Geophysical Research Abstracts,
Vol. 10, EGU2008-A-10253, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-10253
EGU General Assembly 2008

Influence of rock mass structure on the character of rockfalls from hard rock cliffs

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Conventional discrete element analysis of rock mass failure relies on the assumption that the joint geometry within the model defines the geometry of resulting rockfall. To date the validity of this assumption has not been rigorously tested. The resolution of recently developed terrestrial laser scanners provides 3D surface characterization of sufficient resolution to precisely derive joint geometry, and secondly to directly monitor changes to rock cliffs (rockfall). This paper explores a 4 year rockfall monitoring data set collected from actively eroding coastal cliffs in the N. Yorkshire coast, UK. This study focuses upon a single section of cliff approximately 50 m high, and 100 m wide, from which approximately 50,000 rockfalls have been recorded during the monitoring period. The cliffs undergo an effectively continuous process of modification through the action of waves, in addition the areal weathering and desiccation, reflected in a wide range in rockfall magnitude. Geological variation is a key influence on the morphological variability in the evolution of a cliff and wider coast. The lithology consists of numerous strata of lower Jurassic mudstone, sandstone, shale, siltstone and with interbedded limestone and ironstone. Considerable variation in the relative retreat of bands of different rock types has been noted, but the relative magnitude and frequency of rockfalls which contribute to this aggregate rate has not been assessed.

The results demonstrate that rock type hold considerable control over rockfall size and shape. The rock types within the cliff from the analysis presented show a significant variation in joint frequency, continuity and orientation. Significant correlations exist between rock mass structure and resulting rockfall, but concurrently significant scatter is noted around these trends. This is particularly apparent in the small rockfall size fractions, and is attributed to the process of fragmentation of the rock face in the period leading to and following failure. The results have implications for the interpretation of numerical slope modeling of failure with respect to minimum rockfall size generated from jointed rock masses.