The Role of Grain Fragmentation During an Initial Seismic Slip

Powders generated by fault surface comminution together with frictional melt play an important role in controlling the fault strength during an earthquake

During a major earthquake, frictional heat generated by the rapid slip of fault surfaces (velocity > 1 m/s) can trigger numerous physicochemical processes. These processes have been experimentally and theoretically identified as dynamic weakening mechanisms that can significantly decrease the fault strength;[1] for example, flash heating and weakening triggered at initial faulting[2] and melt lubrication occurred after a large slip.[3] The transition between these two weakening mechanisms, however, remains unclear. More relevantly, how the associated products derived from both surface comminution and frictional melting influence the fault strength during a fault rupture is not well constrained.

To address the issue, Li-Wei Kuo's team (National Central University) performed high-velocity rock friction experiments on granitic gneiss using a rotary shear apparatus. The experiments were conducted in various slips to cover the triggered processes, including the flash heating and weakening and melt lubrication. Interestingly, the frictional behavior between the flash heating and weakening and the melt lubrication shows a strengthening trend (faults become strong) that was derived from the combined effect of comminution products and frictional melts. Traditional micro-analytical instruments (*e.g.* optical microscope and scanning electron microscope) show similar results of a distribution of particle size, but this distribution obtained from both optical and electron microscope methods was calculated from the exposed surface of the polished particles. With the highly penetrating synchrotron technique and great spatial resolution, the solidified melt matrix becomes non-destructively observable with resolution to 50 nm, which might be relevant to the observed slip behaviour in a transition. In this research, Kuo's team and Chun-Chieh Wang (NSRRC) used a synchrotron transmission X-ray microscope (TXM) at **TLS 01B1**[4] to obtain two-dimensional radiographic images of survivor grains (**Fig. 1**). Those images were further used to determine the particle-size distribution (PSD) of the survivor grains embedded in bulk samples (**Fig. 2**). Based on these results, the team found that the intact shape and number of survivor grains varied significantly in four distinct states. Abundant ultrafine angular quartz grains were also observed at an initial slip. With an increase of slip, ultrafine quartz grains within the solidified melts became fewer and their shapes altered from angular to spherical. This shape change of quartz grains was proposed to result from partial melting at the sharp edges of the angular quartz grains because of their large surface areas (Gibbs-Thomson effect). Importantly, pervasive partial melting of quartz seems to affect the chemical composition of the melts (increased melt viscosity), which agrees satisfactorily with the chemical data obtained from the solidified melt ma-

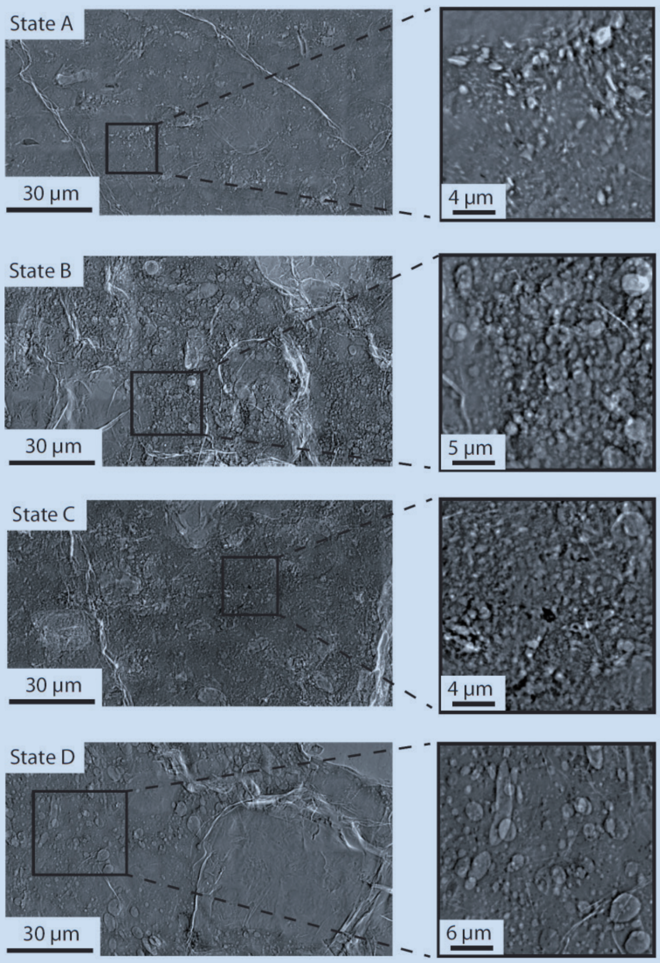

Fig. 1: TXM images of solidified frictional melts in four states. Internal microstructures all show substantial ultrafine quartz grains with sub-angular and angular-to-spherical, and ellipsoidal, shapes surrounded by a melt matrix. [Reproduced from Ref. 5].

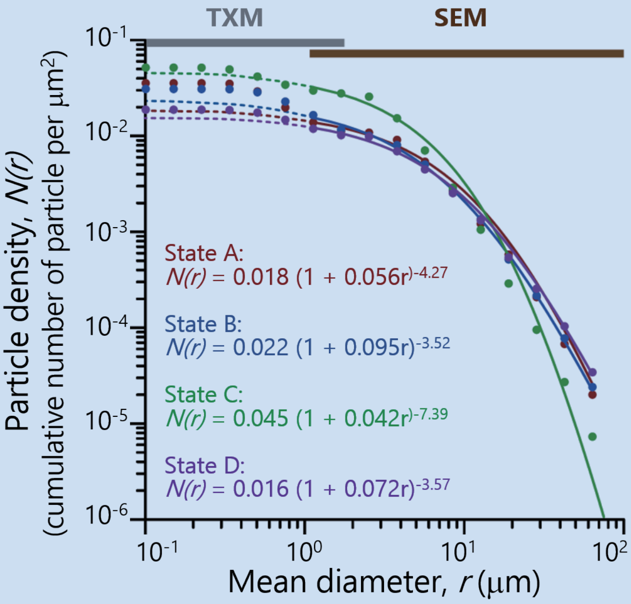

Fig. 2: Distribution of particle size of surviving grains within a melt matrix in four states. [Reproduced from Ref. 5.]

trix. They hence suggested that grain fragmentation during an initial seismic slip affects the melt rheology and transiently increases the fault strength, confirmed with TXM on solidified melts.

In summary, the utilization of a synchrotron TXM improved the understanding of the role of grain fragmentation and its associated products during an initial seismic slip. The additional fragmented grains generated from surface comminution might hamper an initial fault slip by increasing the viscosity of the frictional melt. Most importantly, this fault-strengthening behavior becomes noticeable at smaller depths, which demonstrates that pseudotachylytes might not always be an indication of fault lubrication (Reported by Li-Wei Kuo, National Central University, and Chun-Chieh Wang).

*This report features the work of Li-Wei Kuo and his collaborators published in J. Geophys. Res. Solid Earth **124**, 11150 (2019).*

TLS 01B1 SWLS – X-ray Microscope
- TXM
- Geosciences

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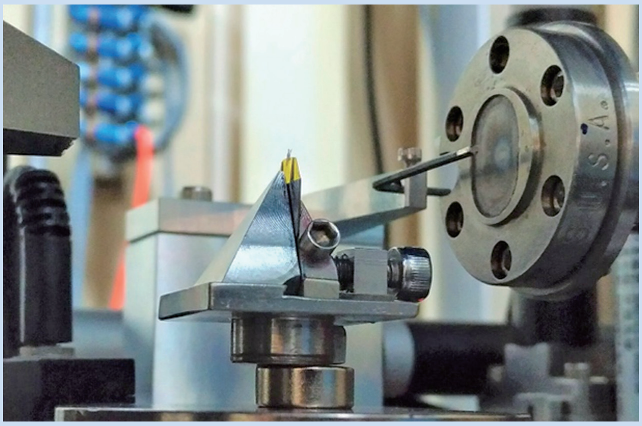

TLS 01B1 SWLS – X-ray Microscope.

What Is to be Expected in a Contaminated Area?

When an agricultural area is located in the vicinity of a steel factory, the nature of arsenic retention by soil must be identified.

Several metals and metalloids are physiologically essential for living organisms as trace elements (TE), but, when present in excessive concentrations, they might have harmful effects for human beings, animals, plants and microorganisms. In most cases, high soil levels of TE derive from particular industrial activities; industrial areas are hence commonly known for their high level of contamination. These areas are typically contaminated with multiple elements, some of which are insufficiently monitored, because they contain elements that are rarely studied. Such elements include V, Mo, Se, Ag, Sn, Sb and Tl, whereas other elements such as As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn are more often studied. In Greece, there are a few known contaminated areas, located mainly around former mining exploration