Scaling relations of moment magnitude and rupture area for intraslab earthquakes

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Intraslab earthquakes that occur in the subducting slab have different source characteristics compare to those earthquakes that occur in the subduction interface. The systematic difference of fault rupture area between intraslab and interface events has been revealed by previous studies of scaling relations for fault rupture area and moment magnitude (Strasser et al.,2010). Such kind of difference has been supported by a later study by Allen and Hayes 2017 which only uses finite fault models in regression analysis. In the study of Strasser et al.,2010 and Allen and Hayes 2017, all data for intraslab earthquakes have complied in a single data set even though source characteristics might also be different between shallow and intermate depth intraslab earthquakes (Satatani et al., 2006). Recent years, more and more finite fault models for intraslab earthquake have been published online which make the discussion of the difference in centroid depth possible. In this study, we compile a data set of fault parameters from 56 finite fault models corresponding to 47 intraslab earthquakes. The fault dimension of each model has been estimated using effective length and width (Mai and Beroza 2000) based on the definition of the autocorrelation width (Bracewell 1986). As in previous studies, averaged effective length, width, and moment magnitude were taken for earthquakes with multiple models. Based on the circular crack model (Kanamori and Anderson 1975), we also calculated the averaged stress drop for each pair of fault rupture area and earthquake magnitude. The results of stress drop show 8 earthquakes have very low stress drop (less than 2MPa). By reviewing the slip distribution of those earthquakes, we noticed the slip of those earthquakes are widely distributed and most of them have multiple slipped areas. Since the distribution of slip of these earthquakes is different from the others, they should be considered in different scaling relations. By visualizing the distribution of centroid depth and Stress drop, we found that there is a gap at a depth around the depth of 80km. In the depth shallower than 80km, the stress drop increase with depth, and in the depth deeper than 80km, although the deviation is larger, generally the stress is independent with depth (Fig 1a). Based on the analysis shown above, scaling relations divided by a centroid depth of 80km is obtained (Fig 1b). The average stress drop for the deeper earthquakes is roughly double the number for shallower earthquakes. The difference of the stress drop of earthquakes at different depths is a result of a complicated combination of the physical properties of materials such as the coefficient of friction of the fault surface, elasticity, viscosity of surrounding rocks, and the forces applied by the bending of unbending of the slab, dehydration, and buoyancy. Although the detail of these factors is still unclear to us and further discussion is beyond the scope of this study, the result of the study shows that the depth dependence of stress drop needs to be considered in the scaling relation for intraslab earthquakes.

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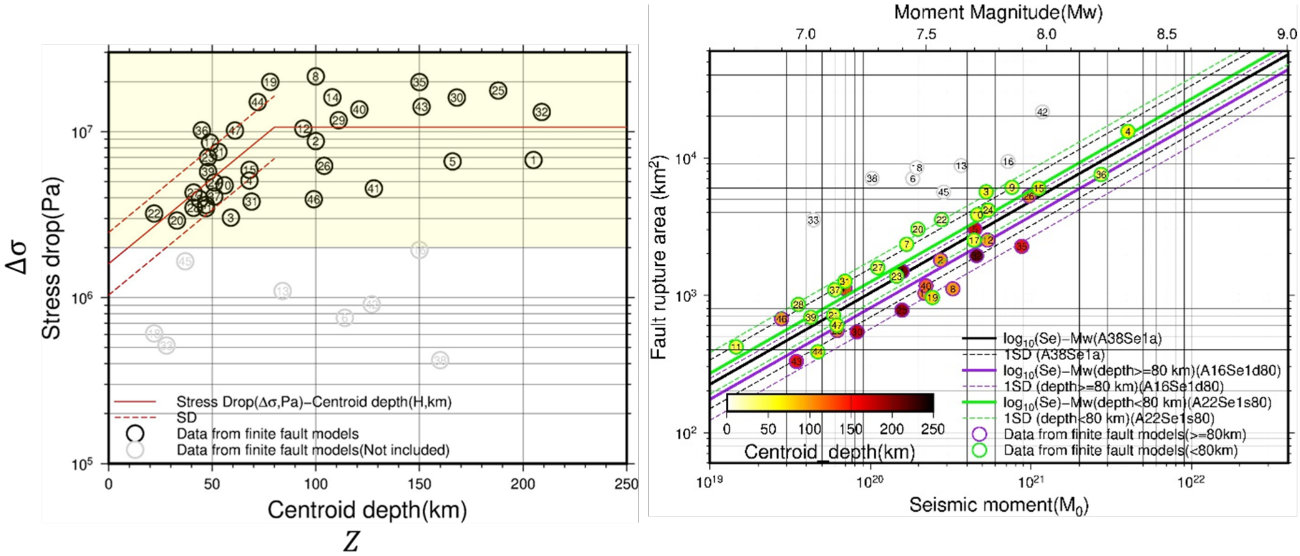

Fig1. (a)Black circles show the relationship between stress drop and Centroid depth. The red solid line and broken line at a depth shallower than 80km are the regression line and standard error derived from data, respectively. A Red solid line at a depth deeper than 80km indicates the averaged stress drop. (b)Solid lines show the scaling relation for moment magnitude and fault rupture area for intraslab earthquake The fill color of circles shows the centroid depth for earthquakes. Gray circles show the magnitude and fault rupture area of those earthquakes whose stress drop are smaller than 2MPa. These earthquakes are not used in the regressions. Green and purple circles are the earthquakes whose centroid depth is shallower and deeper than 80km, respectively. Green and purple lines are the regression lines for the data with the same color. The black line is the regression line for all data except for the gray circle.

