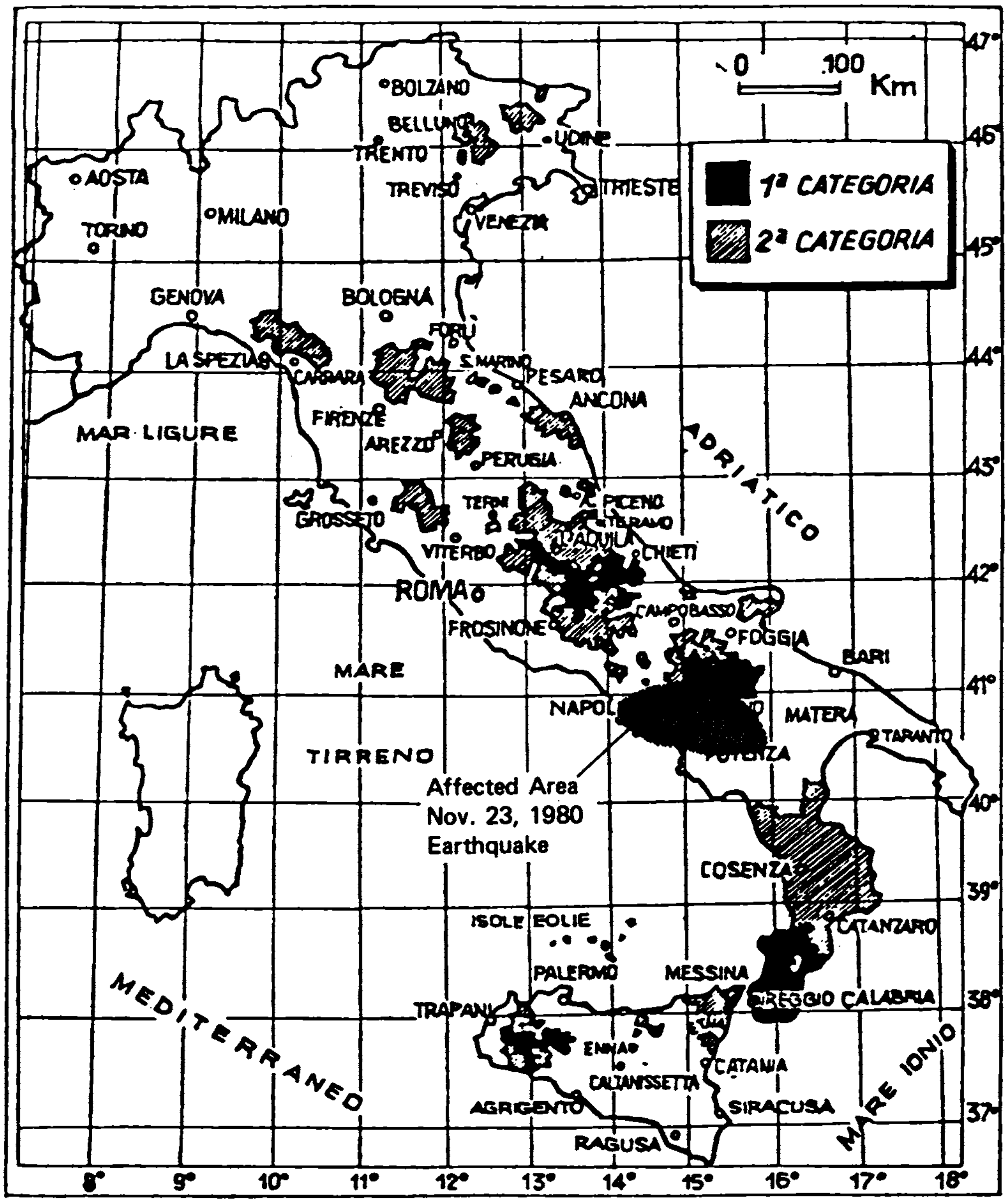

Figure 6. Seismic zoning map of Italy. Horizontal force coefficient for seismic design:

1ª categoria is 10 percent g, and
2ª categoria is 7 percent g. Seismic design is not required in other areas.

Figure 7. Landslides in a gentle colluvial slope near Lavino.

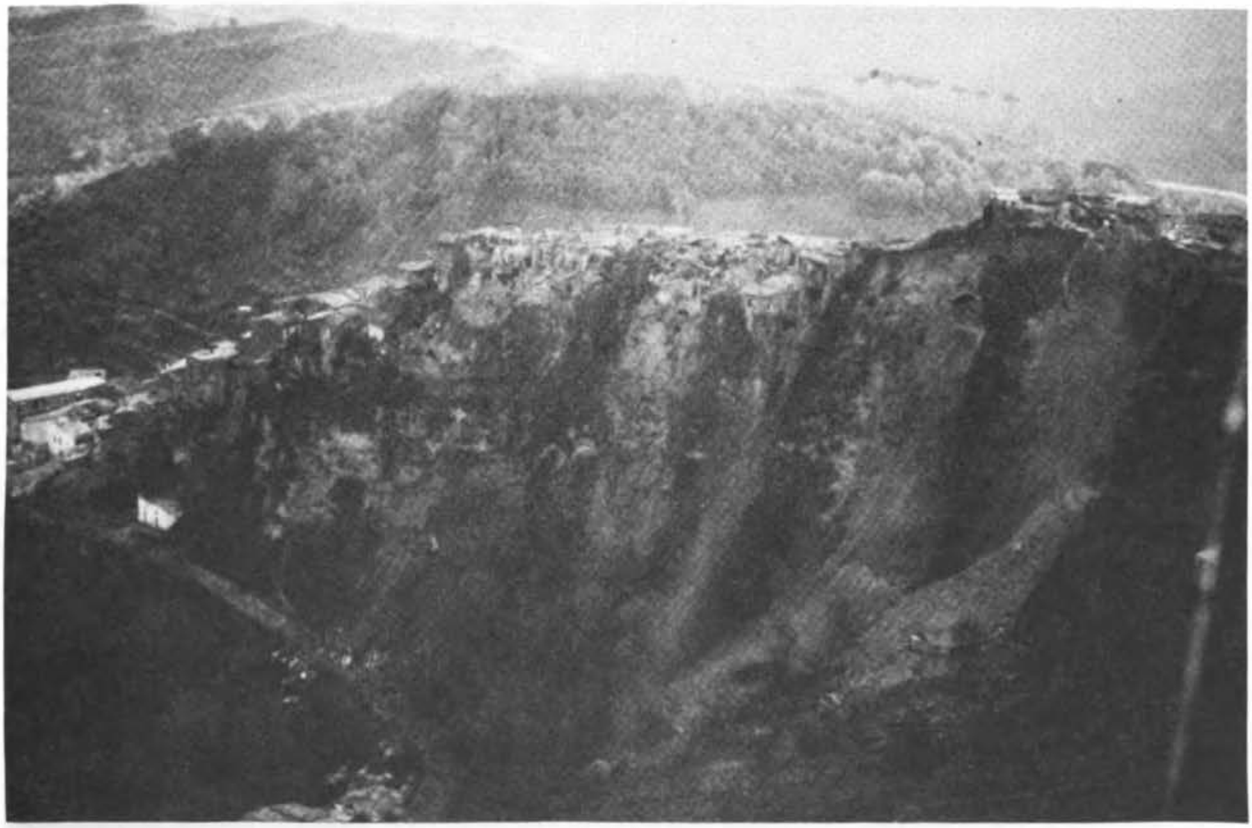

Figure 8. Landslide at Calitri.

Subsurface Cavities

The Naples-Salerno area has many short highway and railway tunnels. There was little shaking in the area and no damage was observed or reported. There were no tunnels or mines or penstocks in the most affected area. No failures in subsurface cavities (tunnels, caves, etc.) are known to have resulted from this earthquake, possibly because such cavities are not found in the areas of severe shaking.

Dams

Small dams are to be found at Valsinna and Montemurro (Figure 1a). Because they were both in an area of Intensity VI or less, they were not subject to any potentially damaging shaking and no damage was reported. No large dams exist in the earthquake-affected area.

Soil Liquefaction

The team found no evidences of soil liquefaction during its reconnaissance.

STRUCTURAL ASPECTS

Failure of Structures

Almost all the buildings that collapsed were either older homes constructed of rubble-stone masonry walls with no reinforcing (Figure 9) or the newer concrete-frame structures with infill walls (Figure 10). The latter structures were not designed or constructed with any appreciable seismic resistance. Infill walls are defined as that area of wall between the concrete columns of the frame and between the floor and underside of the floor above. When this area is filled with rigid--but brittle--materials, such as hollow clay tiles, unreinforced adobe blocks, or concrete blocks or bricks, it creates a very rigid element that attracts the seismic forces. Though it attracts these forces, the wall is very weak, cannot carry the load, and thus fails. In general, we define this by saying that these are stiff elements with no ductility and small ultimate capacities.

The older buildings failed because the weak unreinforced walls and the wood-floor and wood-roof systems were unanchored and had no capacity to act as diaphragms. The newer concrete-frame construction lacked seismic design and failed primarily because of the rigid but weak infill walls. The failure of these walls usually causes cracks that are propagated through the concrete columns, causing the columns to fail. The building often collapses after this series of events. This process often occurs and was vividly demonstrated during this earthquake. The contribution to failure of these infill walls is discussed in an article, "Interaction of Infill Walls and Concrete Frames During Earthquake" (Stratta and Feldman, 1971).

Figure 11a shows two identical structures, one with the completed frame but no walls, and the other with walls being constructed at the time of the earthquake. Note that the pure frame has not sustained any damage, but there is extensive damage to the incompleted infill walls. The infill walls are not reinforced, and Figure 11b shows that they are not tied to the concrete frames by the use of dowels or keyways.

Figure 9. Typical failure of residences with wood floors and roof.

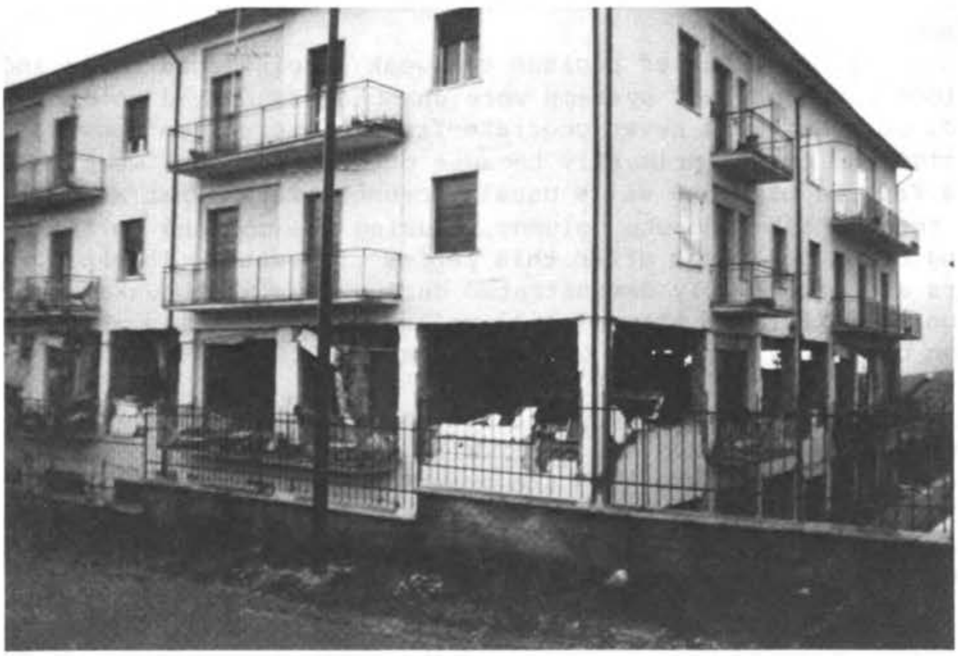

Figure 10. Typical failure of concrete frame with infill walls. Continued shaking could have caused total collapse.

a

b

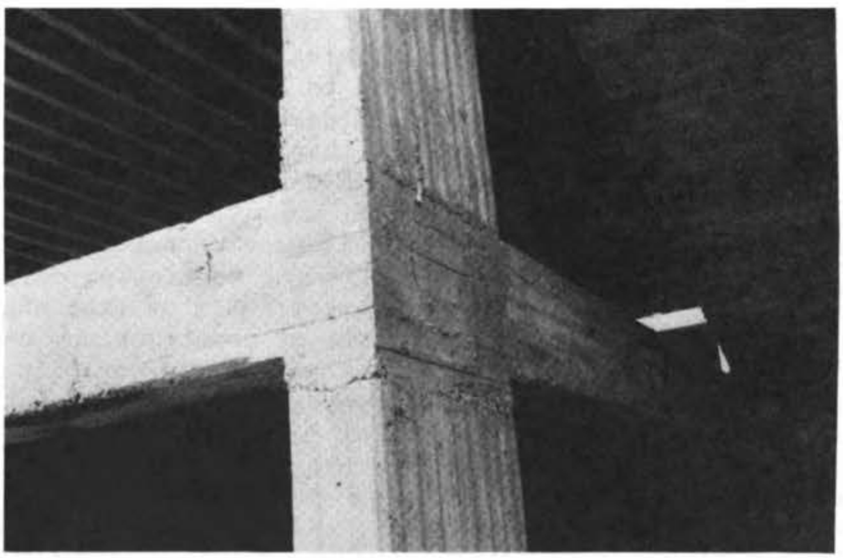

Figure 11. Damage to one of twin residential units under construction. (a) Note that infill walls have caused damage, but the "pure" frame had no damage. (b) Note that neither keys nor dowels were used to connect infill to frame.

Seismic Zoning

The seismic zoning map of Italy in Figure 6 shows two zones that require seismic-resistant design considerations, and a third zone that does not require seismic-resistant design. Structures in Category 1 (indicated by solid black) must be designed for a horizontal force coefficient of 10 percent of dead loads. Structures in Category 2 (shaded areas) are to be designed for a horizontal force coefficient of 7 percent of dead loads. The remaining areas (shown in white) have no seismic design requirements.

In discussion with engineers at CNEN, it was presumed that seismic loading was probably not used in the design of any of the buildings constructed in the affected area. The wind loading used was 70 kg/m^2 (14.3 psf) to 100 kg/m^2 (20.5 psf), depending on the distance from the coast (highest at the coast). The earthquake force coefficients for the typical concrete or masonry building will result in a design lateral force considerably greater than wind design forces. Heavy structures designed only for wind requirements will have a low resistance capacity for earthquake forces.

Seismic zoning in Italy appears to be a reaction to recent earthquakes, rather than the result of a comprehensive study of seismic risk throughout the country. After each earthquake, a small area indicating a seismic zone is added to the map, based on action by local government officials; some of these areas are quite small, as can be seen in Figure 6. This zoning approach is similar to that used by Yugoslavia at the time of the 1963 Skopje earthquake (Berg, 1964).

There appears to be a great deal of reluctance on the part of local government officials to declare their area a seismic zone. Apparently they fear that it may cause industries to locate in another area, may discourage tourists if an area is considered seismically active, or may frighten the general populace to know that they live in a seismic region. They also believe that seismic design generally increases construction costs by about 10 percent.

A large factor in the number of collapses undoubtedly was the duration of the shaking, as evidenced by the continuing collapses that occurred in aftershocks. As the accelerograms show, the shaking was not intense. Cumulative damage to this type of construction, caused by constant shaking over a long period, contributes greatly to eventual collapse. One structure collapsed 3 weeks after the main shocks during a period of inactivity, solely because of cumulative damage. In this case, the cumulative damage left some structures in a state of imminent collapse. For example, the structures shown in Figures 12 and 13 could easily collapse with slight additional shaking.

The response of some of the structures is shown in Figure 13. In many buildings, the infill walls of one particular story were damaged more extensively than walls on the other floors. This difference was

Figure 12. Damage to multistoried residential units. Both of these were so badly damaged that they could easily have collapsed with slight additional shaking.

Figure 13. Examples of damage to concrete frames with infill walls.

Figure 13 (cont'd). Examples of damage to concrete frames with infill walls.

probably caused by a combination of the dynamic response characteristics and the structural resistance characteristics of the buildings. It reveals locations where the effective shear was the greatest, or where the effective resistance was the least for that particular structure. Damage can be seen to have varied between lower and upper stories.

Another contribution to the damage could well have been a ground acceleration amplification introduced by the topography of some of the damaged areas. The aerial views in Figure 14 show some of the damaged towns. The towns were on top of mountain ridges, a situation that could easily create a condition for amplification.

Another topographical problem could have been that older homes on the hillsides collapsed as a result of the earthquake tremors, and as each one collapsed, the structure rolled downhill and demolished (or at least helped to demolish) both old and newer buildings farther down the hill.

The extent of damage in the east-west direction was somewhat large for this magnitude of earthquake ($M_s = 6.8$), whereas the maximum distance over which collapses occurred in the north-south direction was only slightly more than half of that in the east-west direction. Buildings collapsed in Naples and Potenza, which are about 130 km apart.

Some of the cities and towns in the area and the damage they received were:

Naples--Epicentral Distance of 90 km

Naples was the largest city (population 1,225,000 in 1978) within the affected area. Visual inspection suggested a rather low intensity of shaking here. Most of the damage was to older types of construction (Figure 15a). However, two recent structures (about 30 years old) showed severe damage. A 10-story housing unit identical to the one shown in Figure 15b collapsed, killing all 52 occupants. The remaining basement of the collapsed structure is shown in Figure 15c. Close observation of the remaining two structures indicates repairs had been made in the past at floor construction joints (Figure 15d). The cause of the previous problem was not known. What appears to be an exterior shear wall is a concrete frame with infill masonry wall.

Corrective work was being done to the endwall of a 5-story unit of similar construction (Figures 16a and b). Brick was being used here as the infill wall material. These 5-story units were reported to have extensive damage to the interior walls and occupants were very fearful of remaining in the buildings. The 10-story unit in Figure 15b sits at the far end of the 5-story units located in this vicinity. An earthquake similar to the November 23 earthquake, but centered closer to this area, could cause these structures to collapse.

The Jai Alai arena shown in Figure 17 was damaged when its high, unbraced, and unreinforced parapet wall collapsed. The figure also shows a closer view of the damage.

Figure 14. Typical towns on mountain ridges.

Figure 14 (cont'd). Typical towns on mountain ridges.

a

b

Figure 15. Damage to concrete structures with infill walls. (a) A large housing project of 5-story and 10-story units, all constructed of concrete frames with infill walls. (b) Shows a 10-story surviving unit, similar to the one that collapsed.

c

d

Figure 15 (cont'd). Damage to concrete structures with infill walls. (c) Shows basement of collapsed 10-story unit. Note damage to nearby residence due to collapse of high rise unit. (d) Patchwork of some kind had been done in the past at floor lines of surviving unit.

a b

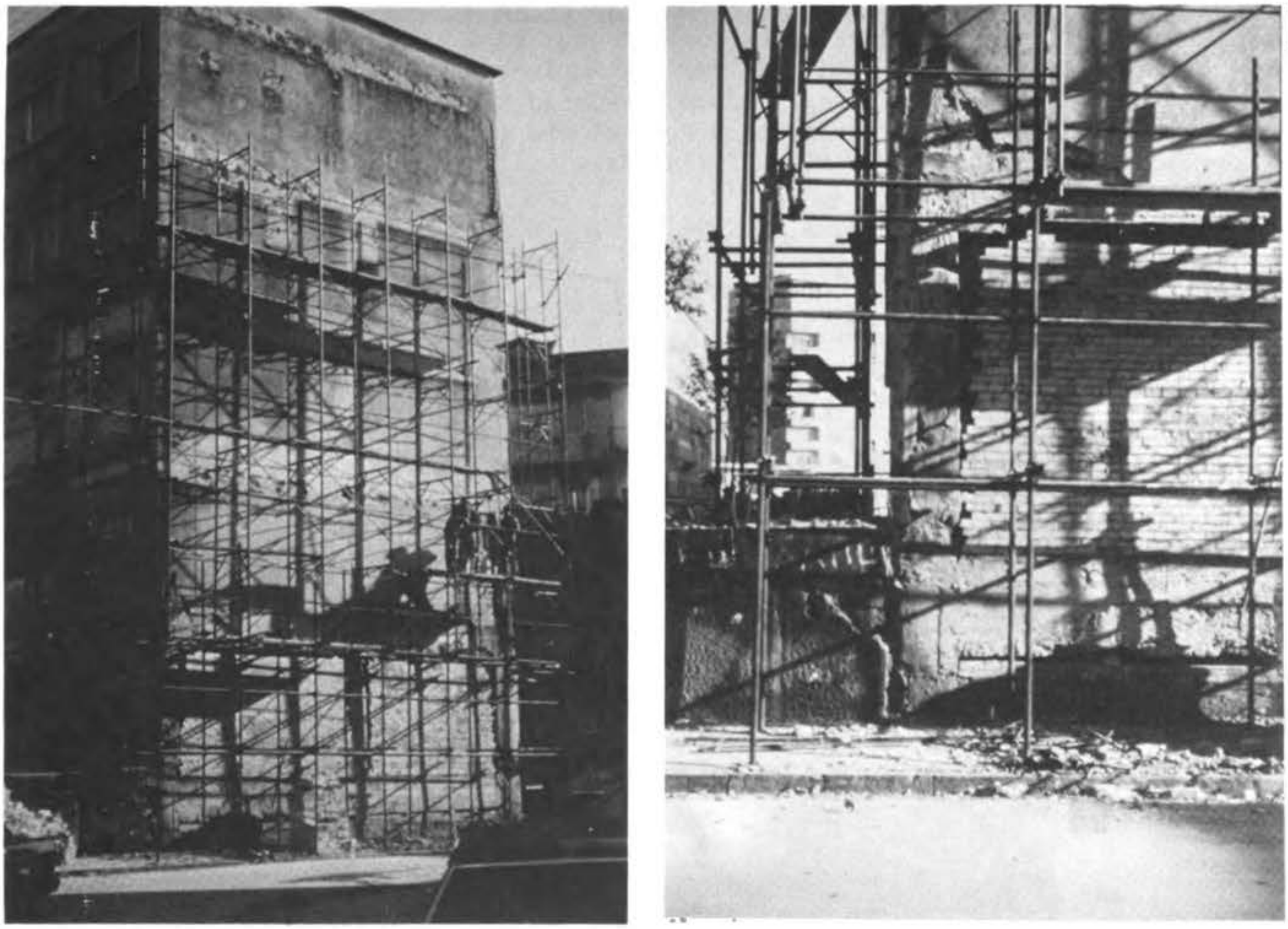

Figure 16. Damage to a 5-story unit in Naples. (a) The endwall is being reconstructed. New infill material is brick. (b) Corner column has separated from wall. There is a drift of approximately 2 inches between the base and the second floor.

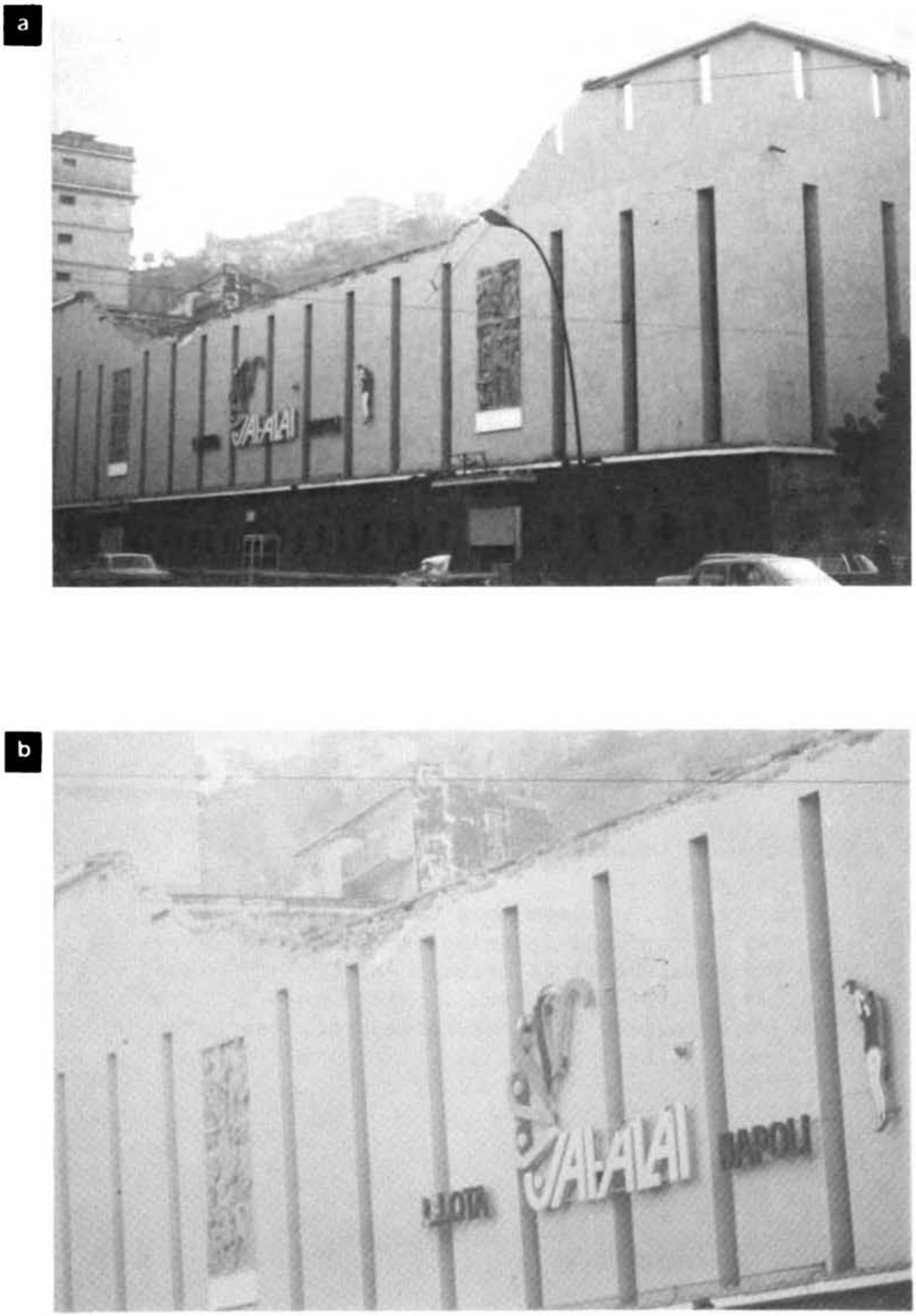

Figure 17. Damage to the Jai Alai stadium. (a) The stadium had a failure of its high, unbraced parapet wall. (b) This close-up shows that the very high, unreinforced parapet was not properly anchored to the wood roof system.

Avellino--Epicentral Distance of 45 km

Avellino is the largest city (population 59,178 in 1978) in the interior area of the affected region. In the aerial view (Figure 18), many multistoried dwellings can be seen. Much of the older unreinforced masonry construction collapsed, even though some recently constructed buildings using the concrete frame with infill walls did not collapse.

Sant' Angelo dei Lombardi--Epicentral Distance of 20 km

Sant' Angelo dei Lombardi was one of the most severely damaged towns (Figure 19). The aerial view shows an overview of the town, and one view of a collapsed condominium that was under construction (Figure 19d). Construction in this area should have conformed to the seismic requirements of Category 2 (7 percent lateral load, see Figure 6), but the construction details used (Figures 19e and f) do not reflect such design levels. For example, proper ties, and adequate splicing and reinforcing were lacking, and the poorly conceived use of infill walls compounded the problems.

A wing of the local hospital collapsed, but bad weather and rescue demolition work made a detailed investigation impossible. The portion that remained standing was deemed too dangerous for closer internal inspection, because an aftershock could cause collapse (Figures 19g and h).

A 4-story housing unit that collapsed is shown in Figure 20a. The demolition work on this building had not yet begun; it was suspected that some of the missing were buried under this debris. Some typical damage to concrete structures and to the police station is shown (Figures 20b and c).

Lioni--Epicentral Distance of 14 km

Lioni was one of the larger communities that suffered damage in the epicentral area. Here was one of the few industrial plants located in the earthquake zone--the Pallante pasta factory. The factory penthouse collapsed, as well as one unit of the main structure, as is shown in the aerial view (Figure 21a). This multistoried structure was also constructed using a concrete frame with infill walls (see Figures 21b, c, d, and e).

Many of the collapsed multistoried newer housing units were located in Lioni. Some of these buildings are shown in Figure 12, discussed earlier. In Figure 22a, additional damage to several units of multistoried housing is shown. A failed first story and danger of imminent collapse are shown in Figure 22b.

Damage typical to old construction is shown in Figure 23. Note the furniture in the room and paintings still on the walls.

The map in Figure 24 shows the random pattern of the streets, typical of all the towns and villages.

a

c

a

Figure 18. Damage at Avellino. (a) Aerial view. (b) Older construction collapsed. (c) The nearly total collapse of the old construction shows a large inward movement of the front wall at the second floor.

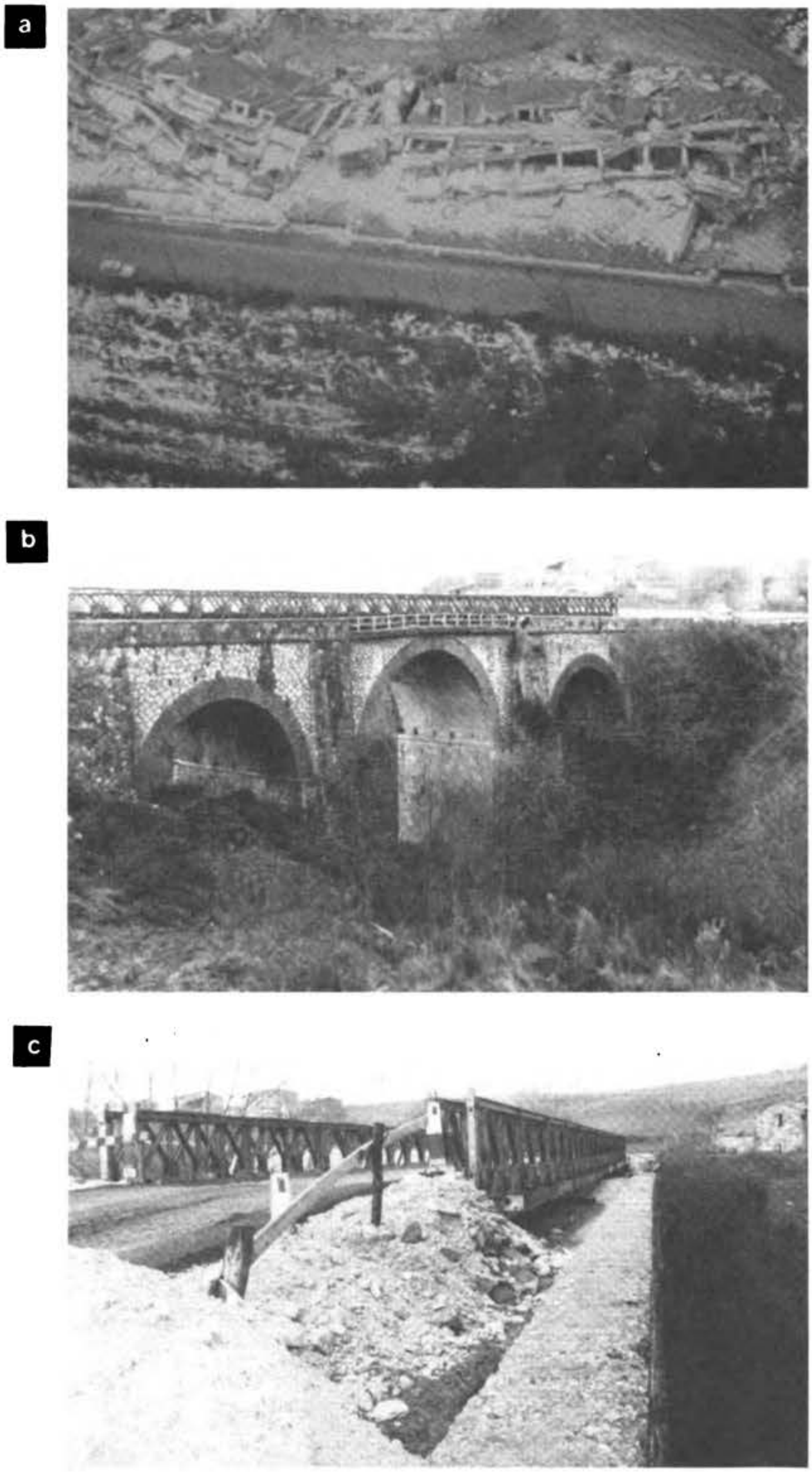

Figure 19. Damage at Sant' Angelo dei Lombardi. (a) Aerial view of a collapsed, newly constructed housing unit. Hammerhead crane was not affected by the ground motion and is still visible at the site. (b) An important bridge near the town was heavily damaged. (c) Portable steel bridge erected over the damaged bridge.

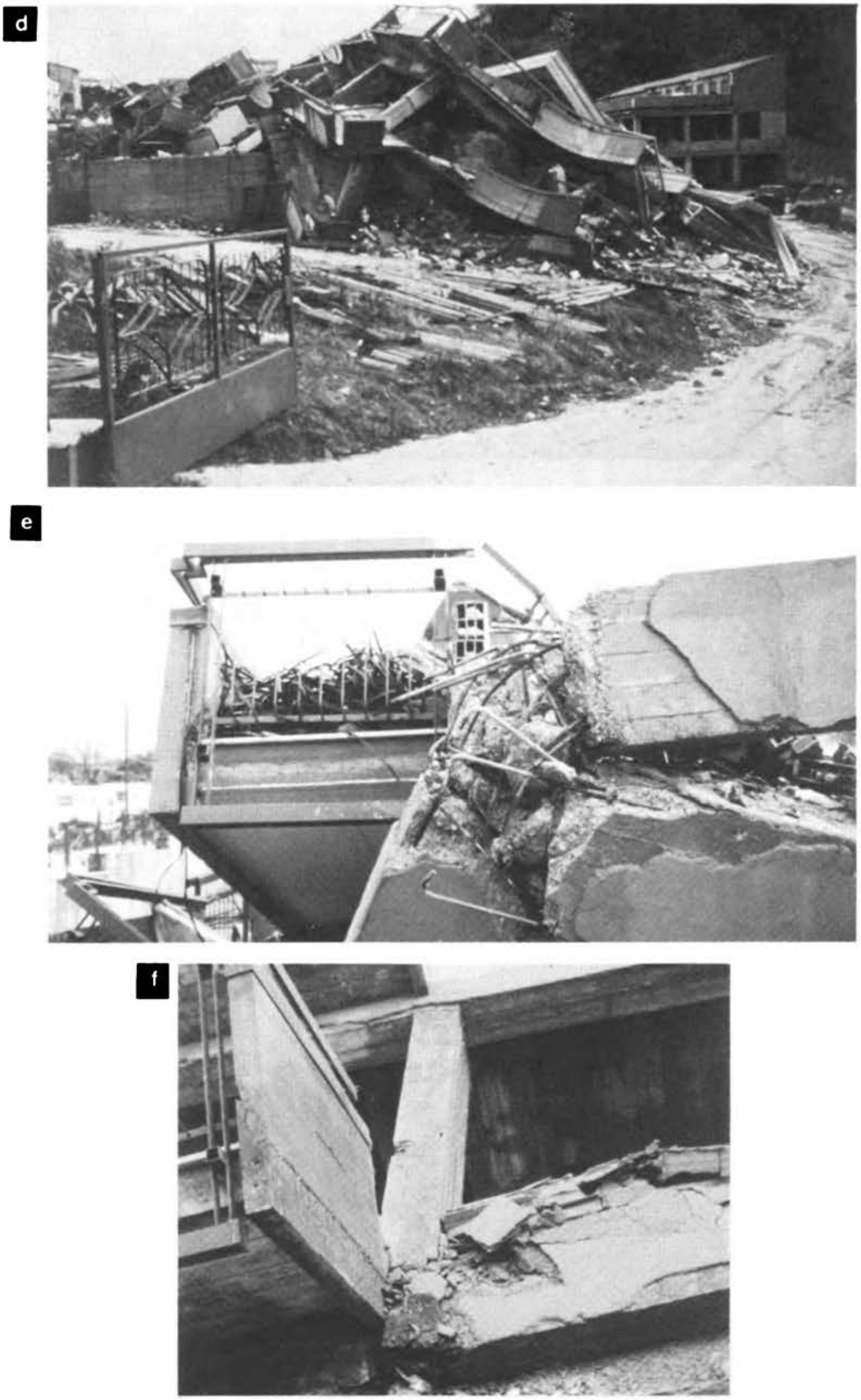

Figure 19 (cont'd). Damage at Sant' Angelo dei Lombardi (d) A recently constructed condominium lies in a heap of rubble. (e) and (f) Beam to column joints, and column reinforcing do not reflect seismic requirements.

g

h

Figure 19 (cont'd). Damage at Sant' Angelo dei Lombardi (g) Two views of the damaged hospital. (h) Close-up view of the corner of the hospital shows the damaged walls and columns. An aftershock could easily cause the rest of this structure to collapse.

a

b

Figure 20. Damage to housing and police headquarters. (a) This 4-story housing unit was totally collapsed. Debris operations had not yet reached this structure. (b) Typical damage to multistoried concrete frame units. Note the outline of the frame.

c

Figure 20 (cont'd). Damage to housing and police headquarters. (c) Failure of the local police headquarters. Need for these facilities to remain operational is obvious.

a

Figure 21. Damage to the Pallante factory. (a) This aerial view shows severe damage. The two housing units in the upper left were discussed earlier; to the right is the damaged housing unit shown in Figure 12.

b

c

Figure 21 (cont'd). Damage to the Pallante factory.
(b) The Pallante "pasta" factory has a concrete frame with infill walls. (c) One unit of the factory has collapsed. Some infill walls of the remaining structure have also failed. The failure occurred at a construction joint.

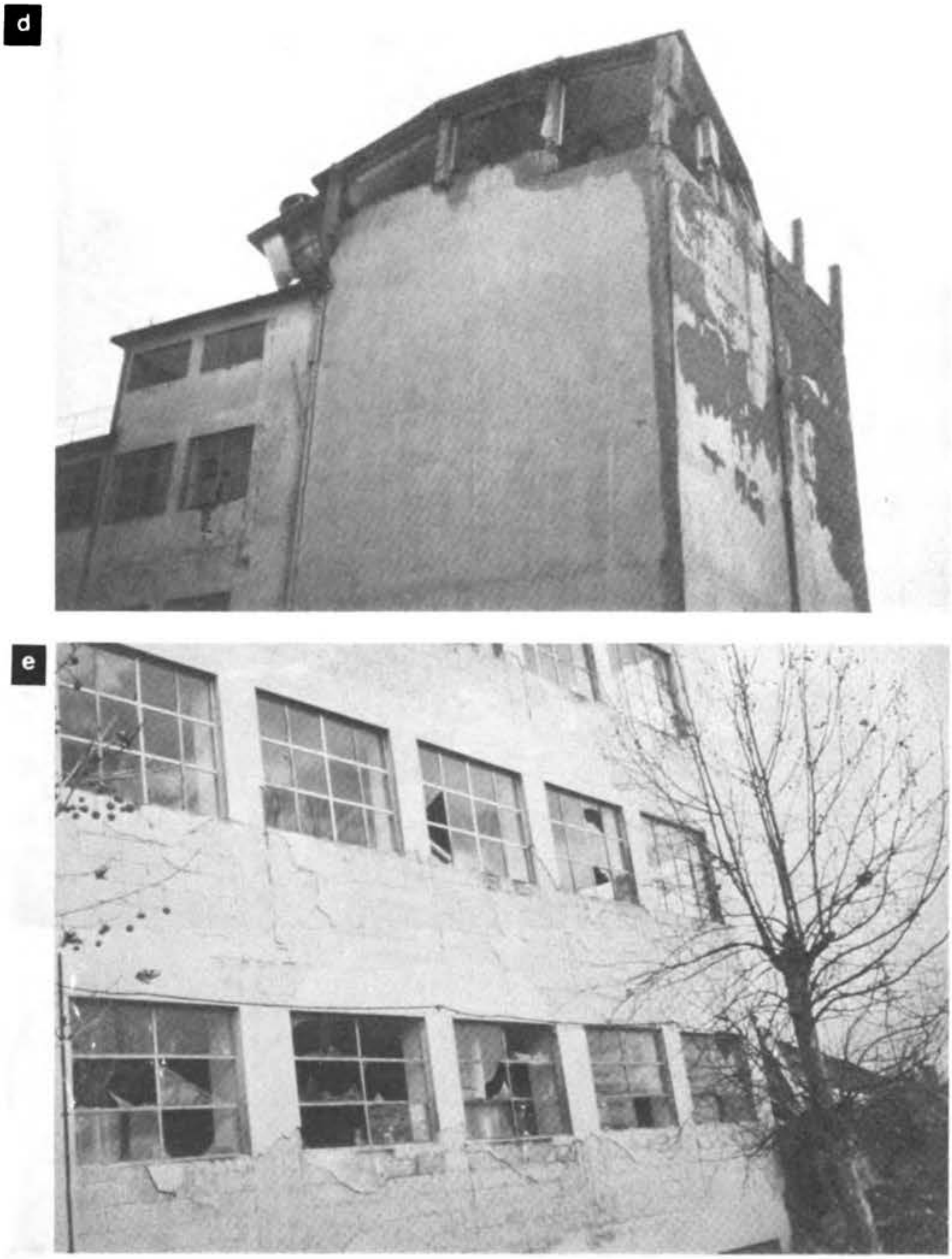

Figure 21 (cont'd). Damage to the Pallante factory. (d) Penthouse failures at the Pallante factory. (e) Exterior plaster has spalled off the factory front, revealing infill walls.

a

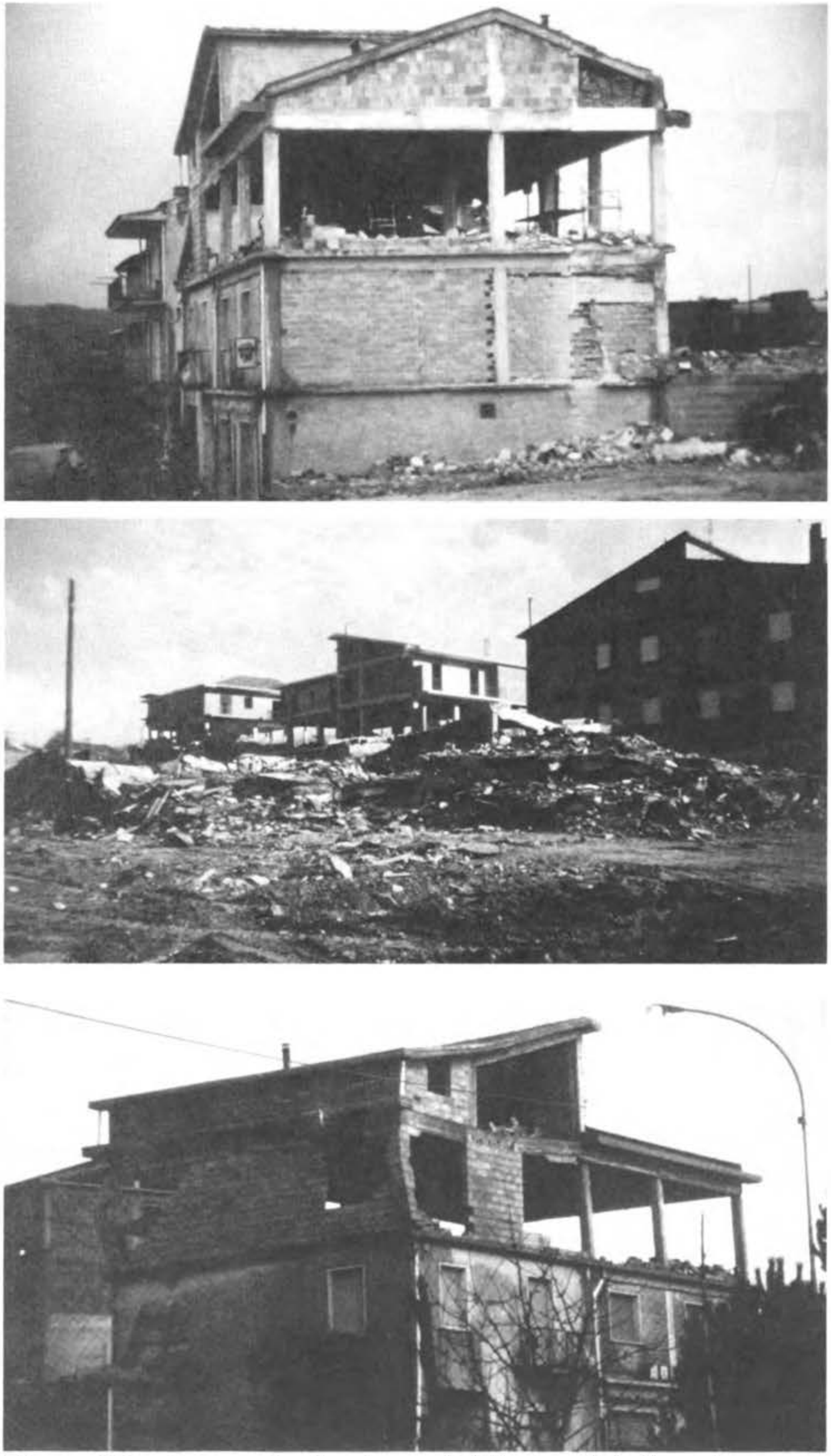

Figure 22. Damage in the town of Lioni. (a) Many two-story and 3-story residential units such as these suffered the typical failures caused by infill walls.

b

c

Figure 22 (cont'd). Damage in the town of Lioni. (b) Residential building with heavy damage to the first floor. Total collapse is imminent. (c) Prefabricated houses being installed in Lioni. The Pallante factory is in the background.

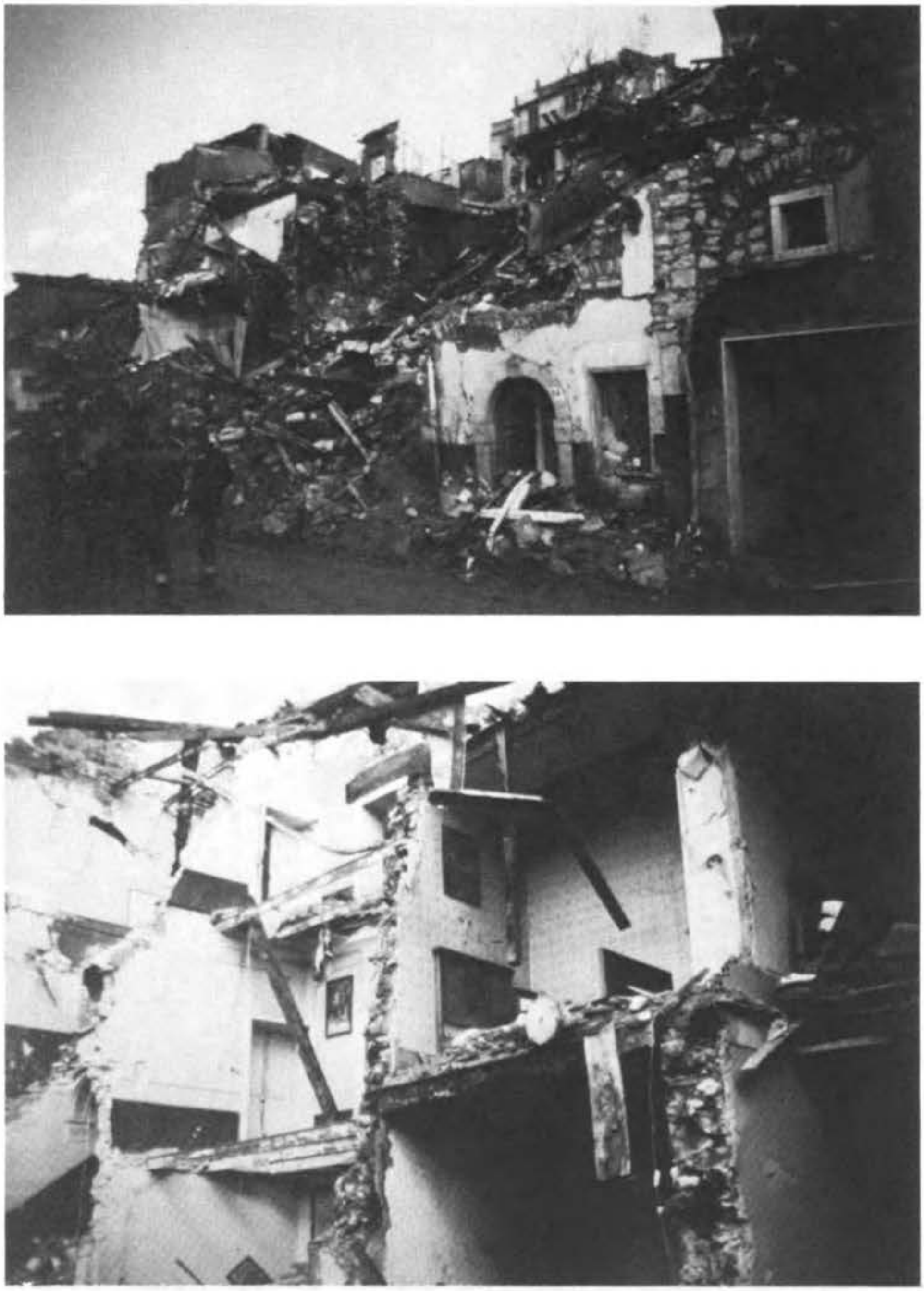

Figure 23. Typical damage to old construction. Note paintings and furniture still in place in the lower photo.

Figure 24. A typical layout of an Italian town. The many meandering streets severely impeded relief efforts.

Laviano--Epicentral Distance of 2 km

Built on a steep slope, Laviano was almost completely destroyed. The cause was not slope instability, but the type of failure discussed on page 24. The result of progressive collapse on the steep slopes is shown in Figures 25a and b. The damage near the town center, which was located on level ground, was somewhat less severe (see Figure 25c).

Potenza--Epicentral Distance of 45 km

Potenza, where 12 people died, was the easternmost area visited by the team. This large town (population 63,000 in 1978) was near the perimeter of the damaged area. There was damage only to the older of construction, although most of the buildings were of newer construction (see Figure 26).

Balvano--Epicentral Distance of 22 km

Set in a narrow deep valley, Balvano suffered considerable damage, primarily because it was comprised mostly of old construction. The town church collapsed, killing 81 persons (Figure 27). In fact, the collapse

Figure 25. Damage in Laviano. (a) Note the complete devastation on the steep hillside behind the damaged 5-story structure. (b) Another view of the same hillside, showing the almost total collapse of structures.

C

Figure 25 (cont'd). Damage in Laviano. (c) A view from the top of the town, showing the city hall in the background.

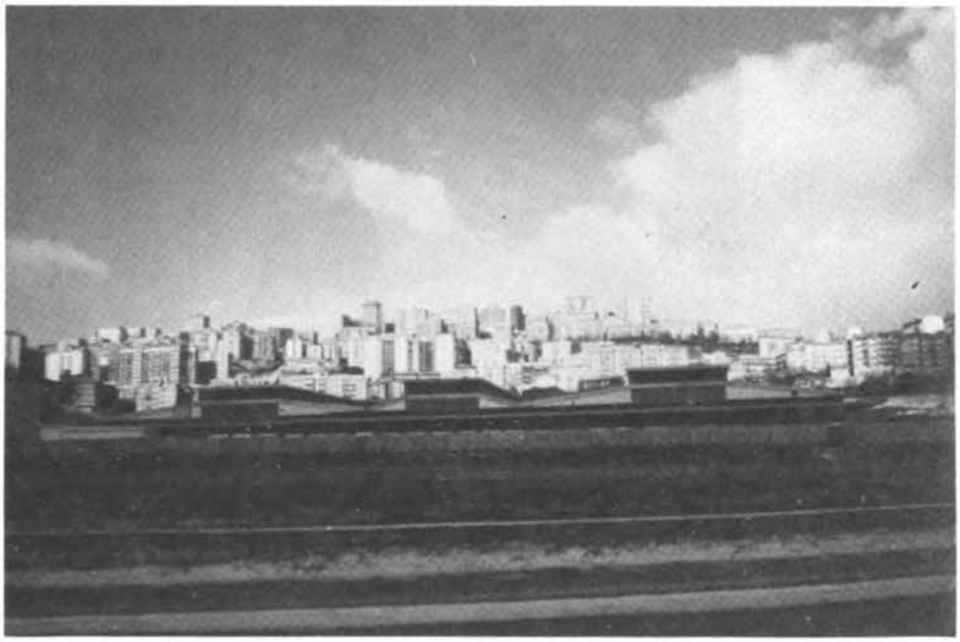

Figure 26. Modern construction in Pótenza. View from the main road.

Figure 27. Damage in Balvano. Two views of the collapsed church in Balvano.

of churches was widespread during this earthquake, as it was also during the earthquake in Northern Italy in 1976.

These churches are usually centuries old. Their inherent lack of seismic resistance and unexplained cracking from previous causes, such as earthquakes and various foundation problems (differential settlement), leave them in poor condition to resist any amount of shaking.

The strengthening or upgrading of these churches to resist seismic forces would be a monumental task that does not appear to be feasible or economical. The Italian populace, with its very close ties to the church, will undoubtedly continue to attend services in these structures.

LIFELINE FACILITIES

Lifelines include power (energy), water, sewerage, transportation, and communications systems. Severe damage occurred within the epicentral region, and moderate damage and interruptions to lifeline systems occurred as far as 90 km away. Damage to these systems varied considerably, even within the epicentral region.

Major lifeline systems components generally sustained little damage and few interruptions. Local system components in urban areas suffered moderate to severe damage, largely because of the collapse of so many buildings within the towns.

Electrical Power Systems

The power systems in the regions of Campania (in the province of Avellino) and Basilicata (province of Potenza) suffered the most damage to power systems. Most of the damage was caused by intense shaking or the collapse of buildings, which brought down distribution power lines.

Electric power is generated, transmitted, and distributed by Ente Nazionale per l'Energia Elettrica (ENEL), the national power utility. All the provinces of Italy are tied into a major transmission network, although specific provincial systems are supplied with power from particular generating stations.

a) The province of Potenza: This province is generally supplied with power from the hydroelectric generating stations, neither of which suffered any damage or interruptions: The Tanagro generating station (epicentral distance--27 km) on the Tanagro River, near Auletta (SMA 1 record: 0.05 g, estimated peak acceleration); and the Agri generating station (epicentral distance--100 km), located on the Agri River east of Sant' Arcangelo (Figure 28). The Tanagro station is connected to the region of Calabria and to a switching station at Montecorvino, near Salerno, through 380,000-volt transmission lines. Neither transmission line was damaged or interrupted. The Agri station is connected to the national network through a 220,000-volt transmission line to Fasano and Brindisi, in the region of Apulia; this line was not interrupted.

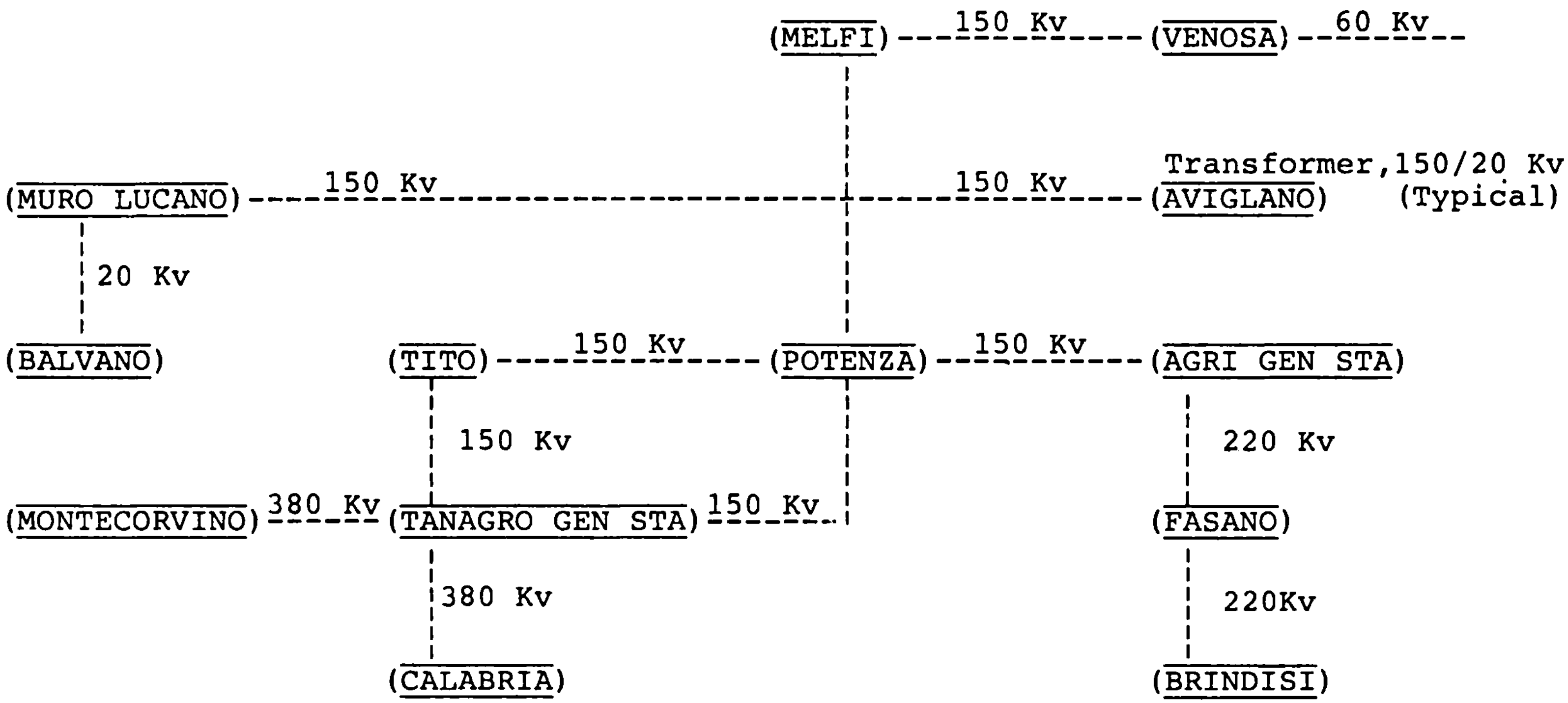

Figure 28. Power system in Potenza.

b) <u>The city of Potenza (epicentral distance--45 km)</u>: The city is supplied power from both the Tanagro and Agri stations through 150,000-volt transmission lines. One line from the Tanagro station was interrupted for 1 hour because the transformer station at Tito (epicentral distance--37 km) tripped off; the other direct line was uninterrupted. These lines supply 100 megavolt-amperes (MVAR) of power to Potenza; one other line from Agri, which also supplies 100 MVAR, was not interrupted. A transformer station in the town of Avigliano (epicentral distance--35 km), supplied through Potenza, experienced an oil circuit-breaker trip that interrupted power to that town for 2 hours.

c) <u>The substation in Balvano</u> (epicentral distance--22 km) was without power for 3 days. At the time of the team's visit, mobile generators (Figure 29) from Bologna in northern Italy were supplying 450 amperes at 220 volts to emergency operations, tent cities, and surviving residences.

Figure 29. Mobile generator unit supplying approximately 10 kilowatts of electrical energy to communications and other equipment in Balvano.

d) In the province of Avellino, which is 45 km east of Naples, and where there was the most damage, fatalities, and injuries, there were the most interruptions. The 220,000-volt transmission lines tied to the national network were not damaged. Although these lines were not interrupted during the earthquake's main shock, circuit breakers tripped 2 hours later (perhaps during an aftershock); the breakers were reset in 2 hours and the connection was restored. At the Calore generating station (epicentral distance--43 km), lightning arrestors (60KV) were damaged and conductors broken. Repairs were completed within 1 day. The transmission system in Avellino is 60,000 volts (Figure 30). Within the epicentral region, where most of the damage occurred, many insulators and conductors were broken, caused by swaying of towers. Most repairs were completed within 1 day.

A 60,000/20,000-volt transformer at Sant' Angelo dei Lombardi suffered broken ceramic bushings (terminals). There was significant damage to the 20,000-volt distribution system. Numerous substations were damaged, and 20 control buildings that collapsed, or were severely damaged, were replaced by prefabricated metal buildings and new control boards (Figure 31a).

One unanchored spare transformer at Sant' Angelo dei Lombardi (epicentral distance--20 km) overturned (Figure 31b). Anchored in-service transformers did not overturn and were not damaged. In fact, one substation controller reported that several latticed-steel power-line towers fell there because of foundation failures. Conductors in low-voltage (220 and 380 volt) lines were reported to have broken as a result of the swaying of steel and precast concrete poles. When these lines became taut, because of insufficient slack, the conductors either ruptured or broke the supporting insulators.

Distribution transformers (20,000/380 and 220 volts) were mostly located on the ground. They received little damage (Figure 32). Several pole-top transformers had ceramic terminal failures that caused power outages, but they did not fall from their platforms.

In Avellino (epicentral distance--45 km), one citizen reported that that electricity in his neighborhood was interrupted after the quake, but was restored section by section within 2 days. Distribution lines were severely damaged within the areas of collapsed buildings. Almost all residents within these areas were evacuated and as of mid-December, these lines had not been restored. There were no explosions or fires in the power system.

Four ENEL employees were killed during the earthquake. Five hundred ENEL employees were brought into Avellino to help operate the system and repair it. According to the ENEL Director of the Avellino district, the major problems after the earthquake were as follows:

- Reinstating service in urban areas.
- Supplying power to public safety facilities (organizations) and for streetlighting.

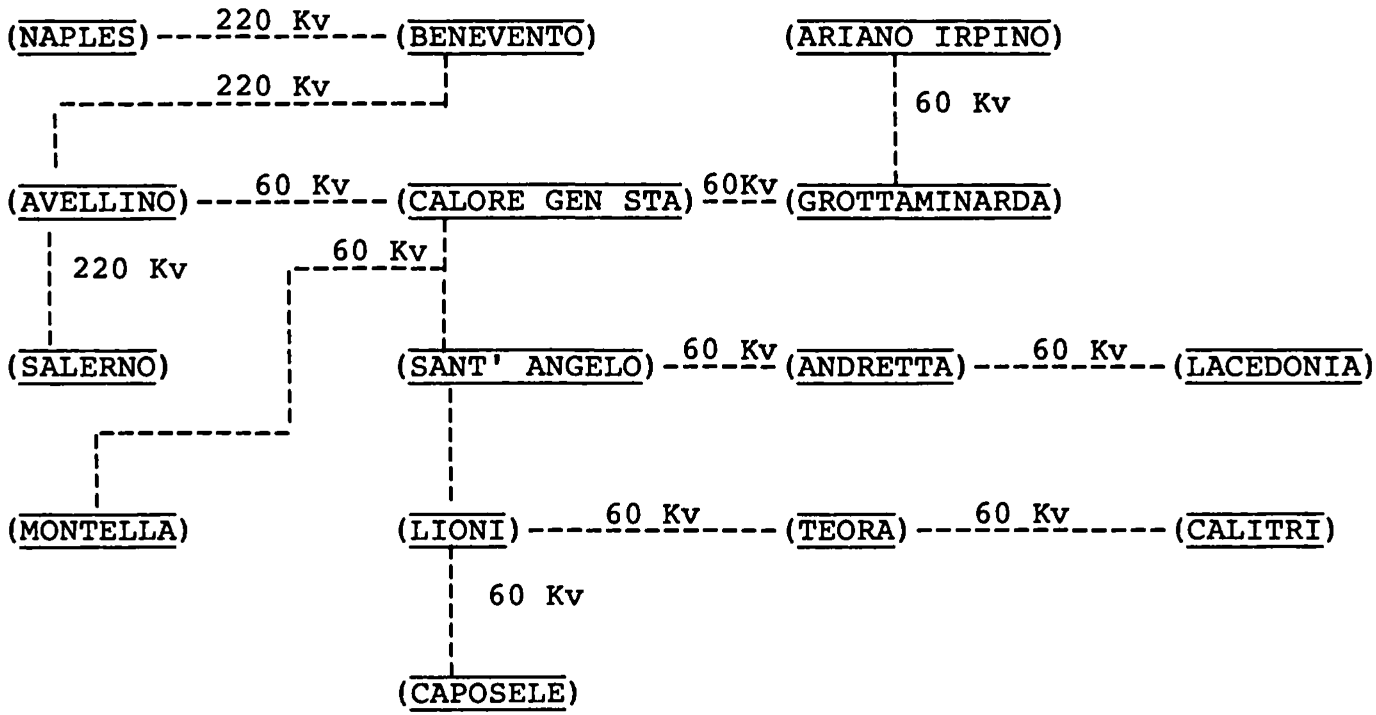

Figure 30. Power system in Avellino.

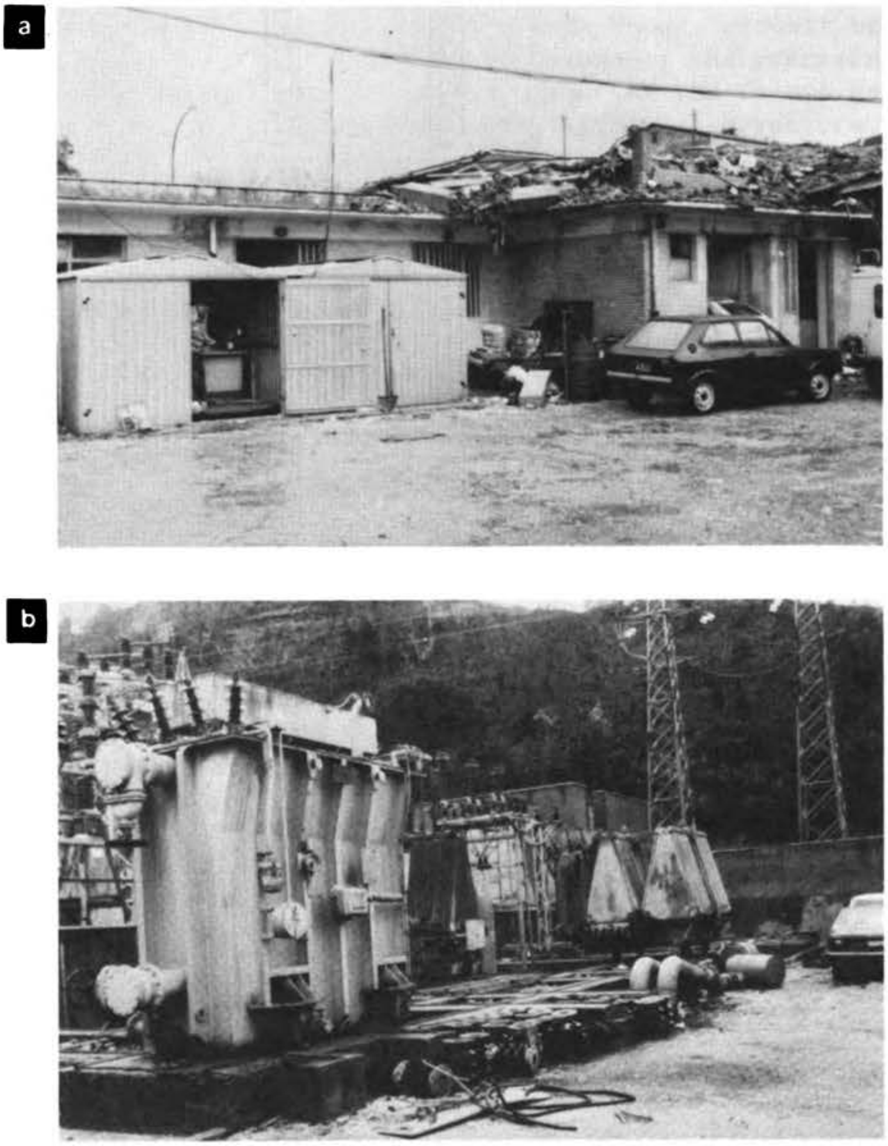

Figure 31. Electrical power in Sant' Angelo dei Lombardi. (a) Prefabricated metal building houses the control equipment of an electrical power distributing station.
(b) Electric power transformer (left) in the distributing station. A spare transformer, unanchored, was overturned here.

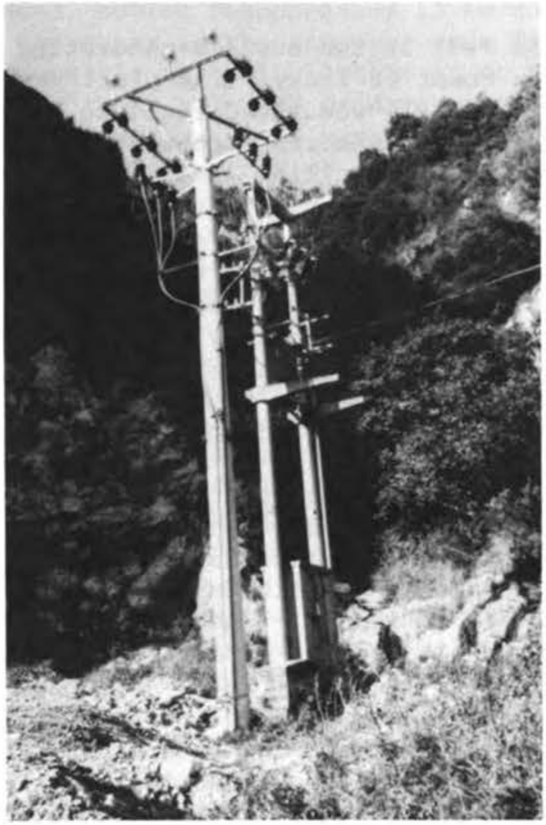

Figure 32. Electric power near Salerno.
Small distributing station.

- o Supplying power to surviving residential areas and new prefabricated substations.
- o Supplying power to field hospitals, tent, and trailer camps.
- o Supplying power to rural networks.

e) <u>The city of Naples</u> (epicentral distance--90 km): The American Consulate General's Office in Naples reported a drop in electrical voltage and an intermittent loss of power caused by selective blackouts on the evening of the earthquake. The elevator in the Consulate General's building descended to the lowest level and was temporarily out of service.

<u>Nuclear Plants</u>

The earthquake was felt at two nuclear generating plants, both located on the western coast of Italy. The plant nearest to the epicentral area (125 km away), was the Garigliano nuclear power plant, located at Sessa Aurunca, 50 km north-northwest of Naples. The plant is a 150 Net MWe General Electric boiling water reactor unit, completed in 1962, and is similar to the Dresden 1 (USA) plant.

Although the plant was in a shutdown condition, the control rod SCRAM system, set at 0.05 g, was actuated by a 0.051 g signal from the vectorial sum seismic device. Three seismic sensors in the safety system were actuated. They recorded readings of 0.03 g SW, 0.028 g NW, and 0.012 g vertical. Two strong-motion accelerographs, believed to be Kinemetric SMA 1's, which were set to trigger at 0.01 g, were actuated. There was no damage to this plant, and no abnormal consequences were detected.

The other nuclear plant at which the earthquake was felt was the Latina Nuclear Power Plant, located at Borgo Sabotina (epicentral distance--217 km), 135 km northwest of Naples. The plant is the Nuclear Power Group (U.K.) 150 Net MWe graphite-moderated gas-cooled reactor (CO) unit, completed in about 1962. This plant was also in a shutdown condition (for maintenance), and its safety system was actuated, causing the insertion of the safety (control) rods. Although the plant's safety system is set to actuate the rods at 0.03 g, the 0.03 g sensors have critical behavior in the 1 Hz frequency range that causes them to be triggered by spurious signals of less than 0.03 g at this frequency. Two strong-motion accelerographs believed to be Kinemetric SMA 1's, set to trigger at 0.01 g, were not actuated. The control rods were subsequently reset and withdrawn. No evidence of damage or malfunctions could be found at this plant. (The above information was obtained from the Comitato Nazionale per l'Energia Nucleare.)

Both plants remained in a shutdown condition for reasons other than the earthquake.

<u>Water Supply</u>

The water supply in the epicentral region is from local springs and rivers. The Sele River, which enters the Gulf of Salerno 25 km southeast of the City of Salerno on a southwesterly course, is a major source of water for the province of Avellino and for large areas to the northeast and east. These areas are supplied from the Sele River by the Pugliese (Apulia) Aqueduct; this aqueduct starts near the towns of Caposele and Calabritto, 80 km directly east of Naples (and within 7 km of the epicenter), and runs toward Barletta on the Adriatic Sea, on the east coast of Italy. This aqueduct was constructed in about 1911. It consists of closed cast-in-place concrete conduits, and reinforced-concrete and steel pipe up to 6 feet in diameter. No damage to this aqueduct had been found, but at Pescopagano, 15 km north-northeast of its start, the level of the water in the aqueduct rose from 20 to 40 cm after the earthquake. (A possible partial blockage is suspected.)

Because many of the towns affected or damaged by the earthquake are located on high ground, their water is pumped from the Pugliese Aqueduct, springs, and other sources. The loss of electric power interrupted the operation of these pumping stations for from 1 to 3 days.

In most of the cities and towns, water was stored chiefly in elevated and underground reservoirs. There were no reports of any damaged or collapsed elevated tanks, but the condition of the underground reservoirs could not be immediately determined in the severely damaged towns.

In Avellino (population 59,178 in 1978), one citizen reported that even though water service was not interrupted, the citizens bought and used only bottled water (or boiled tap water) for drinking, as a precaution against possible contamination of the water supply. This was caused possibly by the lurching of the backfill.

In the severely damaged towns, the water supply systems were deliberately shut down because of fear of contamination from possibly ruptured sewer and water underground lines. Temporary hookups were made to the water supply lines outside the towns, and aboveground pipelines constructed to the surviving residential areas, tent and trailer camps, field hospitals, and other essential facilities. Water spigots were located at many locations along these pipelines (Figure 33).

Because water supply systems within severely damaged residential areas were shut down, damage to these systems was still not determined 3 weeks after the event. In cities outside the epicentral region, no damage to these systems or their pipelines had been found. Cities such as Salerno and Potenza, located at epicentral distances greater than 45 km, reported no damage to water pipelines or supply systems after conducting investigations.

No damage to water supply dams was reported.

Harbors

The nearest major harbor to the epicentral region is Salerno (epicentral distance--47 km). The quay, which is constructed of large, natural stone parallelepipeds and sand and gravel backfill over a large rock subbase, suffered cracks in the masonry. Most of this minor damage occurred at the extreme corners of the quay (Figure 34). This was possibly caused by lurching of the backfill.

No reports were made of damage to the harbor at Naples (epicentral distance--86 km).

Sewerage

The most severe impact to sanitation-sewer systems occurred in the more heavily damaged towns. The water supppy systems were shut down because of the fear of contamination of the water supply, or of spreading

Figure 33. Aboveground water line with hookup for trailer in the town of Lioni.

Figure 34. Damage at the harbor of Salerno. Crack in large masonry and concrete pavement of the quay.

waterborne disease. Sanitary systems that depended on water supply systems therefore ceased to operate.

Larger towns, such as Avellino and Potenza, have modern sewer systems and treatment plants that were not damaged. They continued to function. The smaller towns and villages use septic tanks or individual residential cesspools, which discharge their effluent into nearby spreading grounds or nearby streams. Since many of these ceased to operate, because the water was turned off, it was impossible to determine whether they were actually damaged or were still functional.

Public chemical latrines were installed in tent and trailer camps in emergency areas, and in other localities, for the use of displaced people and assistance personnel.

Communications

The loss of telephone service because of damage to the equipment and the transmission lines exacerbated the tragedy within the disaster area. It was impossible to call for assistance in the early morning hours after the earthquake, and communications were limited for weeks afterward. In urban areas, telephone systems were destroyed by collapsing buildings, including the telephone lines attached to them. Telephone service was lost over wide areas, particularly in Avellino.

One citizen in Avellino reported that some parts of that city were without telephones for 2 days. Employees of the American Consulate General in Naples (epicentral distance--90 km) reported intermittent interruptions; some.could use their home telephones, however.

Temporary telephone switchboards were observed in use by military, power utility, and assistance personnel within the disaster area. In Teora, the Austrian Army was operating a truck-mounted telephone station, with telephone booths on the outside panels (Figure 35).

Two-way radio communications supplemented surviving and new telephone systems. Many police cars with communications equipment were stationed at strategic locations, crossroads, and control points. They were used to obtain and relay information.

Telephone systems were relied on heavily for communications, as they are during any disaster, particularly for communication among organizations and among government agencies. Compared to internal radio communication within these groups, however, radio communications among organizations and agencies was relatively poor.

Transportation

Almost the entire area that suffered damage (including the epicentral region) lies within an area bounded on the west, north, and south sides by modern high speed, limited-access highways, called Autostrade. The northern and southern Autostrade running west to east are about 55 km apart. The pavement of the Autostrade roadway and access ramps, which is

Figure 35. Mobile telephone substation being operated in the town of Teora. Telephones are on the sides of the vehicle.

of concrete and asphalt, suffered minor cracking in widely separated places, but none of the bridges, viaducts, and tunnels showed any damage.

Most of the roads, other than the Autostrade, have two lanes with asphalt pavement. Within the area of most severe damage (epicentral distances less than 20 km), bounded by Sant' Angelo dei Lombardi, Lioni, and Teora, cracks in road pavements up to 4 inches wide were observed (Figure 36a). Generally, these were most prominent on roadways built above the surrounding land and were probably caused by lurching of the compacted fill supported on soft alluvial soils (Figure 36b).

Two days after the main shock, a bridge near Sant' Angelo dei Lombardi (epicentral distance--20 km) was heavily damaged (Figure 19b). Several other bridges suffered minor damage (such as buckled pavements near abutments, rotation of the entire span, buckled railings, and settlement of the compacted backfill behind the abutments). Some existing cracks in abutments grew wider and longer.

The worst damage to transportation was the collapse of buildings into the narrow streets so typical of some of these towns. This blocked the streets to emergency pedestrian and vehicular traffic. Construction equipment literally had to dig into the demolished areas to rescue people and to perform other functions (Figure 37).

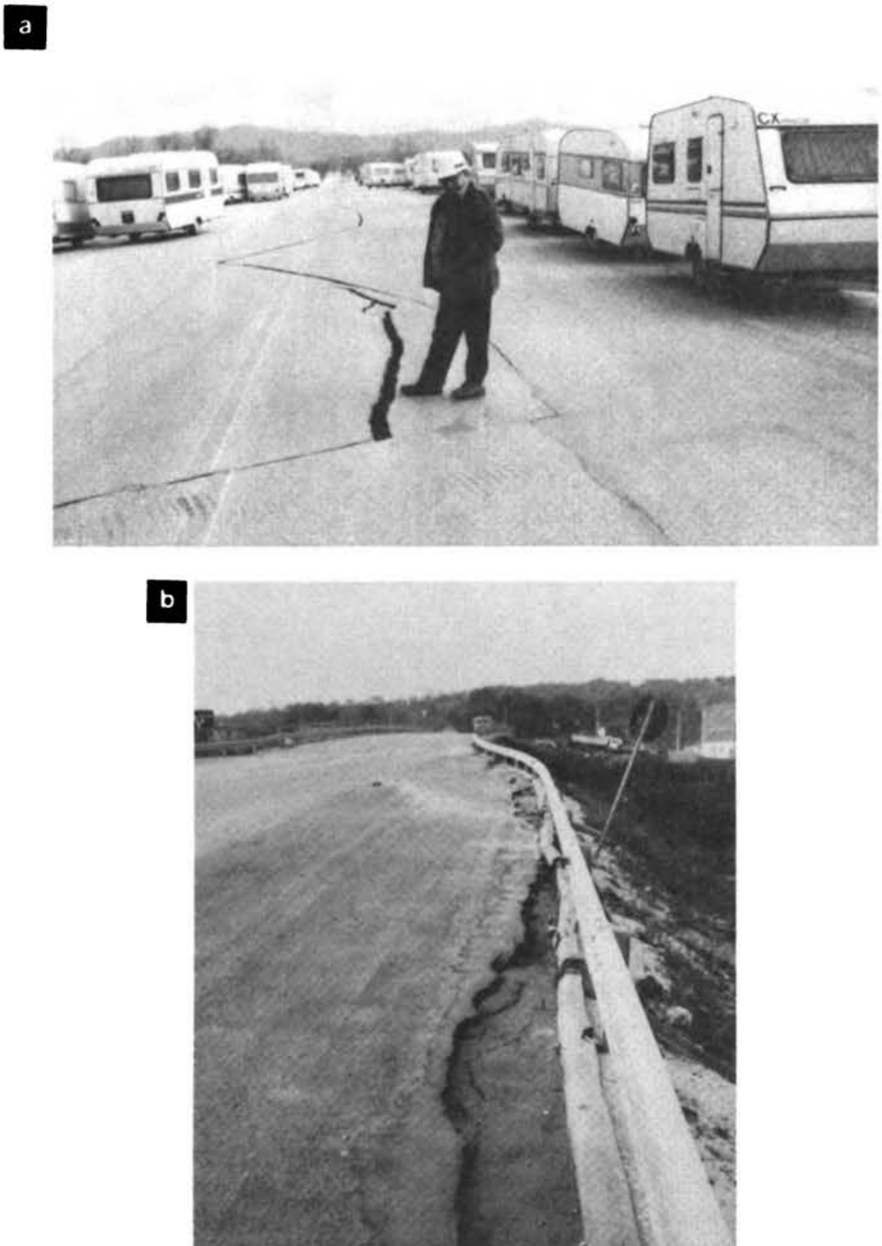

Figure 36. Damage to roads. (a) Cracks in road pavement near Lioni. (b) Damage to pavement and slope of roadway near Lioni.

Figure 37. Narrow streets blocked with debris.

One railway line wends its way through the mountainous epicentral region. It runs from Naples through Avellino and Lioni, within 13 km of the reported epicenter (USGS), through Melfi to Potenza and eastward. No damage to its track, bridges, or tunnels was reported, after a brief interruption caused by slight damage to the tracks from falling boulders. The railway line was used to bring in hospital trains and supplies. Some railway cars were also used as temporary lodging for displaced people and for service and administrative personnel. In fact, passenger service was suspended between Avellino and Melfi because the railway line and all railway equipment was being used solely for these emergency services.

THE RESPONSE AND RECOVERY

The Setting of the Disaster

Physical Setting

The most heavily damaged area covered some 10,000 sq km and extended inland from the coastal plains of Naples and Salerno, through the Appennine region of Basilicata and to the edge of the plains of the region of Apulia. It covered about 3 percent of the area of the whole Italian peninsula (320,000 sq km), and is about one-half the size of the state of Maryland.

Moving inland and southeasterly from Naples, the terrain changes from a coastal plain to mountains and deep valleys. The climate changes quickly, too, from mild weather the year around to cold, wet, and snowy winters and fairly warm, dry summers. The rivers are short, rather shallow, and flow irregularly; the most significant rivers in the heavily damaged area are the Calore, the Sele, and the Ofanto.

Socioeconomic Conditions

The population of this area totals some 3 to 4 million, or from 5 to 7 percent of the population of the country (about 55 million). Naples, Salerno, and their environs contain a number of important industries (especially mechanical and food processing), as well as port and transportation facilities. Naples is one of the major ports of the Mediterranean area. The rest of this part of the country, however, is agricultural. The main products are citrus fruits along the coast; chestnuts, filberts, and apples in the foothills; and grains, corn, olives, and grapes in the inland valleys. Some animal farming is carried on, principally involving cattle, sheep, and goats, raised for both milk and meat.

Because electric power and capital are so scarce, and the transportation network so poor, the area is underdeveloped. Major railroad lines skirt the most heavily damaged area, so that commerce must rely chiefly on road transportation. Aside from the two highways (Autostrade) already mentioned, the road net consists of paved roads that are well-maintained but are narrow, winding, two-lane road beds, with little or no shoulders. Despite many plans to improve the economy of this area since the unification of Italy in 1870, three of the four provinces hardest hit by the earthquake are among the least developed and have the lowest per capita incomes in the country.

Most of the area's hardworking inhabitants live in villages and small towns, with populations of from 2,000 to 15,000. When the towns were founded, several centuries ago, they were often built on top of knolls--to escape the malaria then present in the valleys, and to be more easily defensible against invaders and marauders. But reaching these towns, from the valleys below, meant a hazardous climb through many kilometers of twisting and winding roads.

In the smaller agricultural communities, life still revolves around the extended family, religious activities, and the love of the land and domestic animals. Only gradually are some signs of an industrial development becoming discernible. Since the area has few economic opportunities, there is a continuing tradition of out-migration, originally to the western hemisphere and--since World War II--to other parts of Italy and the European Common Market countries.

Governmental Structure

Italy has a parliamentary democracy with a tradition of a centralized form of government. Some 20 regions are divided into some 100 provinces, which in turn consist of towns and villages. These towns and villages have locally elected mayors and town councils, the only level at which there is direct citizen participation.

Each province is administered by a career civil servant (Prefetto) who is appointed by the Ministry of the Interior. A region is a historical designation that has been institutionalized by Italy's post-World War II Constitution. Each region is also headed by a civil servant (Commissario del Governo), whose role in coordinating regional plans and resources is only now being defined in practice, especially in the southern part of the country.

The most heavily damaged area includes over 200 inhabited localities, in four provinces (Naples, Avellino, Salerno, and Potenza) and in two regions (Campania and Basilicata). Two other provinces (Benevento and Caserta) were lightly struck.

The Magnitude of the Disaster

The disaster was catastrophic in terms of loss of lives, damage, and destruction of buildings--especially housing. The agricultural sector was much less severely damaged. The animal population was affected only slightly (about 3 percent of the estimated 125,000 animals in the area) and the land and forests were untouched.

On December 10, 1980 (17 days after the disaster) the casualty figures were 3,114 dead, 1,575 missing, and 7,671 injured, or a total of

12,360. The casualties in each province are shown in Table 2. Note that the number of missing had remained unchanged for the preceding 8 days, but the total for the dead and injured had climbed slowly. At this point, the missing were counted as dead. (Note: These figures were furnished by the Italian Ministry of the Interior.)

In the earthquake at San Fernando, California, in 1971 (Richter magnitude about 6.6), there were some 65 deaths. Although the Italian earthquake was not even .5 greater on the Richter scale, the death toll in Italy was far greater. The disparity in the number of casualties was probably related to the season and the time of the day, as well as to the type of housing construction. With few exceptions (e.g., the collapse of

Table 2. Earthquake Casualties by Provinces.

Province	Dead	Missing	Injured	Total
Naples	156	-	1,517	1,673
Avellino	2,094	1,104	2,866	6,064
Salerno	634	471	2,580	3,685
Benevento	7	-	32	39
Caserta	12	-	139	151
Potenza	211	-	537	748
Total	3,114	1,575	7,671	12,360

a high-rise building in Naples and a church in Balvano), details of where the casualties actually occurred were not available.

The Italian earthquake struck at about 7:35 p.m. on a Sunday in early winter. Most of the people were indoors at their evening meal, or gathered around their television sets to view a soccer game. In the United States, individual homes are usually one of the safest places to be in case of an earthquake but, in Italy, it turned out to be the opposite. The difference arises from the type of residential construction in the two countries: in San Fernando, mostly wood or brick veneer, with light roofs, offered a measure of safety; in Italy, rigid unreinforced masonry of stone and weak mortar, with roofs of heavy wooden beams and clay tiles that collapsed under intense shaking, there was high risk.

In at least two dozen Italian towns, with populations of from 2,000 to 15,000 inhabitants, the buildings suffered more than 75 percent destruction and had to be evacuated. The towns looked as if they had been bombed. In some cases, it appeared that no part of the town could be rehabilitated and that rebuilding would have to start from scratch. As a result, the number of homeless--another quantitative measure of the disaster--was large.

On December 2, the figure for the homeless was estimated at over 335,000 people, or from 55,000 to 70,000 families. By December 10, the Italian authorities had conducted an actual headcount and had scaled down this estimate to 122,170, or from 20,000 to 24,500 families. (This is approximately the same number of families that required temporary housing in New York and Pennsylvania, during Hurricane Agnes, one of the worst natural disasters to strike the United States.)

Other measures of the disaster (e.g., number of people unemployed, number and types of public facilities destroyed or damaged) were not yet available when the team concluded its visit.

The Response

a) The Legislative Framework. At the national level, Law No. 996, enacted on December 8, 1970, provides the legislative basis for response to natural disasters or catastrophes in Italy. (For a summary of this Law, see Appendix B.)

Responsibility for preparing to respond rests with the Directorate General for Civil Protection and Fire Services of the Ministry of the Interior. All information about the imminence of the event or the actual event are to be sent to the Directorate, which is required to evaluate the information and alert other Ministries, agencies, and private entities.

On his own initiative (or on request of the affected local, provincial, or regional authorities) the Minister of the Interior requests a disaster declaration from the President of the Council of Ministers (the Prime Minister) and the President of the Republic. A decree (law) is then issued and a Special Commissioner is appointed to coordinate the response activities. The decree also states what benefits are to be given to the victims. (For additional details on the basic Law, including data on the organization of the National Fire Service Forces, see Appendix B.)

b) Public Assistance Organizations. Local resources are supposed to be marshalled immediately to respond to a disaster. In practice, however, the burden for emergency response falls principally on the central government, largely because the towns and villages have very scant resources for local disaster response.

For a typical agricultural community of from 10,000 to 12,000 people, there are only one or two local policemen and less than a handful of Carabinieri (National Police Force). They do not have the firefighting, medical emergency, public works, and sanitation resources that are usually available in a typical United States community. In this case, even where such service personnel were present, they were quickly wiped out or overwhelmed by the quake. They either became casualties themselves or suffered severe losses among their families. The homes and offices of key persons also collapsed, or became uninhabitable.

c) Search-and-Rescue Operations. Within 1 hour of the earthquake, the Directorate General in Rome had correctly identified the area hardest hit--but not the magnitude and severity of the disaster. Within 1-1/2 hours, the Directorate was ready for emergency around-the-clock operations. Since communications with the area were cut off, this negative set of information served as the basis for taking the first steps: alerting the military forces, the Carabinieri, the Vigili del Fuoco (national firefighting forces), and special central government organizations, such as the Guardie di Finanze (border guard and custom personnel), and the Guardie Forestali (park personnel). Before midnight, Giuseppe Zamberletti was selected to be the Special Commissioner. He had held a similar position at the time of the Friuli earthquake of 1976.

d) Communications. Telephone and telegraph communications in the area were cut off immediately when the central offices (generally located in post offices) collapsed, destroying the poles and wires attached to these buildings. The surviving radio-communication net soon became so overloaded that ham operators had to be contacted and organized. Even if a message could have been sent out, all of the local decision-makers in a dozen or more communities had been killed, disabled, or were otherwise unable to function. Bad weather, principally fog, hampered any immediate overflight of the area.

e) Ground and Air Transportation. Rapid movement of forces into the area of greatest damage was slowed by the sparseness of the road network that could not accommodate a large, rapid influx of equipment. The periphery of the area could be reached rapidly by the two main highways mentioned earlier (page 59), but penetration into the area was slow. Rail transportation was of limited usefulness because of its layout and blockage by boulders and rockfalls. The nearest airport was in Naples. Confronted with this situation, outside rescue forces had to be deployed carefully to avoid overtaxing the available facilities and causing even longer delays.

f) Assistance from the Armed Forces. The central government usually relies heavily on the armed forces for disaster response. The Army, however, had only two battalions in the area and no heavy earth-moving equipment. (To satisfy NATO commitments, most of the Italian armed forces are stationed in the northern part of the country so that from 16 to 18 hours are required to move troops from there to the earthquake-struck area.) Because the area is predominantly agricultural, heavy equipment (bulldozers, scrapers, and cranes) were very scarce and their movements were hindered by the layout of the road network.

Within 12 hours, however, 4,000 troops had managed to arrive. That number rose rapidly and reached a peak of some 44,360 on December 2 (the 9th day after the disaster); it then started to decline very slowly. A week later, the total was still 42,797. The composition of the rescue forces on December 2 is shown in Table 3.

Table 3. Composition of Rescue Forces in the Earthquake Area.

Army	17,240
Air Force	5,400
Navy	1,380
Carabinieri	7,485
Fire Fighters	4,792
Security Forces	4,300
Customs Personnel	1,218
Park Personnel	591
Foreign Military	1,577
Civilian	376
Total	44,359

These forces used about 2,400 motor vehicles of all types, 80 helicopters (including 6 from the United States and 3 from the West German Federal Republic), and light fixed-wing aircraft. They also used 200 pieces of special equipment; 110 ambulances, 7 field hospitals, 385 field kitchens, 8 field bakeries, and 150 tank trucks. Additional support was provided by 40 electric generators, 7 mobile disinfection units, 6 field bathing facilities, 6 field laundries, and 235 field radio sets.

g) Search-and-Rescue Problems. The first task of the search-and-rescue forces was to find any victims that were still alive under the debris, and remove them--a very difficult and time-consuming job. The mountain-top communities, such as Laviano, often had only one or two access roads, and they led to other heavily damaged localities. Collapsed structures blocked the narrow streets with debris (Figure 37) so that massive quantities of materials had first to be pushed aside to open a path for emergency vehicles--always with the fear that injured persons might still be underneath. This fear also slowed the search for victims among the collapsed structures.

Next, the response forces had to perform other tasks such as traffic control and debris removal. They had to erect a number of tent cities, construct helicopter pads, remove and identify bodies, construct temporary potable water lines (Figure 33), and carry out mass feeding of victims. (They prepared and served over 1,750,000 meals during the first 8 days after the main shock.) They had to provide thousands of household items (including sleeping bags), rescue and feed animals, recover usable goods from damaged structures, inspect buildings for safety, demolish hazardous structures, and restore lifelines.

h) Volunteer and rescue work. The role of the Italian Red Cross in a disaster is typically different from the tasks of mass lodging and feeding as undertaken by the American National Red Cross in U.S. disasters. The Italian Red Cross concentrates first on caring for the injured, and on performing other public health tasks.

In this disaster, it supported the military's mass inoculation of victims against typhoid, tetanus, and influenza. Then it helped restore the social fabric by coordinating the return of telephone communications. It also found prefabricated structures that could be used as day centers and homes for the elderly near tent cities or trailer camps.

In the burst of altruism that occurs in most large disasters, many volunteers from less-damaged areas offered to help the search-and-rescue operations in heavily struck communities. Government authorities discouraged this movement, however, because it proved to be ineffective. Instead, the government favored the use of organized groups of volunteers who had discipline, definite skills, and a measure of logistic self-sufficiency. Many such organized groups from sister cities located in other parts of the country could be readily identified in the heavily damaged localities.

Assistance to the Victims

Organizational Arrangement

The Special Commissioner[1] who was placed in control of emergency action and the recovery of the struck area was named in an implementation decree issued on November 26, 1980, according to the Italian basic law of

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[1]The Commissioner is charged with taking any proper and necessary action to assist victims and "set the area on the road to civilian, administrative, social, and economic recovery" (free translation from the implementation decree). He has full powers to call upon the departments and independent agencies of the government for help and act in their behalf to accomplish his responsibilities. He is to report to the Parliament every 3 months, with his power expiring on June 30, 1981. It is interesting to note that plans and measures for final long-range recovery and reconstruction are specifically excluded from his powers.

1970. Within 3 days of his appointment, the Special Commissioner had organized a four-section staff and a three-tiered line network of operations centers (centri d'operazione)(see chart, Figure 38).

The Associate Commissioners were selected from the top rank of the Italian civil service (e.g., Prefetto di Prima Classe). Two administrative Associate Commissioners acted as the Secretariat for the Office of the Special Commissioner and were responsible for the usual administration and management functions necessary to operate (e.g., fiscal management, personnel, logistics support). One technical Associate Commissioner was in charge of coordination and direction of the military forces. The fourth was in charge of the firefighting forces in the earthquake zone.

The Commissioner's Operations Center expedited assistance operations in the disaster area, and acted as the focal point in dealing with the ministries and agencies in Rome. This Center also coordinated activities of the lower echelon centers, allocated scarce resources, and resolved competing demands. It included representatives of all operating organizations and a representative from the Foreign Office. At the provincial and sector (local) levels, the operations centers have similar functions and composition (except for the Foreign Office representative) for their province or municipality. The scope of their activities is correspondingly restricted. Table 4 indicates where each sector (local) operations center is located (see map in Figure 1a).

At first, it was not clear whether the Commissioner would set up one-stage assistance centers to distribute aid directly to the victims, or whether that task would be done in the operations centers. In any case, the organizational arrangement was somewhat similar to that used in the United States following a Presidentially delared disaster, allowing for certain constitutional and cultural differences. For example, the federal coordinating officer in the United States is charged with making effective and efficient use of all federal resources, as is the Special Commissioner in Italy. In both countries, a network of field offices is set up in the damaged areas and staffed with representatives of all entities that can assist the victims.

<u>Types of Assistance</u>

The same decree that appointed the Special Commissioner on November 26 also stated the benefits that would be made available to the inhabitants of the disaster area. The exact geographic definition of the area, however, was left to a still later decree that had not yet been issued by the end of the team's visit to Italy, but by law had to be signed no later than December 31, 1980.

It was reported that many localities were applying strong political pressure to be included in the later decree, so that their inhabitants could receive the disaster benefits. It was unofficially estimated that over 200 localities eventually would be designated "disastrati" (badly damaged communities in the disaster area eligible for relief).

Figure 38. Organization of the earthquake assistance staff and forces.

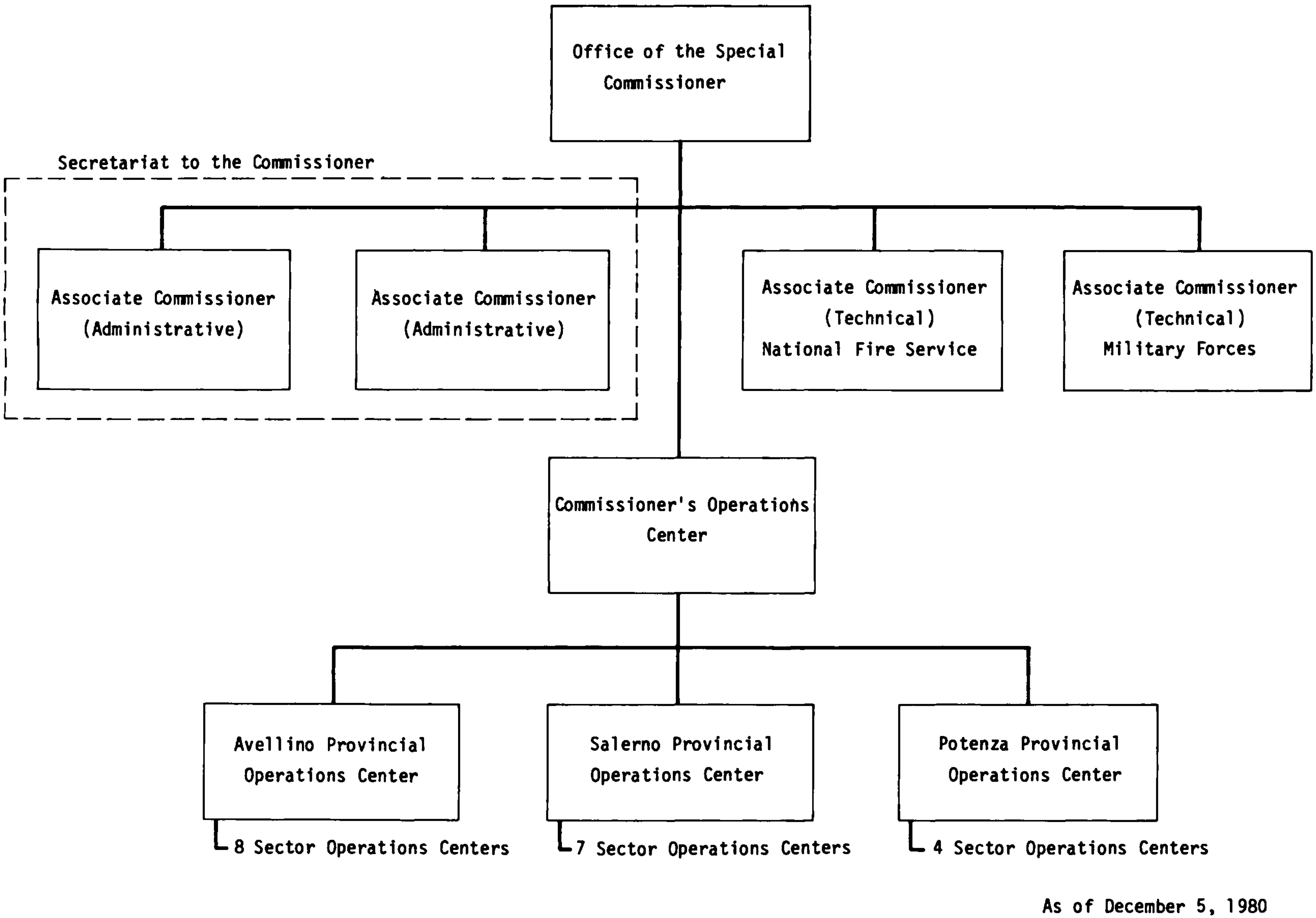

Table 4. Location of Sector Operations Centers.

Name of Province	Location of Sector Centers
Avellino............	Avellino Serino Ariano Irpino Sant' Angelo dei Lombardi Mirabella Eclano Frigento Salza Irpina Materdomini
Salerno............	Oliveto Citra Buccino Laviano Nocera Inferiore Mercato San Severino San Gregorio Magno Sala Consilina
Potenza.............	Potenza Pescopagano Balvano Rionero del Vulture
Naples..............	(This area is handled directly from the Special Commissioner's Operations Center.)

The disaster assistance provided to Italian victims is generally greater than that available to victims in the United States. Its scope reveals the far more pervasive role played by the Italian central government in economic and social activities (for example, lump-sum death benefits and forbearance on taxes). The absence of any provision for low-interest loans to individuals or businesses, however, is rather surprising. It may be that such loans are considered a part of long-range recovery (rather than immediate assistance) and therefore may be covered by the provisions of subsequent laws.

These benefits were to be provided to the inhabitants of the designated localities:[2]

[2]Summarized from the Italian text.

Individual and family assistance

- o Food and medicine and other necessities of life (still being distributed by the military forces some 3 weeks after the earthquake.)
- o Other needs of an extraordinary nature (unspecified).
- o A grant of 4 million liras (or about $4,575) for each member killed in the earthquake or in relief operations; 10 million liras (or about $11,425), if the deceased member was the principal wage earner in the family.
- o Up to 3 million liras (or about $3,430) per family for replacement of personal effects, clothing, furniture, or other household items lost as a result of the earthquake.

Housing

- o Campers, trailers, or prefabricated housing, including necessary utility hook-ups.
- o Incentives (of an unspecified nature) to encourage the homeless to find a permanent housing solution by themselves (relocation may have been the ultimate objective).
- o Construction material and cash grants to repair damaged, but restorable dwellings.
- o Housing requisitioned by the Commissioner outside the area of maximum damage.

Other benefits

- o Income, property, or estate tax payments (whether owed to the central government or to a locality by individuals or corporations) due between November 23 and December 30, 1980, and transaction and registration taxes and fees on official papers, stocks and bonds, contracts, and other documents were postponed for 6 months, in some cases then to be paid in installments running for up to 2 additional years.
- o Contributions due between November 23 and December 31, 1980, by both industrial and agricultural firms to funds for social security, workman's compensation, and orphan benefits were postponed without penalty for up to 3 years.
- o Full compensation and no loss of seniority for all employees (managerial, professional, and support) in cases of unemployment, reduced employment, or absenteeism due to the consequences of the earthquake for a period of up to 1 year.
- o Expediting of payments to employees of all types and their dependents for disabilities suffered in the earthquake.

- Shortening of the notice-of-withdrawal period from 90 to 30 days on bank deposits, savings certificates, savings bonds, and similar investment papers.
- Suspension until June 30, 1981, of all legal and financial deadlines and maturity dates falling due in the period between November 23 and December 31, 1980.
- Postponement until after December 31, 1980, of eviction notices for residential dwellings.

Temporary Housing

Temporary housing for victims is a crucial part of any disaster assistance effort. The Italian assistance authorities were confronted by some severe constraints: (a) a large number of homeless, (b) a high percentage of damage to the housing stock, (c) unavailability of vacant dwellings, (d) a scarcity of building inspectors to see whether the damaged structures were safe to reoccupy, and (e) severe winter conditions. Consequently, they tried first to find housing for the large number of victims in tents. This meant sending requests for tents to all parts of the country and to foreign governments.

According to the earliest figures from the Office of the Special Commissioner, a population of some 178,000 were installed in 7,325 tents by December 2. (Since this would indicate almost 25 persons per tent, the occupancy figures are suspect.) Tent cities were established in public squares, in open fields, in a stadium (see Figures 39 a, b, & c); also, individual tents could often be seen next to a heavily damaged individual dwelling.

Realizing that tent living could be only a stopgap measure, the authorities began to purchase and requisition trailers, and to assemble railroad cars at a very early stage. By December 2, they had placed 3,894 trailers on sites and had located 12,652 more trailers (5,309 through purchase, 3,402 transferred or rented from government sources, 3,428 obtained from the private sector through gifts or leases, 487 requisitioned, and some 26 obtained abroad).

Of the 12,652 trailers, 9,502 were already en route to the earthquake area by December 2, and the rest were being prepared for shipment. Trailers were installed where most convenient to the victims, in groups of 20 to 30 units (Figure 40). Some were installed at crossroads along main routes, or near single homes that had been heavily damaged. The task of moving people from tents into trailers had top priority. Little site preparation was done; in fact, only leveling was done in some cases (Figure 41). Utilities were austere, sanitary facilities primitive, and kitchen facilities communal. Some prefabricated houses were also acquired.

Transportation was free to victims who were willing to relocate and stay for up to 3 months (rent free) in hotel rooms or second homes requisitioned by the government in provinces nearby those that were

a

b

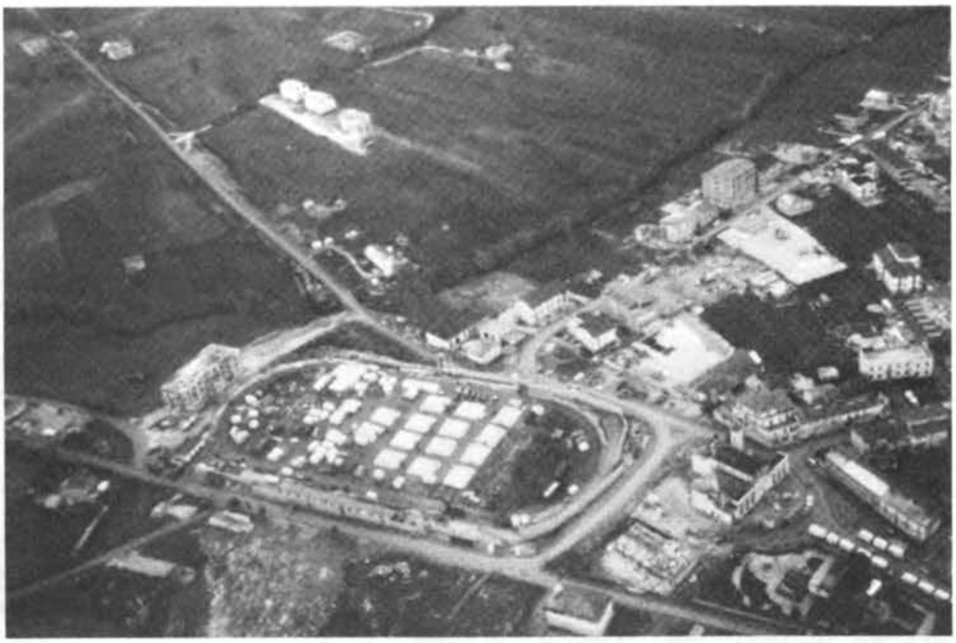

Figure 39. Examples of recovery operations. (a) One of the many tent cities erected to house the homeless. (b) Aerial view of a soccer field being used as a field hospital.

c

Figure 39 (cont'd). Examples of recovery operations.
(c) View of tent city at ground level.

Figure 40. Trailer camp in a town square.

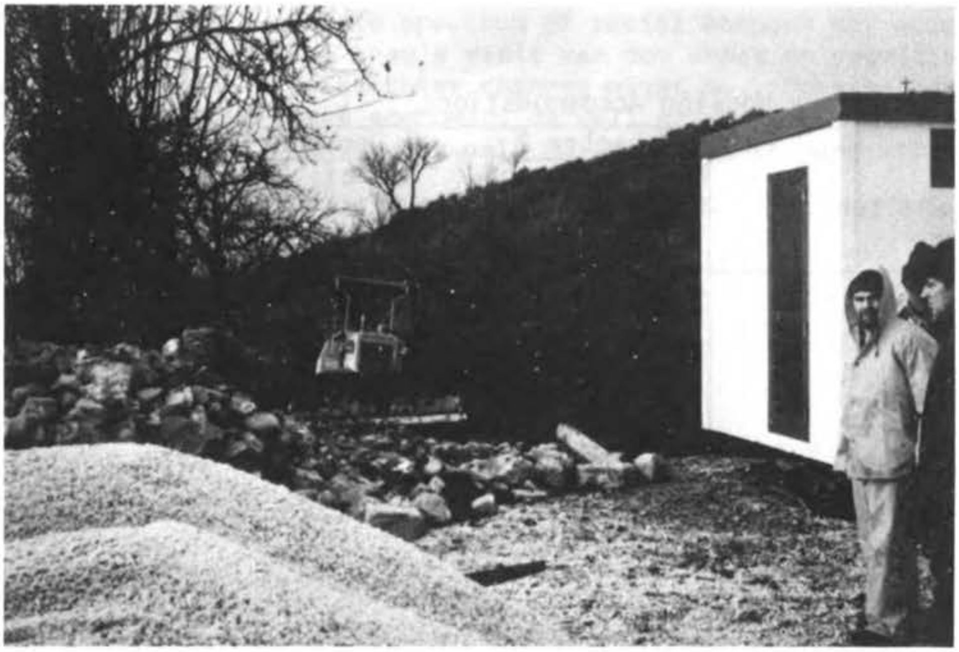

Figure 41. Site preparation for prefabricated buildings.

heavily damaged. Because of strong ties to home and property, however, less than 10 percent of the more than 22,000 available rooms were occupied by December 10, 1980.

The number of homeless, and the number and types of accommodations available to them from December 2 to 10, 1980 (the 9th to 17th day after the earthquake) is shown in Table 5. Caring for the homeless in this as in most disasters, was an enormous effort.

Funding Provision

The decree of November 26, 1980, that spelled out the assistance provisions, also authorized a special funding of about 1.2 billion liras (about $1,375,000) to augment monies already available to the Ministry of Interior for disaster response. Money for this special funding was to be raised principally by adding about 9 percent to the cost of fuels used by trucks and automobiles. Contributions from foreign governments, such as the $3.5 million contributed by the U.S. government for emergency relief needs, could also be used to supplement this special funding.

Table 5. Temporary Housing Accommodations.

Types of Shelter or Housing	December 2 No. of Units	December 2 No. of Victims Housed	December 6 No. of Units	December 6 No. of Victims Housed	December 10 No. of Units	December 10 No. of Victims Housed
Tents	7,325	178,000*	9,894	206,160*	10,184	36,662
Trailers	3,894	14,000	9,791	34,269	12,408	43,428
Railroad Cars	.....	......	1,578	31,560	1,839	36,780
Hotel Rooms						
Available	.....	......	24,732	.....	24,329	.....
Occupied	.....	......	1,798	.....	2,154	.....
Other Types of Shelter (schools, ships, etc.)	.....	......	.....	87,700	.....	53,000

*These figures indicate an unusually high occupancy per tent and should be considered suspect.

Long-Range Recovery

At the end of the team's visit to Ialy, damage assessment was still going on, with no indication when it could be completed. An Interministerial Committee consisting of representatives of the Ministers of Interior, Treasury, Public Works, and Labor had been charged with formulating a plan for long-range recovery by December 14, 1980, but many questions remained to be answered. There were no indications as to which ministry would have the lead responsibility for implementing the plan, what roles would be played by the various levels of government and the private sector, where funding would come from, or what the role of the Office of the Special Commissioner would be in managing long-range recovery activities.

In addition to these financial and managerial problems, a number of difficult technical and socioeconomic questions persist, such as whether (and where) to rebuild the most heavily damaged communities, how to stimulate new economic growth in the predominantly agricultural area, and how to strengthen the existing physical and economic infrastructure.

The Italian government faces a monumental task of organizing long-range recovery from this disaster. Resources for this effort will seriously affect the economic development of the whole country for many years. In fact, the initial effort has already affected the Italian taxpayers. Moreover, a whole spectrum of social changes may occur in the heavily damaged area. The team's visit was too short to permit even a preliminary estimate of what these changes might be. Nonetheless, solutions to the long-range economic, as well as social, problems will obviously be of significance, not only to Italy but to many other countries.

CONCLUSIONS

The team reached these conclusions.

Concerning Geotechnical Aspects

The strong motion records indicate sources in two or more locations, accounting for three to five shocks registered in the first few minutes. The multiple shocks create an additional difficulty in specifying the duration of shaking but this experience suggests that a pattern of multiple shocks, that diminish progressively in severity, must be considered in specifying earthquake ground motions for certain designs. More work should be done with the technical information from this and other earthquakes, to define appropriate durations and peak motions.

Any interpretation of the Italian strong-motion records for multiple epicenters should be coordinated with the microearthquake monitoring now being done. In combination, the two can define the boundaries of the source area and perhaps help in working out the mechanics of the fault rupture that is involved.

It was not possible to assess the significance of potential premonitory events. For example, the behavior of hot springs, the blow out of a gas well, and possibly other evidence, should be investigated.

Surface ruptures from faulting were not observed nor were evidences seen of soil liquefaction. Considering that the epicentral area is mountainous, very few landslides occurred. The most pronounced landslide was a minor one at Calitri in a slope that was bare from ravelling before the earthquake.

Concerning structural aspects

Seismic zonation for building-code requirements should reflect the anticipated seismicity of an area. Zoning that reflects only the areas damaged in recent earthquakes will not be likely to protect human lives adequately during future seismic activity.

Older buildings that are not seismically designed, especially those of unreinforced masonry, are particularly prone to collapse. Reducing the hazards caused by these buildings offers the potential of saving many lives.

Unbraced parapet walls of unreinforced masonry are especially hazardous.

Buildings and structures should be designed and constructed to account for the influence of nonstructural elements on the behavior of the vertical and lateral force structural systems, especially during earthquakes. The use of weak masonry for infill walls in concrete frames is detrimental and has caused structures to collapse during many earthquakes.

Cumulative damage to structures should be considered.

Concerning lifeline facilities

Electric-power distribution lines and telephone lines should not be supported from hazardous buildings or from other structures vulnerable to earthquake damage.

Electric-power transmission towers and distribution poles should be able to resist seismic motion effects. Pole-top transformers and other equipment should be firmly anchored to the poles or pole-top platforms.

Electric conductors between towers, poles, or equipment should have enough slack so that the seismic displacements do not cause conductors to become taut and impose loading on adjacent towers, poles, insulators, equipment, and equipment terminals.

Electric power substation equipment should be anchored to prevent overturning.

Mobile power generators should be immediately available to furnish emergency power to essential facilities.

Alternate means of short- and long-distance communications, such as radio transmitters and receivers, should be available to police, fire, and utility departments--and to hospitals--in case telephone service is interrupted.

Compacted soils for roadways and bridge approaches should be designed to prevent large settlement and lurching.

The proper authorities should have facilities and procedures available promptly to test domestic water for contamination after the earthquake. Sources of water that are not likely to become contaminated in an earthquake should be found and catalogued.

Concerning response and recovery

Federal and local authorities should prepare specific plans for responding to an earthquake, and see that the personnel responsible for putting the plans into effect are properly trained.

Trained local response services should be organized and equipped. These services are essential to save lives and their presence is critical in mountainous or other areas with sparse road networks.

The immediate availability of heavy equipment should be planned, especially in areas that have many unreinforced masonry structures and other types of hazardous buildings. Earth-moving equipment (such as scrapers and bulldozers) is essential to open routes through the debris. Lifting equipment (such as cranes and forklifts) is needed also, to move heavy rubble and large chunks of material. To save lives, the equipment is needed quickly.

Routes in and out of the areas of heaviest damage must be cleared quickly. In the older sections of a community, narrow streets and collapsed multistory buildings can create severe obstacles to rescue personnel and equipment that need to move quickly to save lives.

Plans should be made to evacuate areas that may become uninhabitable after an earthquake (for example, areas where large numbers of people live in older sections of communities, or in areas that have a large number of unreinforced masonry structures).

To protect the lives of survivors, and lessen the burden of providing temporary housing, competent personnel should be available to inspect damaged buildings. Survivors who need temporary lodging could be housed in dwellings that, even though damaged, could be declared safe for occupancy through timely inspection.

The proper authorities should try to improve the techniques available for rescuing people trapped in heavy debris. (Judging from the large number of missing persons presumed dead in this earthquake, these techniques are now rudimentary.)

As soon as the urgency of the emergency-response phase begins to lessen, the proper authorities should identify and analyze the long-range economic-recovery problems and the social implications of catastrophic disasters. They should make a systematic effort at observing the events of long-range recovery in Italy to gather data and make preliminary analyses. Perhaps a small team (of maybe two persons) might be sent to make periodic observations at intervals of from 4 to 6 months and conduct the necessary analyses.

The proper authorities should organize a substantial research project to (a) collect worldwide information on the techniques, equipment, and procedures for finding and rescuing victims from heavy debris after a disaster; (b) find out where the most advanced such equipment is located now and who is trained to use it; (c) establish procedures for use in alerting and deploying such personnel and equipment to points of greatest need within hours; (d) develop a plan to improve this capability where improvement is needed.

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APPENDIX A

Abbreviated Mercalli-Cancani-Sieberg (MCS) Intensity Scale

Intensity and Effect

I, Imperceptible
II, Very Light
III, Light
IV, Moderate
V, Moderately Strong
VI, Strong. Damaging only to very bad construction.
VII, Very Strong. Cracking in plaster. Very little damage to good construction. Some damage to bad construction.
VIII, Destructive. Damage to buildings around 50 percent.
IX, Strongly Destructive. Damage to buildings around 50 percent
X, Ruinous. Damage to buildings around 75 percent.
XI, Catastrophic. General destruction, landslides.
XII, Totally Catastrophic. Complete destruction. Large topographic effects, diversion of rivers and emptying of lakes.

APPENDIX B[1]

Summary of the Italian Disaster Relief Law of December 8, 1970 (No. 996)

Article 1--Natural disasters or catastrophes are defined as the occurrence of situations that pose such serious risk (or threaten to pose serious risk) to the safety of individuals and their possessions by their type or severity to require extraordinary "technical" measures.[2]

Article 2--The Ministry of the Interior is assigned responsibility to prepare for, organize, assume control, and ensure the coordination of the response activities of public and private entities at all levels of government. The Italian central government has a primary role.[3]

Article 3--An Interministerial Committee is established in the Ministry of the Interior, to be chaired by the Minister, with representatives from the Ministries of Treasury, Defense, Public Works, Transportation and Civil Aviation, Agriculture and Public Lands (Forests), and Public Health. The main duties of the Committee are to: (a) encourage research and prepare procedures to abate or lessen the probability of occurrence of natural disasters or catastrophes; (b) stimulate the coordination of emergency response plans; (c) encourage studies on measures to take during the search and rescue operations and assistance activities; and (d) stimulate the collection and dissemination of all relevant information for the protection of the civilian population. The Directorate General for Civil Protection and Fire Service[4] within the Ministry of the Interior acts as Secretariat for

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[1]This summary was prepared from the Italian text of the law.

[2]There is no enumeration of natural disasters, as there is in the United States Disaster Relief Act of 1974 (P.L. 93-288).

[3]This contrasts sharply with the United States concept of the federal government playing a supplemental role to local and state governments in disaster response.

[4]An approximate counterpart of the Federal Emergency Management Agency in the United States.

the Committee and ensures the implementation of committee decisions. A technical commission headed by the Director General is also available to provide specialized knowledge to the Committee.

Article 4--Warning of an impending disaster or information of the actual event are to be transmitted by the most rapid means to the Ministry of the Interior. Emergency plans are to be put into effect immediately upon occurrence of a disaster or catastrophe.

Article 5--A disaster declaration is made by the President of the Council of Ministers, upon proposal of the Ministry of the Interior, with or without request from regional and municipal authorities. The declaration also names a Special Commissioner who will take control of all civilian assistance forces in the field and ensure their effective and efficient utilization. The support of the armed forces is requested through the Minister of Defense.[5]

Article 6--The Ministry of the Interior is charged with planning and implementing the means necessary to provide urgent technical measures, equipment, and emergency aid to the victims of disasters or catastrophes. The principal means at the Ministry's disposal to reach these objectives is the National Fire Service (Corpo Nazionale dei Vigili del Fuoco). Specially equipped mobile groups and helicopter support from the Fire Service are to be available to move swiftly into the stricken area and provide search and rescue. The Service is responsible for the recruitment and training of volunteers that will assist the regular members of the Service.

Article 7--In each region, the Regional Commissioner is responsible for executing the directives of the Ministry of the Interior related to civil protection of the population. For this purpose, a regional office headed by a Regional Director for Civil Protection is created within the Office of the Regional Commissioner. Also, a Regional Committee for Civil Protection is established, consisting of the President of the Regional Council, the Regional Director for Civil Protection, heads of the various regional departments, mayors of the seats of provincial governments, the Inspector General (Regional Chief) of the Fire Service, a representative of the Italian Red Cross, and selected consultants. Relevant plans and programs developed by the Region are to be submitted for coordination and approval to the Ministry of the Interior.

Article 8 through 16--These articles deal with the restructuring of the National Fire Service, including organization and grade structure of the national office; duties and responsibilities of this office; duties

[5]As in the United States, the Italian disaster declaration is made by the highest political level, but the request for assistance need not originate at a lower level. Further, there is considerable similarity between the functions of the Special Commissioner and those of the Federal Coordinating Officer in the United States declared disasters.

and responsibilities of Regional Inspectors (chiefs) and their commands; table of organizations with grades, personnel ceilings for two years, methods of recruitment and appointment, length of work week (i.e., 40 hours, starting on January 1, 1972), compensation for overtime work, and exemption from further military duty for career personnel; and similar topics in regard to volunteer firefighters.

Article 17--Regional funding in the amount of 4.5 billion liras (or about 5.2 million dollars) are authorized, one million liras of which is available for each year 1970 through 1973 and one-half million in 1974. In addition, 500 million liras (or about $600,000) are authorized in 1970 for equipment and current expenses.

Article 18--For each year 1970 through 1974, the Italian Red Cross is authorized to expend 200 million liras (or about $230,000) for the upgrading of its mobile equipment and for public health services in case of natural disasters.

Article 19--The Ministry of the Interior is granted special powers to bypass the usual procurement practices in obtaining equipment, goods, and services (not otherwise available from current stocks) to assist victims of natural disasters.

Article 20--The Ministry of the Treasury is charged with making the necessary adjustments in the budget of the central government, so that there is no net increase as a result of the authorizations contained in this law.

Article 21--Implementing rules and regulations are to be issued within one year. In the interim, rules in effect since the 1926--1928 period remain in force, if they do not contradict provisions of this law.

Article 22--All laws incompatible with the provisions of this law are rescinded.

APPENDIX C

National Research Council Reports of Post-Disaster Investigations 1964-1981

Copies Available From Sources Given in Footnotes a, b, c, and d

Earthquakes

[a]The Great Alaska Earthquake of 1964:

Biology, 0-309-01604-5/1971, 287 pp
Engineering, 0-309-01606-1/1973, 1198 pp
Geology, 0-309-01601-0/1971, 834 pp
Human Ecology, 0-309-01607-X/1970, 510 pp
Hydrology, 0-309-01603-7/1968, 446 pp
Oceanography and Coastal Engineering, 0-309-01605-3/1972, 556 pp
Seismology and Geodesy, 0-309-01602-9/1972, 598 pp
Summary and Recommendations, 0-309-01608-8/1973, 291 pp

[c]Engineering Report on the Caracas Earthquake of 29 July 1967, by M. A. Sozen, P. C. Jennings, N. M. Newmark, 233 pp (1968)

[c]The Western Sicily Earthquake of 1968, by J. Eugene Haas and Robert S, Ayre, 70 pp (1969)

[b]The Gediz, Turkey, Earthquake of 1970, by Joseph Penzien and Robert D. Hanson, 88 pp (1970)

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[a]Available from National Academy Press, 2101 Consitution Avenue, N.W., Washington, D.C. 20418

[b]Available from Committee on Natural Disasters, National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington, D.C. 20418

[c]Available from National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161

[d]Available from "Publications on Demand", National Academy Press, 2101 Constitution Avenue, N.W., Washington, D.C. 20418

[b]Destructive Earthquakes in Burdur and Bingol, Turkey, May 1971, by W. O. Keightley, 89 pp (1975)

[c]The San Fernando Earthquake of February 9, 1971, by a Joint Panel on San Fernando Earthquake, Clarence Allen, Chairman, 31 pp (March 22, 1971)

[c]The Engineering Aspects of the QIR Earthquake of April 10, 1972 in Southern Iran, by R. Razani and K. L. Lee, 160 pp (1973)

[c]Engineering Report on the Managua Earthquake of 23 December 1972, by M. A. Sozen and R. B. Mathiesen, 122 pp (1975)

[c]The Honomu, Hawaii, Earthquake, by N. Nielson, A. Furumoto, W. Lum, and B. Morril, 95 pp (1977)

[b]Engineering Report on the Muradiye-Caldiran, Turkey, Earthquake of 24 November 1976, by P. Gulkan, A. Gurpinar, M. Celebi, E. Arpat, and S. Gencoglu, 67 pp (1978)

[b]Earthquake in Romania March 4, 1977, An Engineering Report, National Research Council and Earthquake Engineering Research Institute by Glen V. Berg, Bruce A. Bolt, Mete A. Sozen and Christopher Rojahn, 39 pp (1980)

Flood

[b]Flood of July 1976 in Big Thompson Canyon, Colorado, by D. Simons, J. Nelson, E. Reiter and R. Barkau, 96 pp (1978)

Dam Failures

[b]Failure of Dam No. 3 on the Middle Fork of Buffalo Creek Near Saunders, West Virginia, on February 26, 1972, by R. Seals, W. Marr, Jr., and T. W. Lambe, 33 pp (1972)

[b]Reconnaissance Report on the Failure of Kelly Barnes Lake Dam, Toccoa Falls, Georgia, by G. Sowers, 22 pp (1978)

Landslides

[b]Landslide of April 25, 1974, on the Mantaro River, Peru, by L. Lee and J. Duncan, 79 pp (1975)

[d]The Landslide at Tuve, Near Goteborg, Sweden on November 30, 1977, by J. M. Duncan, G. Lefebvre, and P. Lade, 25 pp (1980)

Windstorms

[c]Lubbock Storm of May 11, 1970, by J. Neils Thompson, Ernest W. Kiesling, Joseph L. Goldman, Kishor C. Mehta, John Wittman, Jr., and Franklin B. Johnson, 81 pp (1970)

[c]Engineering Aspects of the Tornadoes of April 3-4, 1974, by K. Mehta, J. Minor, J. MacDonald, B. Manning, J. Abernathy, and U. Koehler, 124 pp (1975)

[b]The Kalamazoo Tornado of May 13, 1980, by Kishor C. Mehta, James R. McDonald, Richard C. Marshall, James J. Abernathy, and Deryl Boggs, 54 pp (1981)

APPENDIX D

Earthquake Engineering Research Institute Publications

Available, except as noted, from EERI, 2620 Telegraph Avenue
Berkeley, CA 94704

1. Earthquake and Blast Effects on Structures, Proceedings of the Symposium held in Los Angeles, California, 1952. 322 pp.*

2. First World Conference on Earthquake Engineering, Proceedings of the Conference held in Berkeley, California, 1956. 536 pp.

3. Bibliography of Effects of Soil Conditions on Earthquake Damage, by C. Martin Duke, 1958. 47 pp.**

4. Earthquake and Fire, by Donald F. Moran, et al, 1959. 15 pp.

5. Earthquakes: Construction Inspection, by Harry W. Bolin, et al, 1959. 20 pp.**

6. Translations in Earthquake Engineering, by K. V. Steinbrugge, et al, 1969. 150 pp.**

7. Earthquake Damage Survey Guide, 1964. 20 pp.*

8. State-of-the-Art Symposium, Earthquake Engineering of Buildings, Abstracts of Papers, February 5-6, 1968; S. B. Barnes, Chairman.**

9. Peru Earthquake of May 31, 1970, Preliminary Report, by J. L. Stratta, et al, 1970. 55 pp.*

10. Bibliography of Earthquake Engineering, by Edward P. Hollis, 1971. 247 pp.

*Available from University Microfilm, Inc., 300 North Zeeb Road, Anne Arbor, Michigan 48106.

**Out of print.

11. Investigations of the San Fernando Earthquake, Program and Abstracts of Papers, National Conference on Earthquake Engineering, February 2-9, 1972, R. B. Matthiesen, Chairman.

12. Managua, Nicaragua Earthquake of December 23, 1972, Reconnaissance Report, by J. F. Meehan, et al, May 1973. 214 pp.

13. Proceedings of the Managua Earthquake Conference, November 29, 30, 1973, Christopher Rojahn, Chairman; 2 volumes. 975 pp.**

14. Report on the San Fernando Earthquake of February 9, 1971, performed by EERI for NOAA, Donald F. Moran, Chairman.**

15. Peru Earthquake of October, 1974, Reconnaissance Report, by D. F. Moran, et al, 1975. 85 pp.

16. Proceedings of the First US National Conference on Earthquake Engineering, June 18-20, 1975. 661 pp.

17. The Oroville Earthquake, by J. F. Meehan, et al, EERI Newsletter, Vol 9:5B, September, 1975.**

18. The Lice, Turkey Earthquake of September 6, 1975, by Peter Yanev, EERI Newsletter, Vol 9:6B, November, 1975.**

19. The Island of Hawaii Earthquake of November 29, 1975, by C. Rojahn, et al, EERI Newsletter, Vol 10:1B, February, 1976.

20. The Guatemala Earthquake of February 4, 1076, A Preliminary Report, by D. F. Moran, et al, EERI Newsletter, Vol 10:2B, May, 1976.**

21 6th World Conference on Earthquake Engineering, Programme and Author Index, New Delhi, January, 1977. 34 pp.

22. Earthquake in Romania, March 4, 1977. EERI Newsletter, Vol 11:3B, May, 1977. 85 pp.

23. Learning from Earthquakes, 1977 Planning Guide. 41 pp.**

24. Learning from Earthquakes 1977 Planning and Field Guides. 200 pp.

25. Mindanao, Philippines Earthquake, August 17, 1976, by J. L. Stratta, et al, August, 1977. 106 pp.

26. Engineering Features of the Santa Barbara Earthquake of August 13, 1978, by Miller and Felszeghy, 1978.

27. Miyagi-Ken-Oki, Japan Earthquake, June 18, 1978, Peter Yanev, Editor, 1978. 165 pp.
28. Proceedings of the Second US National Conference on Earthquake Engineering, August 22-24, 1979. 1168 pp.

29. Reading and Interpreting Strong Motion Accelerograms, a monograph by D. E. Hudson, 1979.

30. Potential Utilization of the NASA/George C. Marshall Space Flight Center in Earthquake Engineering Research, R. E. Scholl, Editor, December, 1979. Available from NASA.

31. Friuli, Italy Earthquakes of 1976, by James L. Stratta and Loring A. Wyllie, Jr., 1980. 97 pp.

32. Thessaloniki, Greece Earthquake, June 20, 1978. J. A. Blume and Mary Stauduhar, Editors. 1980. 86 pp.

33. Learning from Earthquakes, Project Report, 1973-1979, 1980.

34. Imperial County, California, Earthquake, October 15, 1979, Gregg Brandow, Coordinator; David J. Leeds, Editor. 1980. 200 pp.

35. Greenville (Diablo-Livermore) Earthquakes of January, 1980. EERI Newsletter, Vol 14:2, March 1980. 70 pp.

36. Northern Kentucky Earthquake of July 27, 1980, by R. D. Hanson, et al, September, 1980. 105 pp.

37. The 1976 Tangshan, China Earthquake, Papers Presented at the 2nd US National Conference on Earthquake Engineering Held at Stanford University August 22-24, 1979; Introduction by James M. Gere and Haresh C. Shah, March 1980.

38. Results of the Information Exchange in Earthquake Research Between the United States and the People's Republic of China (August 20 to September 15, 1979), Identification of Mutual Research Needs and Priorities, October 1980.

39. Montenegro, Yugoslavia Earthquake, April 15, 1979, Reconnaissance Report, D. Anicic, G. Berz, D. Boore, J. Bouwkamp, U. Hakenbeck, R. McGuire, J. Sims, and G. Wieczorek, Contributors, R. B. Matthiesen, Coordinator, Arline Leeds, Editor, November 1980.

40. El-Asnum, Algeria Earthquake October 10, 1980 and Trinidad-Offshore California Earthquake November 8, 1980. EERI Newsletter, Vol 15, No 1, Part B: January, 1981. 113 pp.

41. Introduction to Dynamics of Structures, a monograph by A. K. Chopra. 1981.

42. Mexico Earthquakes: Oaxaca-November 29, 1978; Guerrero-March 14, 1979, Reconnaissance Report, by Nicholas Forell and Joseph Nicoletti. October, 1980. 89 pp.

Also available: Soil and Structure Response to Earthquakes. A video-taped lecture series, by H. B. Seed, A. K. Chopra, P. C. Jennings, and A. S. Veletsos.