# ERI Research Report

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While visiting at ERI (from 1 December 2013 to 28 February 2014), I have been working on developing physical models that, based on available data from friction experiments in laboratory, could provide a better understanding on the particle-size distribution in friction of granite and velocity-weakening mechanisms at earthquake slip rates. At the same time, an up-to-date review has been made on the advance related to fractal studies in volcanology. The preliminary results are briefly summarized as follows.

*On the steady-state fractal size distribution of fragments*: The statistical analysis was performed on fragments collected from friction experiments of granite. It is shown that the steady-state particle-size distribution follows a power law with an exponential cut-off, in which the exponent or fractal dimension is about 2.2. According to the dimensional analysis, we showed that fragmentation during friction of granite can be considered as a self-similar collision cascade process. A weakness plane model without solid pillars was proposed for a renormalization group approach to fragmentation, and the estimated fractal dimension is well consistent with experiments. The possible implications for underlying mechanisms of fault weakening were also discussed.

*On identification of rate-dependent friction models*: The steady-state friction coefficients were measured for granite, chromite sand and glass beads at a wide range of sliding velocities up to earthquake slip rates (O. Kuwano and T. Hatano, *GRL*, 2011; O. Kuwano *et al.*, *GRL*, 2013). In terms of the log-likelihood analysis and Akaike information criterion, we compared several models such as the rate-and-state dependent friction, quadratic, and flash heating and weakening laws. It is shown that flash heating of asperities is just one of the most possible reasons that induce the velocity-weakening behaviour at earthquake slip rates. There is still lack of a consensus on the intrinsic weakening mechanism. Further analysis will be carried out by using available testing data in publications. It is also worth noting that, similar to the fault gouge dynamics or stick-slip behaviour in an earthquake spring-block model, multiple interactions of shear and friction were also observed in high-speed cutting.

*On fractals in volcanology*: A brief review has been made on fractals in volcanology. The main contents include an introduction on fractal and multi-fractal, fractal features of volcano morphologies, fractal distributions of mineral depositions, vesicles and pyroclasts, and fractals in magma fragmentation and eruptions. If is of interest to mention that there are many similarities between magma fragmentation and fracture, induced by the nucleation, growth and coalescence of numerous bubbles and cracks, respectively. Here we focus our attention to implications of these findings for mechanics of volcanic eruptions and volcanism.

So in sum, I have had a very fruitful stay at ERI. One paper on the self-organized dynamics in high-speed cutting has been submitted to *Physical Review E* and other papers relevant to the abovementioned research topics are in preparation. Here I would like to thank my host researchers, Prof. Takehiro Koyaguchi and A/Prof. Takahiro Hatano, once more for their kind reception and insightful discussions, and also Ms. Yuka Ijuin and her colleagues at the international office for their hospitality and assistance.