CALIFORNIA INSTITUTE OF TECHNOLOGY

EARTHQUAKE ENGINEERING RESEARCH LABORATORY

THE SALONICA (THESSALONIKI) EARTHQUAKE OF JUNE 20, 1978

BY

IOANNIS PSYCHARIS

EERL 78-03

A Report on Research Conducted under Grants
from the National Science Foundation and
the Earthquake Research Affiliates Program
at the California Institute of Technology

PASADENA, CALIFORNIA

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SALONICA EARTHQUAKE OF JUNE 20, 1978

Abstract

The 6.5 magnitude Salonica earthquake of June 20, 1978 is an earthquake of major interest from the engineering point of view, since it occurred near a city of 700,000 inhabitants. In general, the damage was not extensive and modern buildings performed quite well during the earthquake, while some old ones suffered severe damage.

The author was on vacation in Athens at the time of the earthquake and visited Salonica on June 23rd. As the intention of this visit was to make a general survey of the affected area, detailed descriptions of the engineering features of the earthquake and the building damage are not included in this report.

INTRODUCTION

At 11:04 (local time) on the night of June 20, 1978 one of the strongest earthquakes that have struck the northern part of Greece in this century occurred. According to the National Observatory of Athens it was of magnitude 6.5 on the Richter scale, and, therefore, it was not a big earthquake in the seismological sense. From the engineering viewpoint, however, the earthquake was important since its epicenter was located only 25km away from Salonica, a city of 700,000 inhabitants and the second largest city in Greece.

As illustrated in figures 1 and 2 the seismic activity of the northern part of Greece has been moderate in the last 70 years. However, a few earthquakes of magnitude 6.0 or bigger have occurred in the region which was hit by the earthquake of June 20th. In 1932 an earthquake of magnitude 7.0 occurred 75km east of Salonica and in 1905 Agion Oros, about 130km away from Salonica, was hit by an earthquake of magnitude 7.5. Some other big earthquakes have also occurred this century in the southern parts of Yugoslavia and Bulgaria (see figure 3).

SEISMOLOGICAL FEATURES OF THE EARTHQUAKE

As mentioned above, the magnitude of the earthquake was 6.5. The ground shaking in the epicentral region was Intensity VIII on the Modified Mercalli scale. In the city of Salonica the Intensity of the shock was VI+. The maximum ground acceleration in Salonica was 15%g. The earthquake

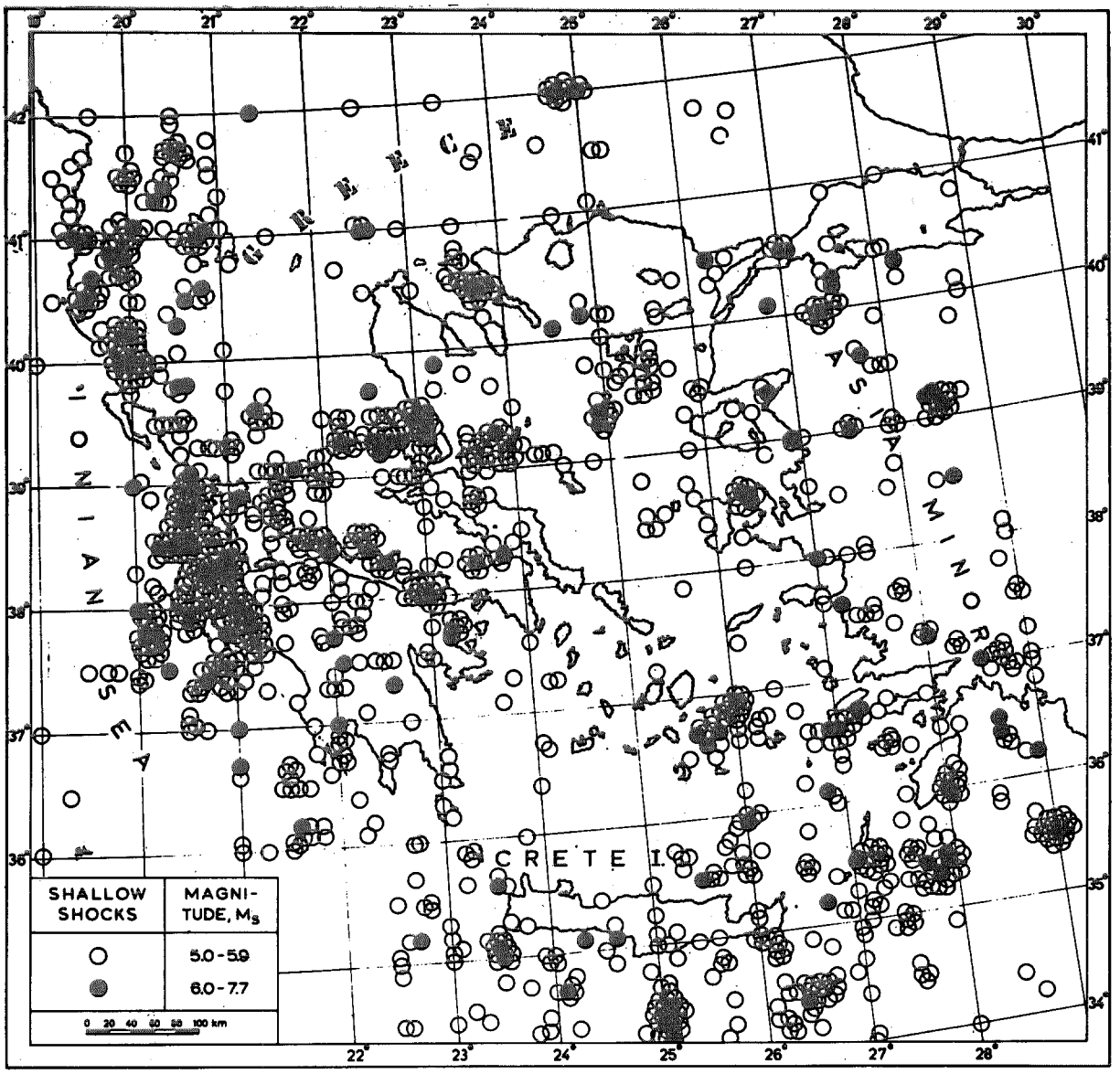

Figure 1. Distribution of epicenters of shallow earthquakes in Greece in the period 1911-1970 (from P. E. Komninakis, Ph.D. Thesis, University of Athens, 1975).

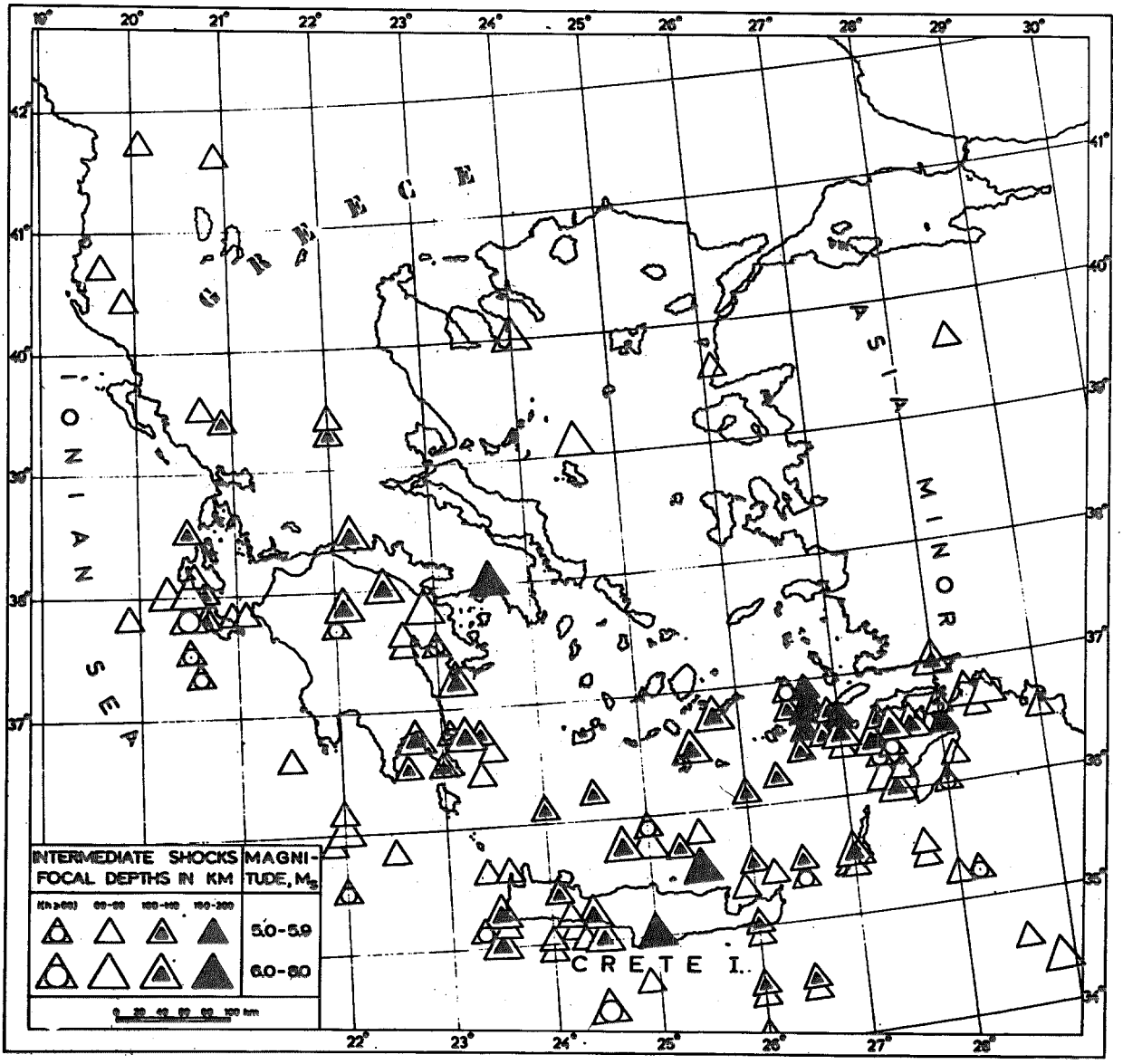

Figure 2. Distribution of epicenters of intermediate earthquakes in Greece in the period 1911-1970 (from P. E. Komninakis, Ph.D. Thesis, University of Athens, 1975).

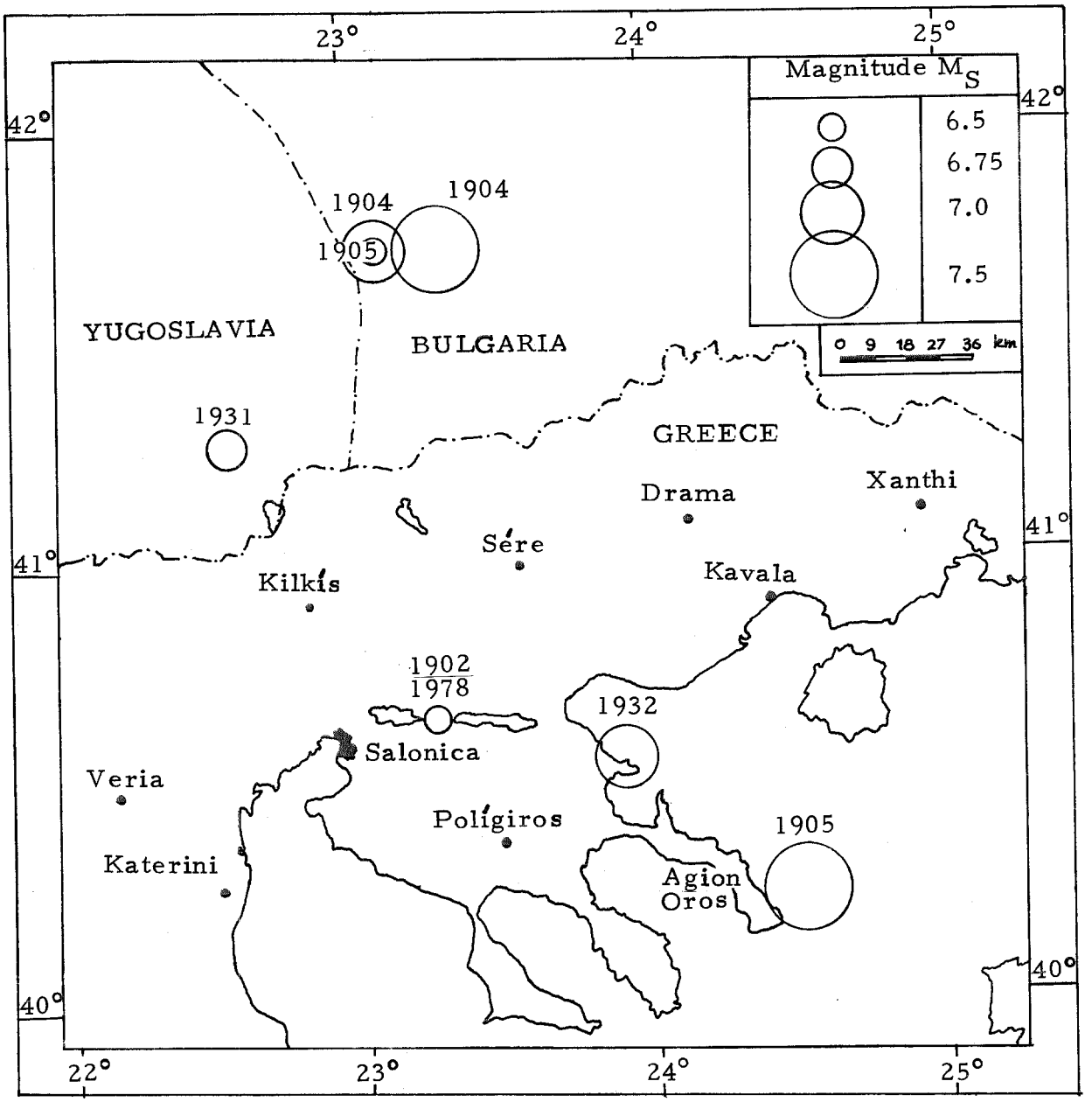

Figure 3. Distribution of epicenters of earthquakes of magnitude 6.5 or bigger, that happened this century in northern Greece and southern Bulgaria and Yugoslavia.

was a shallow one, since its hypocenter was reported to be at a depth of 10-to-15km.

As of mid-July, the epicenter of the earthquake had not yet been determined precisely, but it was expected to be near the villages of Stivos and Scholari, 25km east of Salonica (see figure 4). It is interesting to note that another earthquake of the same magnitude had occurred at the same place in 1902. However, according to the Seismological Center of Uppsala (Sweden) the epicenter may be a distance of about 20km north of Salonica.

A large number of foreshocks preceded the earthquake, the activity starting about 2 months earlier. One of these was of magnitude 5.8 and occurred on May 24th. It was assumed then by some seismologists that this was the main shock and that the seismic activity after May 24th was due to the aftershocks of that earthquake. It now seems clear, however, that the earthquake of May 24th, whose epicenter was also located near the villages of Stivos and Scholari, was a foreshock of the larger earthquake of June 20th.

The earthquake was also followed by a large number of aftershocks. The recording of Poligiros seismic station on June 23rd gives an example of the aftershock acitivity. An 8-hour long recording of this station on June 23rd indicates 180 aftershocks. The aftershocks, which were still occurring in mid-July, had their epicenters spread out over a region about 10km in diameter around the epicenter of the main shock. The largest one occurred on July 4th and was of magnitude 5.0.

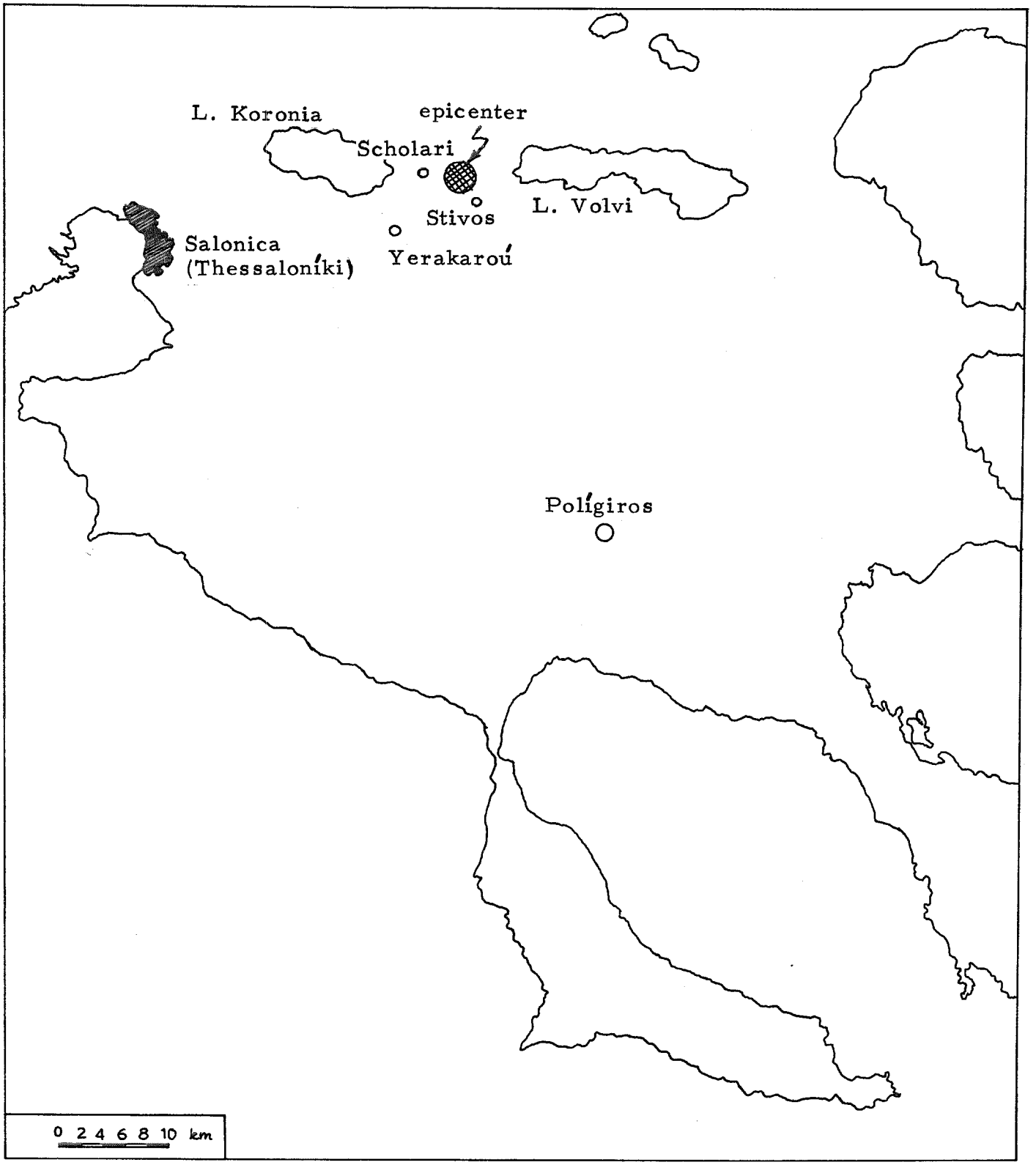

Figure 4. Location of the epicenter of the earthquake of June 20, 1978.

Seismograms of the earthquake and its foreshocks and aftershocks were recorded by many stations. There exist 13 seismic stations in Greece, the closest to the epicenter being the one at Paligiros. At the time of the earthquake a strong-motion accelerograph was also operating in Salonica. The record of the earthquake by this instrument is illustrated on figure 5. This record was furnished by Dr. P. Carydis of Athens, who is preparing a detailed report of the earthquake for the Earthquake Engineering Research Institute.

The earthquake produced a net of cracks, which appeared at two places in the epicentral region near the village of Yerakorou and between the villages of Stivos and Scholari. Near Yerakarou, the cracks were oriented E-W and the horizontal slipping was 2 cm. Between Stivos and Scholari, the cracks were oriented SE-NW with the same amount of motion. The width of the cracks in some places reached 20 cm. Local vertical slipping also occurred in some places, the maximum being 20 cm in a place at Scholari. As of mid-July, it was not know whether the cracks were related to faults or were merely local effects.

Some other geological phenomena occurred after the earthquake in the region near the Lake Volvi. The water table rose and some wells overflowed. In the same region, local liquefaction of the soil occurred in some places, forming "craters" of diameter 0.5-to-3.0 m and depth 60-to-70 cm.

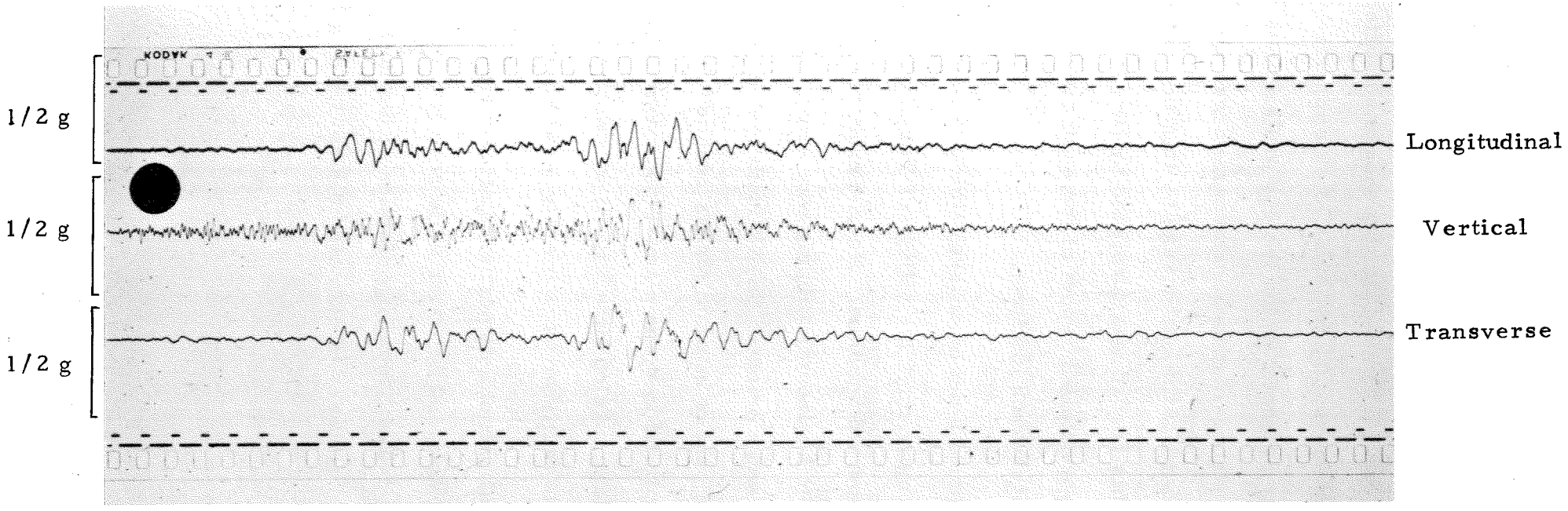

Figure 5. Strong-motion accelerograph record of the Salonica earthquake of June 20, 1978 (by courtesy of the National Observatory, Athens, Greece).

DAMAGE FROM THE EARTHQUAKE

Forty-seven people lost their lives during the earthquake of June 20th. The major loss of life occurred when an 8-story concrete frame apartment building in Salonica collapsed killing 37 people. Another 4 people were killed elsewhere by falling bricks and an additional 6 were reported to have died from heart attacks. About 150 people were injured.

The 8-story apartment building, situated at the crossing of Nikiforou Foka and Ippodromiou streets, collapsed completely. Fortunately, 8 families who lived in the building had been on vacation at the time of the earthquake, otherwise the number of casualties would have been much higher. The building, which was an old one, was designed before the adoption of the modern building code. In any case, investigations started a few days after the quake in order to clarify the reason for the collapse.

Two other apartment buildings on 23 and 25 Vasilisis Sofias street, of about the same height as the one which collapsed, were damaged to the point that they no longer could be occupied. The columns of these buildings were badly cracked above the ground surface and the steel reinforcing bars were bent (see figure 6a, b).

These buildings, like the one which fell, were built in the place of the old hippodrome, where the foundation soil was formed by fill. These poor foundation conditions might have played an important role in the

extent of the damage to these buildings. Other buildings in the same area also suffered considerable damage.

A lot of old weak houses were severely damaged, usually in the form of falling masonry. Walls fell down in such buildings, and the damage to the parapet walls and the balconies was also extensive. A 2-story house at Yiannitson street collapsed completely.

However, modern buildings with concrete frames and designed according to the building code requirements performed very well during the earthquake. Most of these suffered little or no damage. Any damage was mainly restricted to the brick walls and not to the frame of the buildings.

The hospitals of the city were also subjected to some small damage. In any case the patients were temporarily transferred to tents immediately after the earthquake.

The telephone service was lost at Toumba in east Salonica, due to the severe damage to the telephone center there. Other facilities suffered restricted damage, which was quickly repaired.

Damage also occurred to the Roman and Byzantine monuments of Salonica. The Rotunda of Galerius, built around A.D. 300, and the church of Agia Sofia and Agios Panteleimon were severely damaged and they were temporarily closed to the public. A few ramparts fell from the White Tower, the best-known monument and the symbol of the city. A minaret, built in the period of the Turkish occupation of Greece, split in two.

Groups of civil engineers were inspecting the damage in all the buildings in Salonica in mid-July. Up to July 13th, 50,316 houses and apartment buildings had been inspected. Of these, 37,013 (73.56%) were found to be safe and not requiring repairs, 9,098 (18.08%) had to be repaired before they could be reoccupied, and 4,205 (8.36%) were found dangerous. The results of this investigation may give information about the way that the damage was distributed around the city and the relation of the damage to the foundation soil, building age or other factors.

In the epicentral region, extensive damage occurred to the villages of Stivos and Sholori, where some houses collapsed and many others were severely damaged. Most of these were already damaged by the earthquake of May 24th, since these villages were in the epicentral region of that earthquake too. Fortunately, the people abandoned their houses after that earthquake, so the big earthquake of June 20th did not cause deaths in these villages.

Most of the damaged houses were built of stone or brick with clay or cement mortar. However, some concrete frame structures were also severely damaged. Damage to the water supply system also occurred in these villages due to the motion of the ground along the cracks which appeared there.

Small damage to buildings was also reported in other cities including Kavala and Drama, which are 100km away from the epicenter.

CONCLUSIONS

Although the damage due to the earthquake was not as extensive as it was first presented by the news media, it was surely significant. It must be said that the modern buildings, designed according to the earthquake requirements of the building code, performed satisfactorily during the earthquake, their damage, if any, being mainly to the interior brick walls. However, it must be taken under consideration that Salonica was 25km away from the epicenter and that the earthquake was only of magnitude 6.5. It is not known how the buildings would have performed if the epicenter had been in Salonica or the earthquake had been of larger magnitude. Before the earthquake of June 20th, the seismicity of the region struck by the earthquake was considered to be moderate by the building code; this is an important point which should be changed.

Most buildings that suffered severe damage were old and weak, designed before the adoption of the modern building code. There are a lot of such old buildings in Salonica that will probably collapse if a strong earthquake were to hit the city. In addition, parapet walls on thousands of such buildings are potentially hazardous.

Most of the hospitals in Salonica pre-date the building code and suffered damage by the earthquake to the extent that they had to be evacuated for a few days. Like the San Fernando, California earthquake of 1971, this earthquake again shows the advantage of having hospitals and other critical structures, which are most needed after an earthquake, designed so that they remain functional even after experiencing very severe ground shaking.

The Salonica earthquake also demonstrated the need for better seismic instrumentation in Greece. During the earthquake of June 20th there was only one strong-motion accelerograph in Salonica, and that was not operating during the earthquake of May 24th. Some other instruments that existed in the epicentral region did not operate because they had not been maintained properly. Also, the existing net of seismic stations was not adequate for the determination of all the seismological features of the earthquake.

ACKNOWLEDGEMENT

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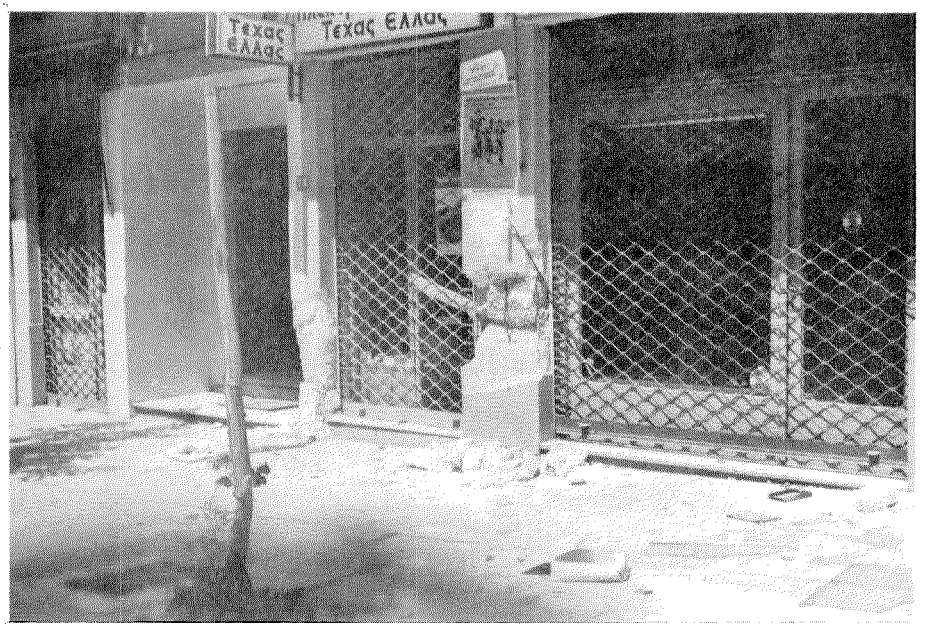
I wish to express my appreciation of the assistance given by Professor P. C. Jennings of the California Institute of Technology in preparing this report. Special thanks are due to my brother Vasilis Psycharis for his help in collecting the information and for the interesting discussions of the damage. The assistance given by Professor G. W. Housner of the California Institute of Technology is also acknowledged. Finally, I wish to thank Dr. Panayotis Carydis for providing the strong-motion accelerograph record of the earthquake.



(a)

(b)

Figure 6. Severe damage to the columns of the buildings at 23 and 25 Vasilisis Sofias street.

Figure 7. Severe damage inflicted to adjacent buildings by the fall of the 8-storey apartment building at Ippodromiou street.

Figure 8. Damage to old buildings at Vasilisis Sofias street.

Figure 9. Damage to an old house not occupied at the time of the earthquake.

Figure 10. This was a 2-storey old house at Yiannitson street which collapsed.

Figure 11. Damage to the parapet walls and the balconies of "Egyptos" Hotel.

Figure 12. "Egyptos" Hotel. A person was killed here by falling bricks.

(a)

(b)

Figure 13. Damage to the balcony and parapet wall of an old house.

(a)

(b)

Figure 14. Extensive damage to the parapet walls and balconies of old houses.

Figure 15. Separation of two old buildings after the earthquake.

Figure 16. Damage to the plaster of the exterior walls. This kind of damage was very common.

Figure 17. Damage to the parapet wall of an old building.

Figure 18. Cracks along the boundary of the concrete frame of a modern building.

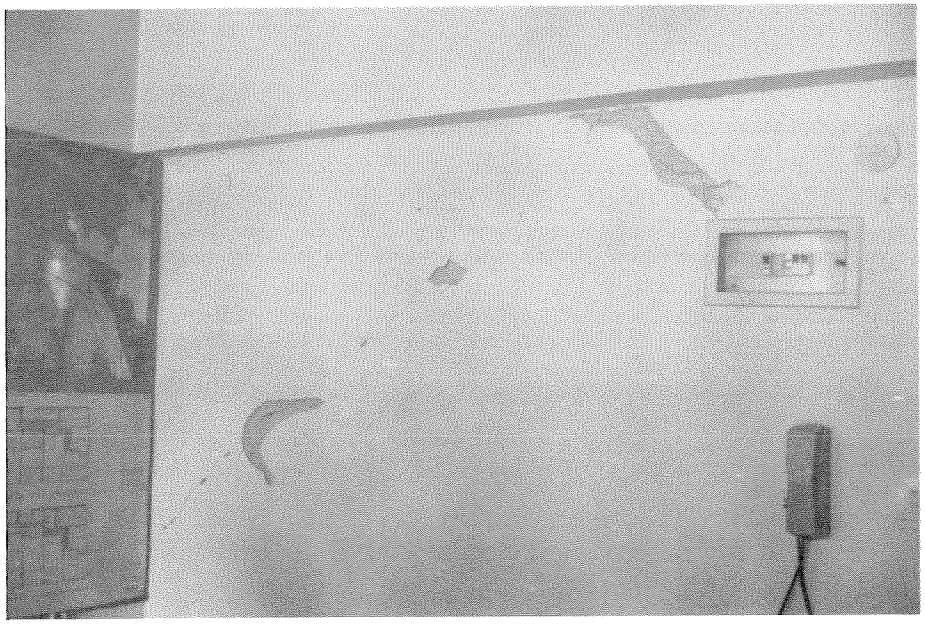


Figure 19. Cracks on an interior brick wall of a modern building.

Figure 20. Church of Agia Barbara in Toumba. Cracks on the interior walls and arches.

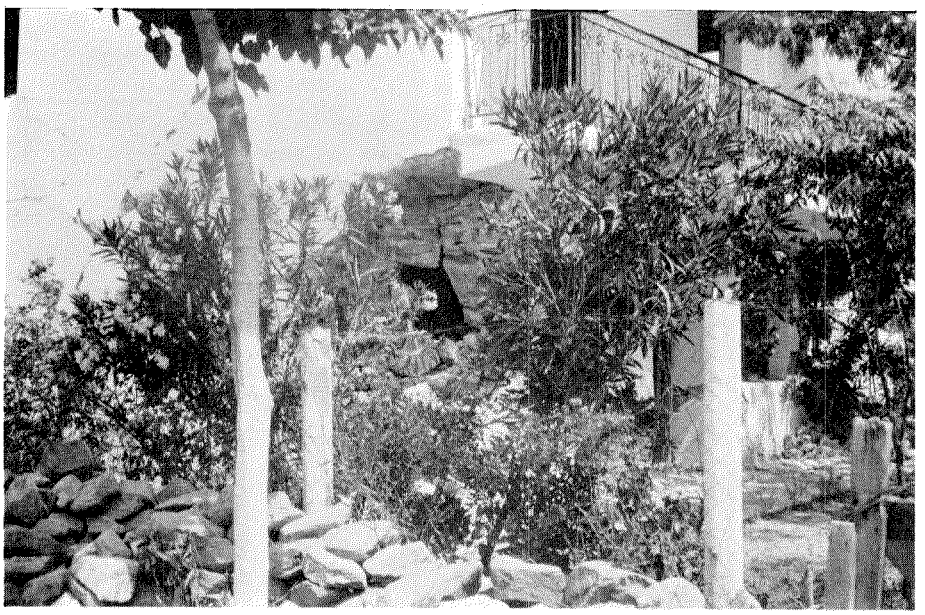
Figure 21. After the earthquake many people abandoned their homes and moved into tents.

Figure 22. Collapse of a house at Stivos Village.

Figure 23. Fall of an exterior wall of a house at Stivos Village.

Figure 24. Typical damage to house at Stivos Village.

(a)



(b)

Figure 25. Damaged house at Stivos Village.

(a)

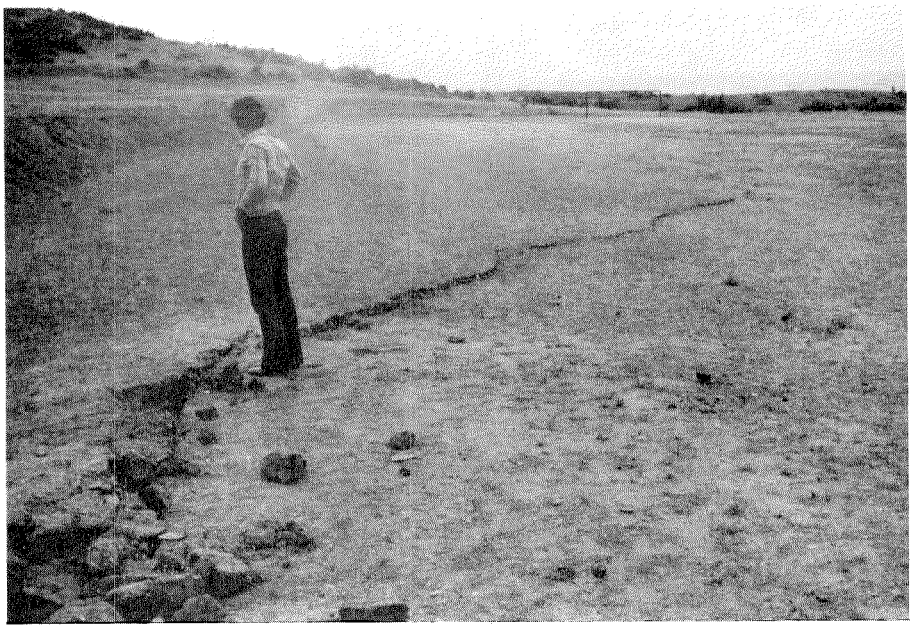
(b)

Figure 26. Damage to the stairway and the exterior wall of a house at Stivos Village.

Figure 27. Damage to the interior of the same house.

Figure 28. Crack which appeared on the earth at Stivos.

(a)



(b)

Figure 29. Cracks on the ground at Stivos.