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Patterns of Clay Minerals Transformation in Clay Gouge, with Examples from Revers Fault Rocks in Devonina Niqiuhe Formation in The Dayangshu Basin

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The role of authigenic clay growth in clay gouge is increasingly recognized as a key to understanding the mechanics of berittle faulting and fault zone processes, including creep and seismogenesis, and providing new insights into the ongoing debate about the frictional strength of brittle fault (Haines and van der Pluijm, 2012). However， neither the conditions nor the processes which clay minerals transformations are well understood. Moreover, understanding of these mineral transformations is required to predict the mechanical and seismogenic behavior of faults. Here, we present a systematic study of clay gouge mineralogy from devonina Niqiuhe formation in the Dayangshu basin, located in the Arong Banner and Oroqen Banner, east of Inner Mongolia, on the east part of Daxinganling orogenic belt. It is in a long narrow shape, with the NNE trending and next to Songliao Basin to the east. Dayangshu Basin experienced multistage deformations, which were characterized by widely develops of fractures (Liu, et al., 2008). Significant differences in clay mineral assemblages and chemical composition were identified in rocks from the fault gouge, through a series of analytical techniques including X-ray diffraction (XRD) and X-ray fluorescence spectroscopy (XRF).

The analysed fault gouge is exposed in the silty mudstone in devonian Niqiuhe formation in the Dayangshu basin. The fault gouge we obtained is dozen centimeters in thickness, and we examined the clay mineralogy of the fault gouge vertical to fault strike and fault plane, the relative samples that obtained by equal interval sampling method were labeled as XY0, XY1, XY2, XY3, XY4, XY5 (Fig. 1). The samples were hand-crushed and grounded to powder, and then the <2 μm fraction was separated by pipetting and deposited on glass slides. Clay minerals in this fraction were identified according to the position of the basal reflections (d_{001}) on XRD patterns of air-dried (AD), ethylene-glycolated (EG) and heated (T) (350° C for 3h) respectively. Chlorite/smectite (C/S) mixed-layer, chlorite and illite minerals were identified and the respective proportion of chlorite components determined according to a standardized procedure (Moore and Reynolds, 1989). Almost all samples include mixed-layer C/S, and illite. Among the samples, the highest chlorite content (>90%) in the C/S is found on the edge of the fault gouge.

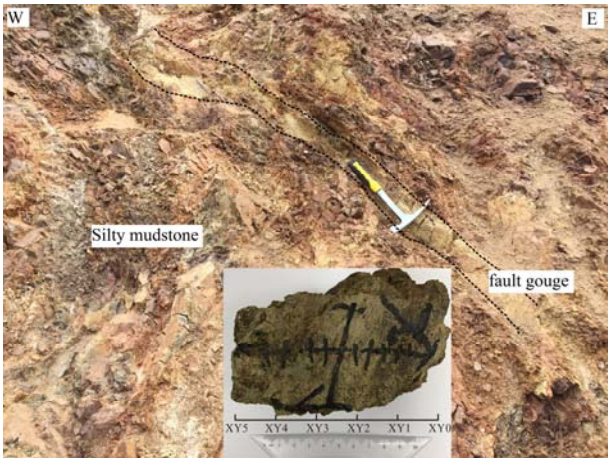

Fig. 1. Occurrence of the fault gouge (dotted line) showing injection structure. the relative samples were labeled as XY0, XY1, XY2, XY3, XY4, XY5 from one side of the fault gouge to another

The major elements analysis of clay minerals are determined by XRF. For easy comparisons of clay minerals with different chlorite proportion, data was

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normalized on the basis of 25 oxygens, and with all Fe as Fe^{3+}. In Fig.2a, the chemical compositions of clay minerals are presented as total Al vs cation totals of Si+Al+Fe+Mg+Mn+Ti. These elements are generally assumed to be noninterlayer cations, coordinated octahedrally or tetrahedrally by oxygen. The Al content varies from～2.7 in the core to ～3.5 in the edge of the fault gouge. Such an incremental increase in Al is compatible with progressive chloritization (Robinson, et al., 1993; Schiffman and Staudigel, 1995). Shau et al. (1990) suggested that the smectite layers in corrensite have significantly low ratios of Al^{IV}/Si^{IV} and $Fe^{VI}/(Fe+Mg)^{VI}$ (IV and VI indicate octahedral and tetrahedral sites, respectively). This could casuse an incremental decrease in Si and Mg due to chloritization in the progression toward the edge of fault gouge (Fig. 2b).

The significant chloritization on the edge of the fault gouge is unlikely to reflect hydrothermal alteration and regional very-low-grade metamorphism during the fault happen, instead, it is interpreted to have resulted from frictional heating associated with localized slip. This study highlights the clay mineralogy assemble in the fault gouge and will offer basic parameters to analysis the slight temperature rise during frictional heating on C/S bearing faults.

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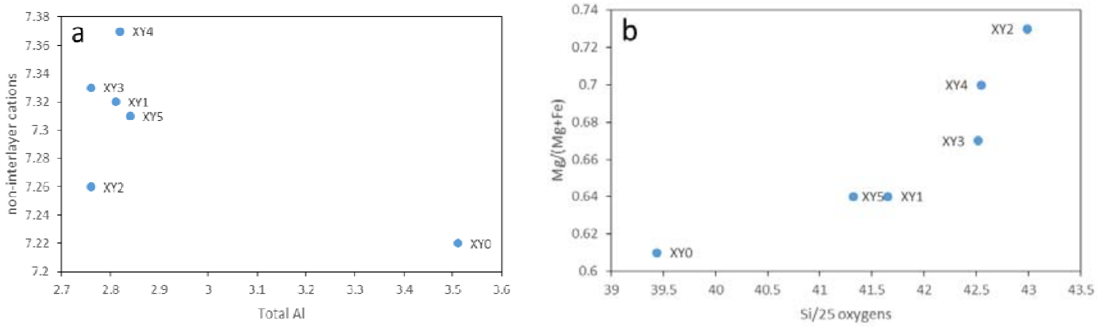

Fig. 2.Non-interlayer cation totals (Si+Al+Fe+Mg+Mn+Ti) vs Al contents (a) and Mg/(Mg+Fe) vs Si contents (b) for fault gouges in the samples. All date are recalculated on the basis of 25 oxygens and all Fe as Fe^{3+}.