Earthquake Scaling of Small Earthquakes observed at the Western Nagano Deep Borehole, Central Japan

Stork A.L.[1], Kazutoshi Imanishi[1], Hisao Ito[2]

[1] AIST, [2] Geological Survey of Japan

The scaling of earthquake source parameters for small earthquakes has been the subject of much debate and is still unresolved. In this work the phenomenon has been investigated using data recorded at the borehole in western Nagano, central Japan. Recordings of shallow, nearby earthquakes by the three component seismometer, situated at a depth of 800m, show less attenuation and higher frequency components of the seismic waves than surface recordings. Therefore a more accurate investigation into the source parameters is possible. Waveform analysis was conducted in the frequency domain for more than 100 events with magnitudes between -0.8 and 3.2 for events with hypocentral distances less than 15km. The objective was to determine the scaling relationships between stress, seismic moment and radiated seismic energy. The spectra were fitted to an omega square source model (Aki, 1967) to establish the corner frequency and quality factor, hence enabling the determination of source parameters.

So far, this investigation has shown that there is an almost constant stress drop with seismic moment. Almost all the earthquakes have stress drops between 0.01MPa and 10MPa with only a slight decrease in static stress drop with seismic moment and no minimum source radius. The apparent stress decreases with the radiated seismic energy. The fall off in apparent stress with energy appears to occur below seismic moments of around 1011Nm. This is the case even when the energy is corrected for the miscalculation due to finite bandwidth recording (Ide and Beroza, 2001). This result is in agreement with the conclusions of Abercrombie (1995) and Prejean and Ellsworth (2001). The static stress drop (SD) and apparent stress (AS) have a nearly constant relationship with AS ≈ 0.3 SD. The stress drop and apparent stress both seem to fall off with hypocentral distance for events occurring further than 4km away for M less than 1.0 and further than 10km away for M greater than 1.0 giving results of smaller radiated seismic energies and smaller seismic moments.

These results indicate that the observed relationship between apparent stress and seismic moment is a consequence of the inclusion of data with hypocentral distances larger than 10km. Therefore I suggest that it may be necessary to consider path effects in this region, even for relatively clean borehole recordings, unless the hypocentral distances are very small. Studies conducted on data from other areas may also need to include such effects to obtain more accurate results. To determine the actual relationship between apparent stress and seismic moment it will be necessary to study more small earthquakes with hypocentres within 10km of the borehole and also to try and eliminate any path effects contaminating the results.