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Microstructural and geochemical evolution of sliding surfaces in landslides and comparisons with crustal fault zones

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The formation of basal sliding surfaces in mass movements is known to be associated with chemical and physical alteration of rock and regolith. To evaluate their microstructural and geochemical evolution we collected samples from bedrock, the sliding surface (gouge) and adjacent deposits within two different landslides in Central China. The sample locations reflect different geological conditions.

Comparing qualitative and quantitative geochemical analysis we found indications for weathering of the sliding surface area and the accumulation and genesis of clay minerals, explaining its reduced shear strength. The cataclasites (gouge) are mainly composed of quartz, illite, calcite, pyrophyllite, kaolinite and feldspar with grain sizes in the range 0.5 - 5μm. XRF data show an increase in Al_2O_3, Fe_2O_3, K_2O and decrease in SiO_2 and CaO contents towards the sliding surface, pointing to alteration processes. The existence and increase of pyrophyllite content in sliding surface samples may indicate its initial formation to be caused by a high energy event, because pyrophyllite forms by hydrothermal alteration at approximately 450 $^{\circ}$C. The accumulation of pyrophyllite at the sliding surface is expected to result in reduced shear strength. Comparison of the microstructures, using transmission electron microscopy and focused ion beam technique for sample preparation shows a significant reduction of grain size and increase of pore space due to grain comminution by creeping and moving processes. High- angle annular dark field images show the occurrence of amorphous carbon which may indicate the occurrence of graphite. Graphitization (crystallization) of amorphous carbon was recognized in the slip zone of several fault zones, which underwent frictional heating due to rapid sliding. Graphite is well known as a solid lubricant in fault zones with a friction coefficient as low as that of smectite (μ = 0.1). The process of sliding surface formation in some landslides seems to be comparable to fault gouge formation by brittle deformation in crustal fault zones.