NOTES

A NOTE ON THE 26 DECEMBER, 2004 GREAT SUMATRA EARTHQUAKE

Main Shock — NGRI Seismic Stations

National Geophysical Research Institute (NGRI), Hyderabad is operating broadband seismic stations in different parts of India. The stations are equipped with latest generation seismometers with high sensitivity like CMG-40T, CMG-3ESP. The data acquisition systems have high dynamic range (144dB), achieved by a 24-bit digitizer and recorded at 100 samples per second. This earthquake was recorded at Hyderabad, Cuddapah, Kothagudem, Naldrup in southern peninsular India, at stations of Tezpur seismic network in Northeast India and at stations of Koyna seismic network in Western India. Surface waves are clipped at most of the stations (except at Kothagudem and Cuddapah where the seismometer is CMG-40T), which did not allow us to estimate earthquake parameters using surface waves. The nearest NGRI seismic station to record this event is at an epicentral distance of about 2230 km. Waveforms recorded at NGRI seismic stations are shown in Fig. 1.

Estimation of Moment Magnitude from Amplitudes of Filtered Velocity Traces

The Moment magnitude (Mw 8.6) is estimated using the broadband seismic waveform data recorded at Kothagudem. Singh and Pacheco method (1994) was used to compute long period magnitude (Ml), which is equivalent to Mw. The magnitudes estimated by this method are found to differ by 0.2 units for large and moderate earthquakes. In this present study the waveforms are band passed in 0.03 to 0.08 Hz range. The estimated magnitude (Mw=8.6) found to be reasonable keeping in view the reported magnitudes varying from 8.2 to 9.0 by different international organizations. The difference in reported magnitudes by different agencies is normally due to using different wave groups like Rayleigh waves, mantle waves and method of estimation.

Aftershocks

Seismological Observatory (HYB) operated by National

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Fig. 1. Magnitude 9.0 Earthquake Off west coast of Northern Sumatra 2004 December 2600:58:50 UTC Recorded at seismic stations of National Geophysical Research Institute

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Geophysical Research Institute, Hyderabad, is about 2420 km NW of the epicenter. This observatory is equipped with 3 matched short period (1 sec and 100 K gain) Benioff Seismometers and 3 matched long period (15 sec period and 1500 gain) Press & Ewing Seismometers recording on photographic paper is in continuous operation since December 1967.

With this standard of sensitivity, any earthquake of magnitude 5.0 and above from the above region is well recorded. More than 200 aftershocks of magnitude >5.0 were recorded at Seismological Observatory, Hyderabad till 05 January 2005 00:00 hrs GMT. Detailed classification is given below.

<table>
<thead>
<tr>
<th>Magnitude range</th>
<th>No of events</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0 to 5.9</td>
<td>186</td>
</tr>
<tr>
<td>6.0 to 6.9</td>
<td>16</td>
</tr>
<tr>
<td>7.0 to 7.9</td>
<td>1</td>
</tr>
</tbody>
</table>

International agencies like United States Geological Survey (USGS) and European Mediterranean Seismological Centre (EMSC) display preliminary epicentral details in near real time in their web sites for scientific research/alert purpose. The bulletins from both the agencies were collated and a (homogeneous) preliminary epicentral catalogue of aftershocks from the above region was prepared for guidance. Repetitions and doubtful locations were eliminated while preparing this catalogue.

Expected arrival times for P and S phases for all the aftershocks in the catalogue were computed and verified in the seismograms of Hyderabad Seismological Observatory (HYB). However, because of the limitations in reading of analog seismograms after such a big event, like mixing of traces, some of the aftershocks in the catalogue could not be distinguished during the first two days. Hence the total number of aftershocks reported by Seismological Observatory, Hyderabad is fewer than the total number of aftershocks.

Earthquake Source Parameters

Reported focal mechanisms from agencies like Harvard, USGS, and CPTP along with the location of the main event are shown in Fig.2. The focal mechanism for the main event by the above agencies shows thrust faulting, excepting a minor strike-slip component in USGS moment tensor solution. The focal mechanism basically depicts a thrust fault with movement on NW-SE trending fault plane with strike 329°, dip 8° and slip 110°.

Rupture Process

The source process of Great Sumatra earthquake in Fig.3 by Jose et al. (2005) using 29 teleseismic P waveforms recorded at IRIS-DMC stations suggests, dominant rupture azimuth (φ = 281°±12°) and the rupture velocity (Vr = 1.2±0.2 km/s) with bilateral rupture, towards NW.
The rupture process was explained in three stages with a total duration of 210 secs. The rupture propagated about 200 km to the northwest from hypocenter during the first 45 secs in the first stage. The next two stages started about 80 sec and 135 sec after the initial rupture. The second rupture propagated northwestward with 400 km long and the final rupture towards southeastward with 350 km long.

The source process of the Great Sumatra earthquake as shown by Yuji Yaig (ISEE, BRI, 2004) suggests that the process occurred in two stages (Fig.4). In the first stage the rupture mainly propagated about 300 km to the northwest from hypocenter during initial 100 sec. The second rupture started about 100 sec after initial break, which generated ultra long period seismic wave. This may imply that slow and large dislocation occurred in the second stage.


References


