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Groundwater flow and formation of smectite-rich surfaces in fault zones inducing landsliding in marly materials from the External Zone of the Betic Cordillera

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We have studied the influence of water circulation processes and clay mineral crystallization in fault zones on the landsliding processes occurring in carbonate and marly materials from the External Betic Cordillera (Jaén province, Southern Spain). Groundwater in the aquifers is mostly characterized by Ca-Mg-HCO_3 hydrochemical facies and a low temperature in the discharge. Nevertheless, Ca-SO_4 facies, hot and high mineralized waters discharged in some thermal springs close to the landsliding area. XRD, SEM and TEM data have revealed that fault rocks are enriched in phyllosilicates, being smectite the most abundant phase. Smectite was detected in the XRD diagrams from its 14.1 Å spacing expanding to 16.5 Å after ethylene-glycol treatment. The dioctahedral nature of these smectites could be revealed by the (060) reflection near 1.50 Å. Compositionally, AEM analyses reveal that dioctahedral smectites are Al-dominant (between 1.45 and 2.05 a.p.f.u). SEM images from fault zone rocks show rupture surfaces with striations and S-C structures.

Brittle rock deformation in fault zones favours fluid–rock interaction processes that can produce the crystallization of clays. The occurrence of smectitic materials, either in discrete form or as mixed-layered clay minerals, has been previously described as the result of low-temperature fluid-rock interaction in fault areas. This study reveals the presence of water-rich mineral assemblages located along fault zones. The high water content is related to the crystallization of swelling phases as discrete dioctahedral smectite. This hydrous mineral phase can be considered to have formed during enhanced circulation of aqueous fluids along the fault. The crystallization of these phases help to explain the presence of localized mechanical weakness zones that can promote landsliding procceses. The presence of this mineral is critical for the geotechnical properties of rocks. The presence of smectite increase plasticity, compressibility, and swelling potential of the fault rocks (Seed et al. 1962; Yilmaz and Karacan, 2002). Moreover, the smectite-rich materials, when are water saturated, can easily flow favouring landsliding of blocks separated these phyllosilicate rich materials. The existence of smectite-rich surfaces produced by the alteration associated to the hot and high mineralized water flow in fault zones is the main factor controlling landsliding in the study area.

References

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