Geophysical Research Abstracts
Vol. 12, EGU2010-10520, 2010
EGU General Assembly 2010

Weak soil units in volcanoes: origin, properties and role in the initiation of sector collapses

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Recent work on the geotechnical properties of volcanic materials suggest that most volcanic rock masses have shear strengths above a threshold value to allow the development of a landslide failure surface, and hence a flank collapse, even at the realistic top end of external disruption due to transient stresses, pore fluid pressurisation and magmatic intrusions. A number of studies have therefore suggested that the presence of weak volcanic materials within volcanic edifices is likely to play an important role in the initiation of large-scale deformations and flank collapses. A number of mechanism by which large volumes of low-shear strength materials can be present within a volcanic edifice have been proposed. Here we focus on the weakening effect of weathering and hydrothermal alteration of phonolitic ignimbrites and phonolitic lavas and pyroclasts from the Island of Tenerife. We have performed geochemical analyses, grain size distributions, consolidation tests, direct shear tests and some triaxial tests and microstructure analyses of undisturbed and remoulded samples of the weakest soil units exposed in the central Las Cañadas Edifice. The most significant results reveal that, from weathering, the weakest units are porous, sandy-silty, non-plastic soils (SM) that are cohesionless, with high peak strength angle of friction ([U+03D5] > 40º) and significantly lower constant volume and residual strengths ([U+03D5] < 30º). In the case of hydrothermal alteration, the weakest units are porous, silty, clay-rich, medium plasticity soils (MH) with low cohesion values and varying angles of internal friction (17-45º). An evaluation of the variations of shear strength of the different soils analysed shows that it appears to be determined in each case by the secondary mineralogy produced by alteration, mainly halloysites and the presence of bonding in weathered soils and kaolinites or alunites in hydrothermally altered soils. The low shear strength values of the soil units analysed reduces the overall strength of a volcanic edifice and, in some cases, can generate volumes through which failure surfaces can develop.