THE BROADBAND SEISMIC EXPERIMENT IN YUNNAN, SOUTHWEST CHINA

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ABSTRACT

Since August 2001, a broadband portable seismic network has been operating in Yunnan, southwest China, to collect seismic data for advanced studies on regional crustal and mantle structures, earthquake prediction, characteristics of wave propagation, and earthquake and explosion sources. The area of interest in southwest China is situated in a transitional tectonic region between the uplifted Tibetan plateau to the west and the Yangtze continental platform to the east. The region displays varying crustal thickness from 35 km to over 60 km with seismic activity strongly associated with the mapped active faults. The portable seismic network, consisting of nine stations equipped with the STS-2 seismometers and RefTek data loggers, and ten stations with the Chinese broadband instruments, is deployed in the region of 98°E-105°E, 21°N-29°N. There are also 23 permanent digital broadband seismic stations recording in the region. Yunnan has the strongest intra-plate seismic activities in China. Moreover, Yunnan is a very interesting area considering its position relative to several strong seismic zones in China, such as Tibet, Xinjiang, Sichuan, and northern China, as well as those in the rest of the world, like Burma, India-Pakistan, Tonga-Fiji, Japan, and the west coast of South and North America. So far, we have recorded several moderate (M=4.5-6) local earthquakes, including one located only 100 km north from the auxiliary International Monitoring System (IMS) station KMI. These moderate earthquakes are well surveyed by the provincial Yunnan Seismological Bureau and yield high-quality ground truth information. A large amount of local events are routinely recorded, among which, many are believed to be industrial explosions. Moderate to large earthquakes in other parts of China, as well as large events worldwide, are also routinely recorded, including

- the November 14, 2001, Ms=8.0 Qinghai earthquake,
- the December 18, 2001, Ms=7.3 Taiwan earthquake,
- the September 11, 2001, Ms=6.4 Iranian earthquake,
- the October 12, 2001, Ms=7.3 Mariana earthquake,
- the January 2, 2002, Ms=7.6 Vanuatu Islands earthquake, and
- the March 3, 2002 Ms=7.2 Hindu-Kush earthquake.

The waveforms recorded in this project are being processed and analyzed to provide very useful information on the source, path and site terms for regional seismic studies.

OBJECTIVE

The major purpose of this project is to collect fundamental ground truth data for advanced studies on regional crustal and mantle structures, earthquake prediction, and regional characteristics of wave propagation and seismic sources in Yunnan, China, through deploying a broadband portable seismic network there. The area of interest in southwest China is situated in an evolving tectonic region transitioning between the uplifted Tibetan plateau to the west and the Yangtze continental platform to the east. The region displays varying crustal thickness from 35 km to over 60 km with seismic activity strongly associated with the mapped active faults. Figure 1 shows the topography of the Yunnan province and the layout of our broadband network. The red triangles are STS-2 seismometers from the US, while the red circles are Chinese broadband instruments (the long-period corner at 20s) from our Chinese collaborators. Please notice that we modified the distribution of the stations a little from the original pattern that was reported last year in order to provide better coverage of more interesting areas with respect to tectonics and ground truth sources. Yunnan has the strongest intra-plate seismic activities in China. There are several strong seismic zones in its surrounding areas, such as Tibet, Sichuan, Burma, and India. There is also an abundance of mining activities in this area. Moreover, the distances from the Yunnan area to many of the strongest seismic zones in the world, such as Tonga-Fiji, the west coast of North and South America, and the Japan-Kuril region (Figure 2), make the Yunnan area an ideal place top record various seismic phases for tectonic and structural studies. Therefore, the strong seismicity and the intensive mining activities in Yunnan and its surrounding areas, as well as its unique position relative to many strongest seismic zones in the world, provide the foundation for success of this deployment.

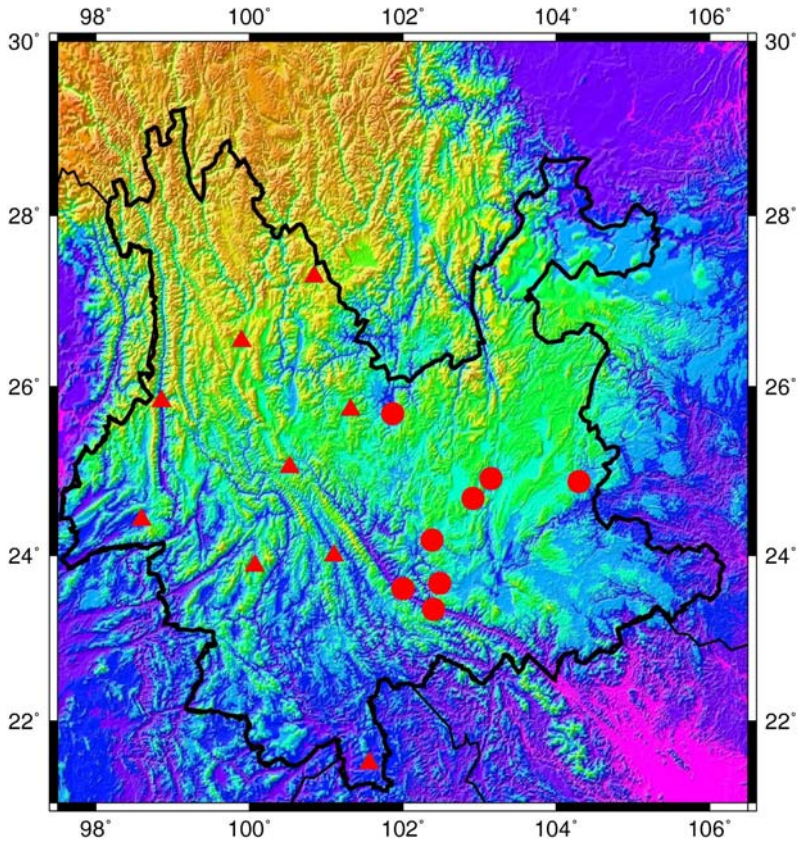

Figure 1. The topography of the Yunnan province and the layout of our broadband network. The red triangles are STS-2 seismometers, while the red circles are Chinese broadband instruments (the long-period corner at 20 s).

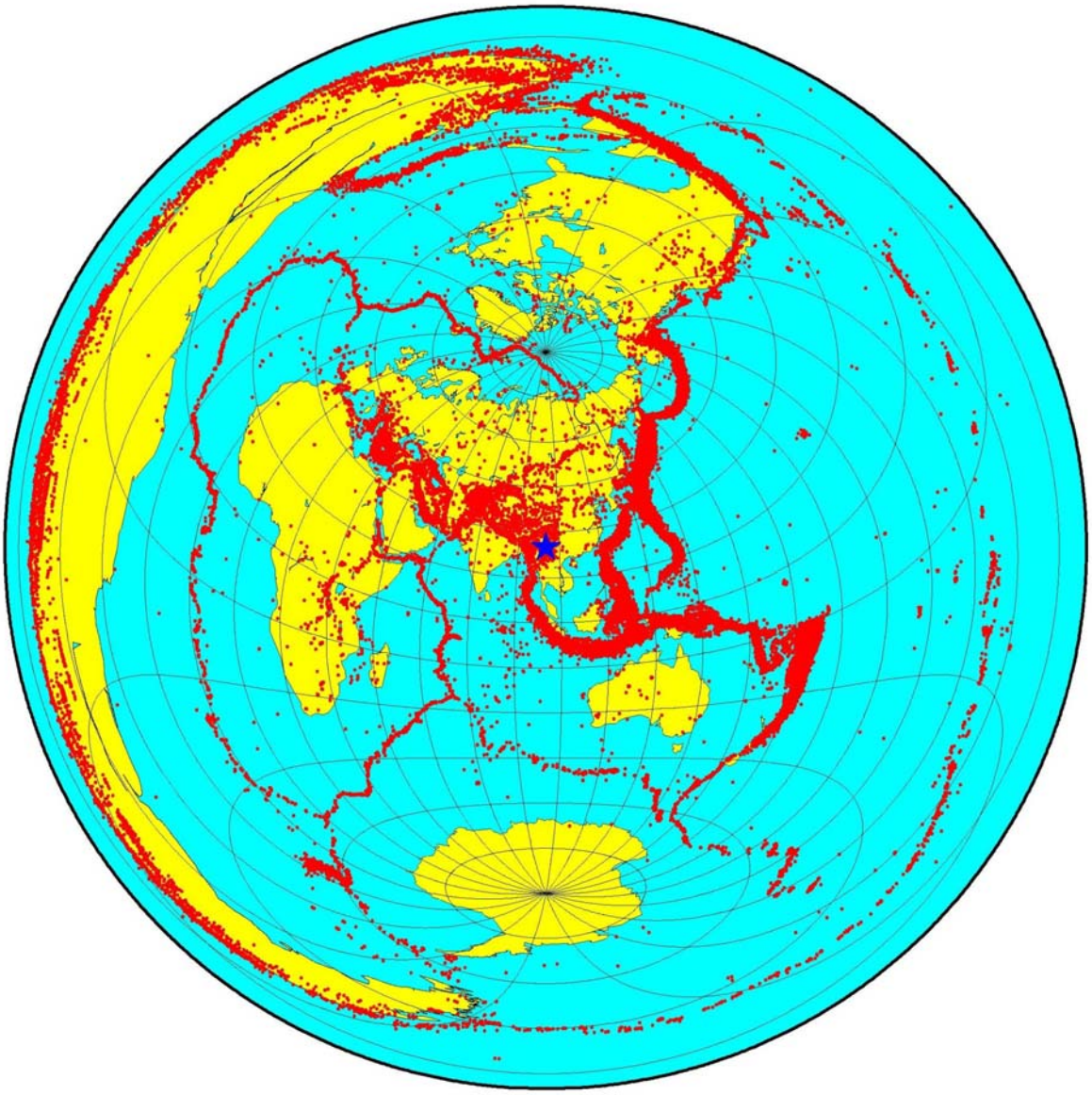

Figure 2. Yunnan province (the blue star in the middle) and its relative position to other strong seismic zones in the world. The small red dots are seismic activities in the world (United States Geological Survey data).

RESEARCH ACCOMPLISHED

All the instruments except at one station are deployed alongside the existing short-period analog seismic stations of the Yunnan Seismological Bureau. The instruments are installed in vaults that are typically 30 m deep extending horizontally into the hillside. Since these piers were usually built professionally by seismological standards, the data quality of this deployment is, on average, very high. The local provincial bureaus provide support for security and maintenance of the instruments. The deployment and data collection ends at the end of June of 2002.

At the present stage of research, the data are being routinely processed. Our analysts are screening all the waveforms recorded and constructing a ground truth database. Basically, the database consists of the waveforms of three kinds of events: small to moderate local/regional earthquakes, industrial explosions, and moderate to large earthquakes at teleseismic distances.

Local Earthquakes

Several moderate local earthquakes occurred during our experiment. After such an event, the Yunnan Seismological Bureau usually dispatches exploration teams to do an on-site geological and geophysical survey. Therefore, they provide excellent ground truth information. Figure 3 is the vertical waveform recorded across our network for a M=5 earthquake at Jinggu on September 4, 2001. The epicentral distances to the stations in our network are from 50 km to 400 km.

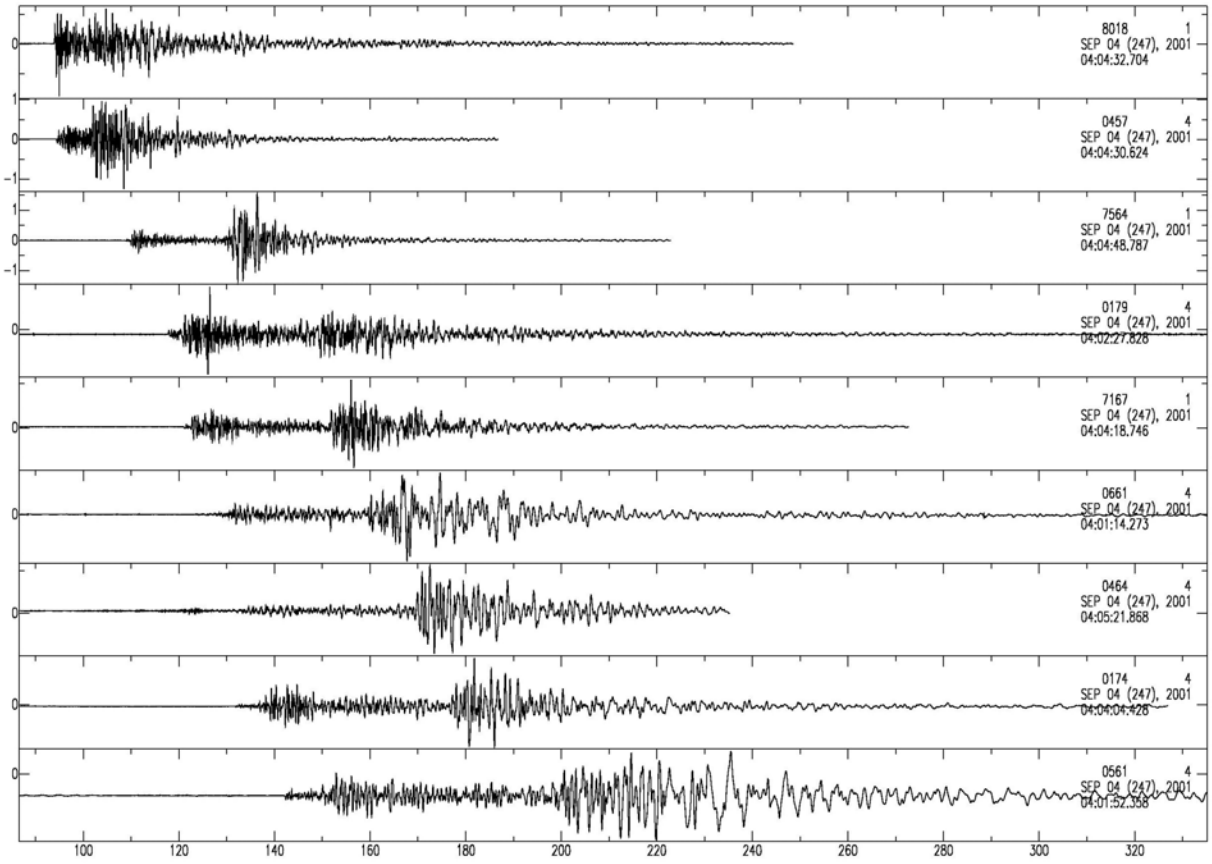

Figure 3. The vertical component of the waveforms of the September 4, 2001, Jinggu earthquake recorded across the network. The epicentral distances to the stations in our network are from 50 km (Lincang, the top trace, to 400 km, Ninglang, the bottom trace).

Screening of Industrial Explosions

The provincial earthquake catalog, compiled on the recordings from the high-density short-period analog seismic network in Yunnan province, as well as the provincial digital seismic network of 23 broadband stations, is a complete list of all the earthquakes with magnitude greater than 1 in Yunnan and its proximity. Of all the 4,144 waveforms we have processed so far, about 923 among them could neither be associated with any earthquakes in the catalog nor be associated with any other events in the global PDE catalog. Figures 4 and 5 show two examples of

such waveforms. These events are most likely to be the local and regional industrial explosions that need to be studied further.

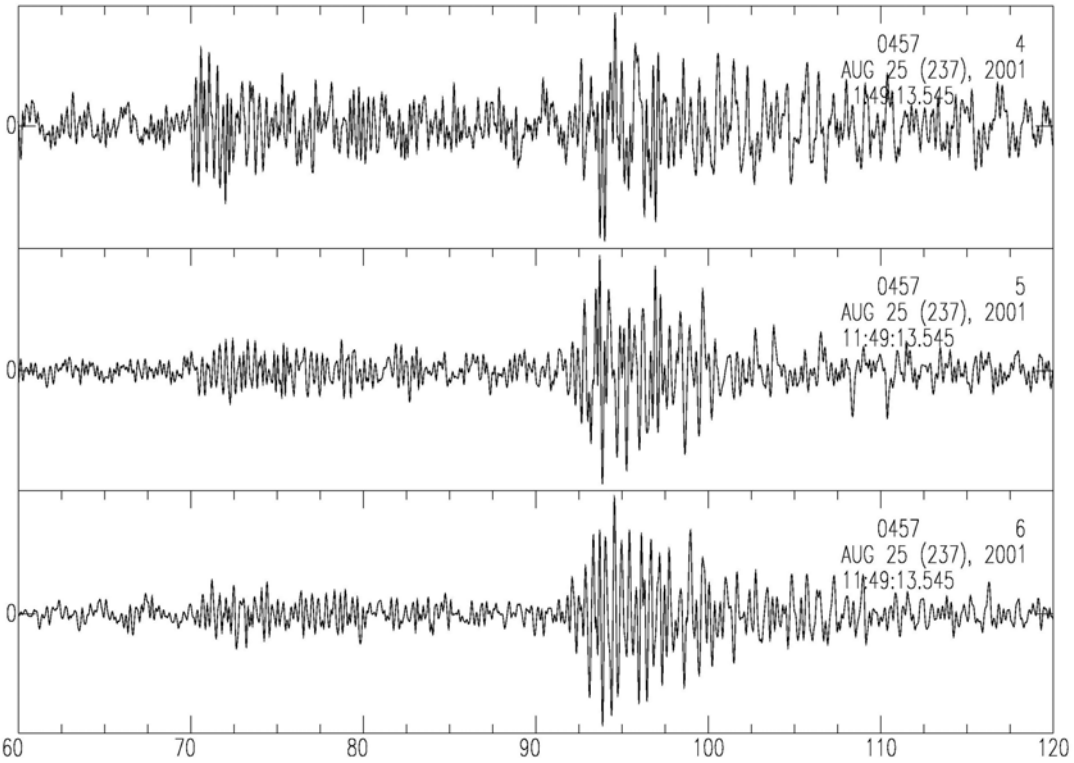

Figure 4. An example of waveforms of a potential industrial explosion recorded at station Zhenyuan.

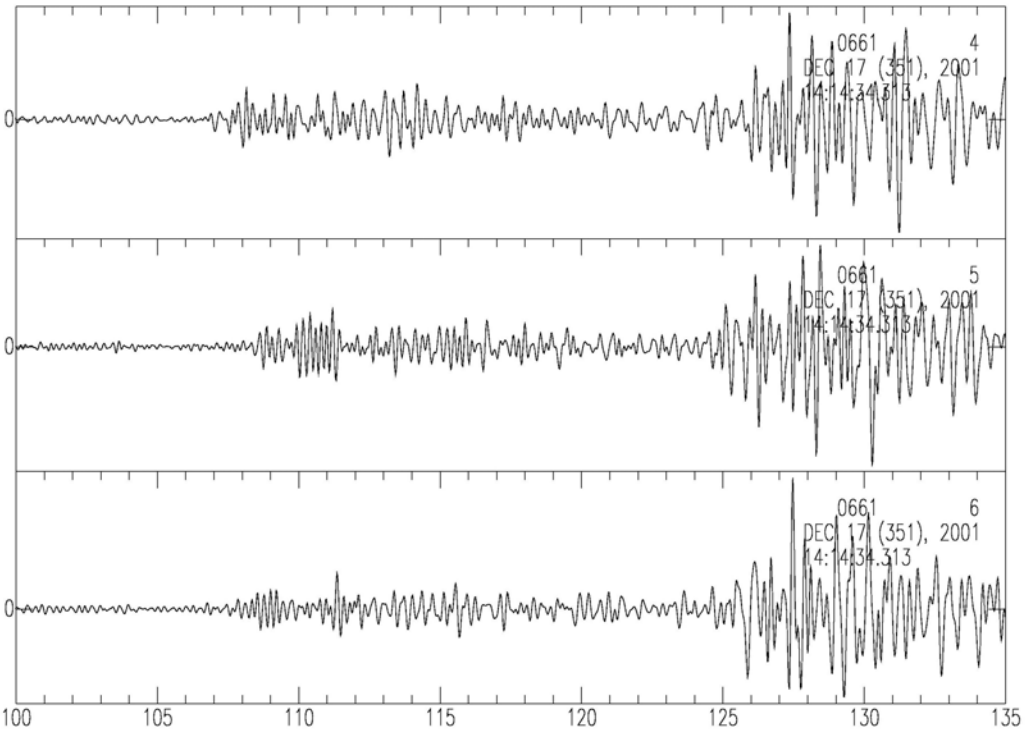

Figure 5. An example of waveforms of a potential industrial explosion recorded at station Mengla.

Moderate to Large Earthquakes at Teleseismic Distances

Moderate to large earthquakes in the world are routinely recorded, including the November 14, 2001, Ms=8.0 Qinghai, China, earthquake; the December 18, 2001, Ms=7.3 Taiwan earthquake; the September 11, 2001, Ms=6.4 Iranian earthquake; the October 12, 2001, Ms=7.3 Mariana earthquake; the January 2, 2002, Ms=7.6 Vanuatu Islands earthquake; and the March 3, 2002, Ms=7.2 Hindu-Kush earthquake, etc. These waveforms are valuable for studying wave propagation along the paths from southwest China to many interesting regions in the world, as well as for studying the source mechanism of large earthquakes. Figure 6 shows the waveforms of the October 12, 2001, Ms=7.3 Mariana earthquake recorded at the network.

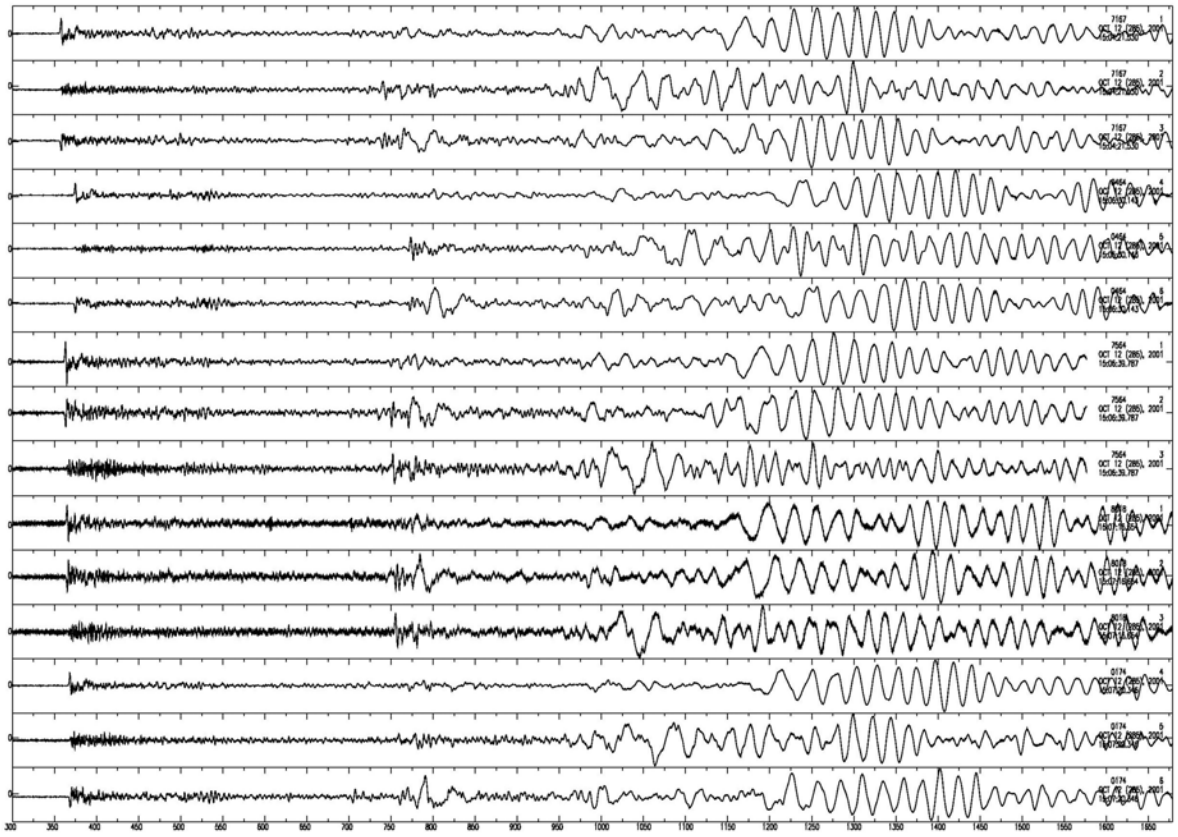

Figure 6. The waveforms of the October 12, 2001, Mariana earthquake recorded at the network.

CONCLUSIONS AND RECOMMENDATIONS

The Yunnan broadband seismic experiment is very successful. A high-quality, unique database of waveforms recorded in this experiment has been building up. In the database, there are basically waveforms of three kinds of events: small to moderate local/regional earthquakes, industrial explosions, and moderate to large earthquakes at teleseismic distances. A screening of the waveforms shows that more than 20% of the events could be industrial explosions. This database includes tremendous ground truth information and provides excellent opportunities for studying regional wave propagation, seismic source discriminants, and active tectonics in the eastern portion of the Tibetan Plateau and seismic hazard reduction in the Yunnan area.

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