Surface and internal textures of clasts in incohesive fault rocks and their significance

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Fault rocks are classified based on the fraction of clasts (visible under naked eyes) and fine-grained matrix (e.g., Sibson, J. Geol. Soc. London). Studies on clasts are important at least for the following three purposes. First, clasts must have formed by fracturing of host rocks and/or old cohesive fault rocks during their formation and past movements, and hence clasts may provide us with old fault rocks and may yield information on deeper parts of fault zones. Second, clasts must have undergone series of physical and chemical intrafault processes and might give clues to recover some of those processes. Third, comparison of surface and internal textures of clasts with those of borehole cuttings may lead to identifying fault zones from the cuttings. Recovering all cores in drilling is very costly and the textural studies on fault-zone clasts may have many practical applications.
Kanaori and his coworkers conducted very detailed SEM (scanning electron microscope) observations on quartz or quartz-rich clasts in fault gouge, collected from more than ten mostly-active faults (e.g., Kanaori et al., 1980, Eng. Geol.). They demonstrated that characteristic surface textures, completely different from those of fresh fracture surfaces, developed on clasts primarily due to dissolution of surface materials. They pointed out that those textures were similar to the surface textures of quartz grains in sediments that had been reported in many publications (note that fault-zone clasts and clastic sediments were exposed to underground water in geological time scale). They classified the surface textures of quartz clasts into 8 types and 4 groups, and proposed a sequence of changes in surface textures with time. The primary target of the work by Kanaori and others was to make rough estimate of timing of fault motion from the surface textures. However, this was not easy and their pioneering work did not progress further.
Present work was motivated from the third purpose listed above. We have not followed the classifications of Kanaori et al, but rather we have intended to study surface and cross-sectional textures of clasts, using all clasts from all parts of fault zones, with broad perspectives. We have studied so far Nojima fault and Arima-Takatsuki Tectonic Line in Japan, and Yangsan fault and Yeongdeok fault in southeast Korea (all granitic fault zones). We have recognized surface textures similar to the orange peel-like and fish scale-like textures of Kanaori and others, but we have not yet confirmed all textures that they have classified. A broken clast from clayey fault gouge in Yeongdeok fault zone exhibits quite interesting internal texture with a broken mineral (probably feldspar) in the center, mantled by thick fine-grained and still-porous fault rock that is rich in phyllosilicates. The texture clearly demonstrates that the surface textures of this clast did not form simply by dissolution of surface material, and there is a possibility that reactions between the clast and matrix formed the fault rock surrounding the clast. If this is the case, such textures may record some physical and chemical processes in fault zones (useful for the second purpose listed above), and we plan to do more detailed work on such textures. Pulverized rock is reported in a wide granitic fault zone along the Arima-Takatsuki Tectonic Line (Mitchell et al., 2011, EPSL). Distinction between clasts and matrix is not always clear in this fault rock and we could observe many fractures in minerals under a SEM. Interestingly, many of those fractures exhibit dissolution textures similar to those of fault-zone clasts and clastic sediments, and old existing fractures in rocks can be distinguished from fresh new fractures from surface textures. All of those textures will be useful in identifying faults from borehole cuttings.

Keywords: fault gouge, fault breccia, drill cuttings

