CHAPTER I

Summary and Objectives
for
a Dense Three-Dimensional Array near
Garni, Armenia

J. Filson, R. D. Borcherdt, W. H. K. Lee, E. Cranswick,
C. Dietel, E. Sembera, J. Mori, and J. Sena
(U. S. Geological Survey)

L. Hakhverdian, R. Amirbekian, V. Aharonian, K. Safarian, H. Galagian, and G. Apoian
(Yerevan Seismic Station)

R. Banfill
(Small Systems Support, Big Water, Utah)

INTRODUCTION

Within two weeks following a major earthquake in December 1988 a team of seismologists and engineers from the United States went to Armenia to investigate the cause and effects of that tragic event. A modest but sustained cooperative effort between seismologists in Armenia and in the U. S. Geological Survey (USGS) has grown from that initial post-earthquake investigation. In 1989 the USGS began to participate in what is now called the Joint Seismic Program (JSP) between the United States and what was then the Union of Soviet Socialist Republics (USSR). This program is led on the U. S. side by the Incorporated Research Institutions for Seismology (IRIS) and on the Soviet side by the Institute of Physics of the Earth. In 1989 the Soviet side suggested that among other things the JSP project should include detailed studies of the seismicity of certain earthquake-prone areas of the Soviet Union. Kirgizia and Armenia were offered as places where arrays of seismometers could be installed for this purpose. As a participant in theJSP and as the organizer of the post-earthquake investigation in Armenia, the USGS was chosen to take up the array work in Armenia.

OBJECTIVES

During the 1988 post-earthquake investigation Armenian colleagues suggested that a portable seismic station be installed at a geophysical observatory near Garni, about 20 km east of the capital, Yerevan (Figure 2-3). A trip to this site revealed a two-story building with a horizontal tunnel, or adit, running from the basement about 200 meters into the hill behind the building. This tunnel had been constructed for the purpose of obtaining geophysical observations relevant to earthquake prediction. The tunnel was lined with concrete and had several small rooms with piers suitable for seismic recording (Figure 2-5). The tunnel is described in more detail in the next chapter.

Given this excellent facility and the charge from the Joint Seismic Program, a USGS team went to Armenia in June 1990 with the purpose of installing a dense seismometer array in and around this tunnel. Other than taking advantage of an exceptional site, the scientific justification for the array can be seen in Figure 2-4. The Garni site lies on the northern edge of a long, steep valley that runs northeast-southwest opening to the southwest onto the larger and broader valley of the Araks River about 10 km south of Yerevan. There is concern that the topography of the narrow valley near Garni is controlled by an active fault. A Roman temple at Garni was destroyed by a “great” earthquake in 1679. If the valley follows the course of an active fault, then this fault represents a considerable hazard to Yerevan, a city of 1.2 million people, with construction of the type that was destroyed in Spitak and Leninakan in 1988 killing over 25,000 people. The purpose of the array is to detect and locate if possible any local seismicity associated with a larger pattern of strain release along this fault. Of course a wider microearthquake network would have been more suitable for this task, but was not considered possible given the time allowed and the funds provided.

The recording scheme is built around the General Earthquake Observtion Systems (GEOS) developed and described by Borcherdt *et. al.* (1985). A PC-based system developed by W. H. K. Lee is also used for recording-backup and display of the data. The seismometers used are 1 Hz Mark Products L-4Cs deployed in three-component sets. The fact that the tunnel is set into a hill provided the opportunity to establish sites on the hill above the tunnel and thus provide a three dimensional array geometry. The GEOS and PC recorders were set up in the observatory building with cable

connections to the seismometer sites. The total aperture of the array is less than 1 km. More detailed descriptions of the array geometry and recording system specifications are given in the next chapter.

(The array deployment was completed within a two-week period during June 1990. Anyone who has ever participated in a similar exercise in a foreign country will appreciate the difficulties endured and the problems that had to be met and overcome. A full description of the effort will probably be wasted on anyone who has not. However, it must be said that the task could not have been completed without the help of Armenian colleagues and their families. We slept in an abandoned dormitory with no running water or other facilities. Our food was bought, cooked, and served by the wives and friends of the Armenians working with us on the project. Our Armenian colleagues carried gear, dug pits, pulled cable, mixed concrete, and generally shared in all of the labor intensive activities.)

SUMMARY

Since the installation of the dense array nearly one thousand events have been recorded at one or more of the array sites. The array has operated since July 1990 with some gaps in recording caused by strains on the infrastructure of Armenia due to the breakup of the Soviet Union and military actions resulting from disputes with Azerbaijan over contested territory. This report documents the recordings of the array and shows examples of the types of events that are available for study. Data from the array has been placed on optical disks and is available on these disks from the USGS and also through the IRIS Data Management Center in Seattle, Washington. Data from the array has proven amenable to three-dimensional analysis as described in Chapter V. The analysis of the local seismicity is not yet complete. It is clear that there is considerable local activity, occurring at times of day random enough that it cannot be due to blasting. Accurate location of these events with an array this small remains a problem of study.