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Nanograins and carbonaceous film on a fault surface: an example from a fossil megasplay fault in the subduction zone

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Friction on the fault plane controls the behavior of faulting during seismic slip. Recent studies suggest that the frictional process on faults shows scale dependency. It is critically important to observe structures on the fault planes in various scales, especially in smaller scale in the sub-micron range. The roughness on fault planes has long been thought to hold fractal property, however, a recent work observed that a mirror fault plane, when examined up to nanometer-scale, does not obey self-affine roughness. Their observation revealed that the fault surface is coated by grains of several ten nanometers in diameter. In this abstract, we show a detailed observation of a glossy fault plane with striations sampled from drilled core of the Nobeoka Thrust taken by a scientific drilling project, the Nobeoka Thrust Drilling Project (NOBELL).

The NOBELL recovered cores with a total depth of 255 m penetrating the Nobeoka Thrust at 41 m below ground surface. The visual observation of the cores and the wireline log of the borehole clearly differentiate the hanging wall and the footwall. In this study, we analyzed a fault plane just below the Nobeoka Thrust main fault core on which gloss and striation develop using an integrated apparatus of Confocal Laser Scanning Microscope (CLSM) and Atomic Force Microscope (AFM). We also analyzed the sample surface applying Raman spectroscopy, Auger electron spectroscopy (AES) and organic component analysis using CHN coder (Yanaco MT-6).

The sample surface was imaged by the CLSM and AFM in various scale and its topography was obtained. The grains of several tens of nanometers in diameter were observed under the AFM image. This surface shows very flat surface with a hight difference of ~80 nm in the imaged square ten micrometers on a side. The X-Z measurement by CLSM revealed an interface of around 1 micrometer below the surface. The interference fringe was observed at the rim of dark area. These facts suggest that the fault surfece is covered by a thin film approximately 1 micrometer thick. The result of the Raman spectrometry indicates that the glossy fault plane material is rich in carbon. The organic component analysis of handpicked samples reported carbon fraction. Applying the AES, we recognized carbonaceous material on the true surface.

In conclusion, the questioned sample here appears to have been polished with fault frictional process so intensely that the surface grains comminuted to sub-micrometers and then a thin carbonaceous film developed. Such nanoscale structure observations in combination with the geometrical fractal property and chemical and surface analysis could provide further details of dynamic weakening during seismic slip.

Keywords: Nobeoka Thrust Drilling Project, subduction zone, accretionary prism, Shimanto belt, fault weakening, fault mirror