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Looking into the gouge layer within a fault under stresses by transmission waves — the effect of particle size distribution

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We are now performing a laboratory experiment in which elastic waves are transmitted across a fault with a gouge layer under normal and shear stresses until a final stick slip occurs.

So far, we have used the quartz sand with a diameter between 150 and 250 microns as the gouge layer. This time, we made an artificial quartz sand gouge layer which has a self-similar particle size distribution with a fractal dimension of 2.6. The upper and lower fractal limits are 250 and 30 microns, respectively.

We found that a considerable difference between the two kind of gouge layers is seen in the process of gouge layer compaction: the gouge layer with a fractal size distribution exhibits thicker compaction of the gouge layer, that is a larger subsidence of the upper block. The porosity of the gouge layer reduces from 44 % to 30 % after the compaction. Further, the curve of subsidence is very smooth, which suggests that the small particles in the gouge layer enhances the mobility of the gouge layer. In this sense, small particles play a key role in the compaction process.

However, the sliding experiments performed after the compaction of the fractal gouge layer showed quite similar results as the experiments using the gouge with 150-250 microns particle distribution: there existed a precursory slip and a large dilatancy prior to a final stick-slip. Moreover it was also observed that the transmission waves were significantly attenuated during the precursory slip. As was shown by a DEM simulation, these phenomena are attributed to the columnar structures selectively developed by large particles in the gouge layer. In this sense, large particles play a key role once a shear force is applied to the gouge layer.