Seismic Scaling Law and Tectonic Conditions Implied from Two Recent Japanese Earthquake Sequences (Mw6.6)

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We investigate the seismic scaling relationship of seismic moment (Mo) versus corner frequency (fc) in relation to seismic activity using two Japanese earthquake sequences, the 2004 mid Niigata prefecture earthquake (MNPE) and the 2005 west off Fukuoka prefecture earthquake (WOFE) sequences. Both of the earthquakes have the same moment magnitude, Mw6.6. The MNPE produced a large number of aftershocks including six events with Mw5.5 or greater over a period of about two weeks. On the other hand, the WOFE sequence did not produce aftershocks that exceeded Mw5.5. The sum of moment released from the aftershocks (Mw3.5 or greater) during forty days after the main event was 6.19x10^{18} Nm for the MNPE sequence and that for the WOFE sequence was 2.17x10^{17} Nm. These moment releases are equivalent to about Mw6.5 and Mw5.6 events, respectively.

To estimate fc's of earthquakes, we develop a spectral ratio method based on the conventional method. Here, we use broadband waveform data of events which are located within about 16 km from the mainshock epicenter and recorded at common stations in an attempt to avoid the effects of near surface heterogeneities. We take the ratio of spectra averaged at four common stations for a pair of a large and a small event. When the ratios are taken, structural and attenuation effects along the propagation paths, and radiation patterns are averaged and minimized.

In the Mo - fc relation obtained from the MNPE sequence, the fc's tend to decrease with decreasing Mo between Mw3.5 and 6.6 and the stress drop is in the range of 0.1 to 10 MPa. The best fit line determined in a least squares sense has a relation of Mo proportional to $fc^{-3.41}$. The small events were sorted into five groups. The fc's of small events (Mw3.5 to 4.0) of the MNPE sequence that occurred in groups 3 and 4 (associated with the major faults) appear to be higher than those in groups 1, 2, and 5 (located off the major faults). The scatter in the narrow range of Mw may suggest the variation of radiated seismic energy of small events, and deviation from an omega-square model that is based on the assumption of constant rupture velocity. In the WOFE sequence, the stress drop is from 1 to 10 MPa and the best fit line has a relation of Mo proportional to $fc^{-3.06}$ in the same Mw range. The fc range of small aftershocks is lower in the MNPE sequence than in the WOFE sequence. In the MNPE sequence which took place in the area of a complex fault system, the small events occurred in the complex process of stress redistribution. We suggest that there is difference (or variation) in the scaling relation even in the same Mw range, probably reflecting different tectonic or seismogenic conditions.