3D microstructural analyses of fault rocks using CT and μCT scanning techniques

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Meso- and microstructures of fault rocks including fault gouge developed in the active fault shear zone can reflect the deformation processes of fault motion and faulting mechanisms (Lin, 2008). Therefore, the study on structural features of fault rocks may provide new insights for understanding the nature of active faults. However, it is difficult to understand the spatial variation of microstructures of fault core zone based on traditional methods using two dimensional images under naked-eye and microscopic observations. Accordingly, it is necessary to develop an analytical method for three dimension (3D) analysis for understanding the spatial variation and internal structures of fault core zone. Computed tomography (CT) apparatus with micro-CT (μCT) accessories is a powerful tool which allows non-destructive 3D X-ray imaging and analyzing the spatial and internal structures within non-transparent objects, mainly determined by variations in density, chemical composition (effective atomic number) as well as thickness (Cnudde, 2005).

In this study, the CT and μCT imaging techniques are exploited to observe the 3D internal structures of a series of representative fault rocks: 1) pseudotachylytes of different origins (melting and crushing), and 2) cataclasitic rocks including fault gouge, fault breccia and cataclasite, by utilizing two types of scanning apparatuses (Bruker microCT, 2014): 1) μCT flat panel (FP), and 2) μCT charge coupled device (CCD). The samples of pseudotachylyte are from Fuyun, NW China (Lin, 1994), Ohsumi, Japan (Fabbri et al., 2000), and Musgrave Mt, Australia (Lin et al., 2005), respectively. The samples of fault gouge were acquired from two typical active fault zones in Japan: The Nojima Fault and Arima-Takatsuki Tectonic Line, SW Japan (Lin and Nishiwaki, 2019). The FP analysis shows that 1) the flow structures within the melting-origin pseudotachylytes are denoted by parallel colored glassy matrix layers with numerous rounded quartz clasts and quartz-filled amygdules which are oriented along the flow layers, and 2) chilled margins are characterized by fine-grained microlites orientated parallel to the margins. The 3D scanning images show that the layering structures developed within the fault gouge and fault breccia zones which are marked by sharp colored boundaries, oriented clasts and fine-grained matrixes. Our results demonstrate that 1) the CCD imaging makes it possible to observe sub-micron and even nano-scale 3D microsturctures fault rocks without destruction, and 2) μCT imaging can be further combined with traditional methods (such as optical microscope and SEM observation) to determine the spatial variations for both the meso- and microstructures and chemical compositions of fault rocks.

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