Critical length of nucleation zone and breakdown displacement estimated from slow initial phase

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It is reported that initial phase can be observed in seismograms. Iio (1992) defined convex downward curve at first arrivals as slow initial phase. Ellsworth and Beroza (1995) also defined violating seismograms with low rate of moment release as seismic nucleation phase. On the other hand, some models were proposed, but they were not verified with enough quantity. Some models were verified quantitatively, but initial phase was dealt without clear definition. In this study, we try to explain initial phase quantitatively with clear definition. For this aim, we use seismogram recorded at 800m deep borehole in Western Nagano installed by AIST. Velocity sensors are installed in the borehole, and seismograms are sampled with 10kHz.

Shibazaki and Matsu'ura (1998) pointed out that theoretical seismogram expected from slip dependent law has slow initial phase. Iio (1992) revealed that slow initial phase is not originated path effect but source effect, but it is affected by path effect to some degree. In this study, we obtained moment rate functions by deconvolution with attenuation parameters in Western Nagano reported by Ito (2004, this meeting). Next, we estimate stress drop and seismic moment released during unstable, accelerating phase in slip dependent relationship, and obtained them for 28 earthquakes of which magnitude range is 1e+10Nm to 1e+13Nm. And, we evaluated fault dimension of unstable, accelerating phase; the critical size 2Lc of the nucleation zone. The critical size 2Lc of the nucleation zone is proportional to power of 1/3 of seismic moment, and it can explain the theoretical formula proposed by Ohnaka (2000). Moreover, we estimated the critical slip displacement Dc with theoretical relation by Ohnaka (2000). The critical slip displacement Dc is proportional to power of 1/3 of seismic moment, and it also can be explain the theoretical formula proposed by Ohnaka (2000).

It is suggested that rupture process of earthquakes is controlled by slip dependent law because the relationship between the critical size 2Lc of the nucleation zone and the critical slip displacement Dc and seismic moment is consistent with scaling law expected from slip dependent law. The results of this study obtained with slow initial phase is consistent with the results by Ohnaka (2000) with seismic nucleation phase by Ellsworth and Beroza (1995). This means that slow initial phase and seismic nucleation phase is the same phenomenon in the macro scale. However, the results with seismic nucleation phase are relatively more perturbed than that with slow initial phase. This difference can be explained with quality or variety of data. But, it is possible that seismic nucleation phase is produced by not uniform distribution of asperities on a fault plane.