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Source characterization of the 2007 Java intermediate-depth earthquake: Rarely large slip preceded by small moment release

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Beneath subduction zones, many earthquakes occur at deep portions (depth ~60-700 km) where simple brittle rock failure cannot be predicted due to high pressure and temperature. The physical mechanism of such earthquakes remains mysterious. For the occurrence of intermediate-depth earthquakes (depth ~60-400 km), some hypotheses including dehydration embrittlement and thermal instability have been proposed, but the hypotheses have not been diagnosed enough to answer how they can cause dynamic rupture of earthquakes as observed. To resolve the problem of the physical mechanism of intermediate-depth earthquakes, we should search for some clues in observing their rupture characteristics regarding initiation, triggering, and growing of earthquake rupture as well as slip distribution.

A rare and large earthquake of Mw7.5 occurred on 8 August, 2007 beneath Java, Indonesia at a depth of about 300 km. Activity of intermediate-depth earthquakes generally decreases with depth, and the rate becomes the minimum at depths around 300 km. Since large earthquakes also tend to be infrequent around 300 km, we have few chances to observe what dynamics of rupture occurs there. In this study, we show the rupture characteristics of the rarely large Java earthquake, based on analysis of teleseismic waveforms recorded by the global and Japanese networks. The global waveform data were retrieved from the IRIS DMC. The point-source moment tensor solution obtained from the P waveforms is characterized by down-dip tension, having nearly vertical and subhorizontal nodal planes that approximately strike in the east-west direction. The solution is in good agreement with the Global CMT solution. The P waveforms show that a large and simple P pulse is preceded by small seismic energy. Since the small energy is observed, irrespective of station azimuth and distance, it should be caused by the earthquake source process. The small energy arrives about 6 to 10 seconds before the large P pulse of the mainshock. The difference of arrival time between the precursor and main pulse tends to be shorter at the stations to the west. At almost all stations, polarities of the precursor are the same as those of the main P pulse. The small seismic energy of the precursor is coherently observed over the Japanese high-density seismic network (e.g. F-net).