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The Emergence of Order in Clast-Mantled Desert Surfaces

D.L. Higgitt (1) and N.J. Rosser (2)

(1) National University of Singapore, Geography, Singapore, Singapore (geodlh@nus.edu.sg), (2) Durham University, Geography, Durham, United Kingdom (n.j.rosser@durham.ac.uk)

The paper reports a model to simulate the formation of order (self-organization) in the spatial distribution of coarse clast-mantled desert surfaces. Previous work on the characterization of desert surfaces in Northeast Jordan has demonstrated continuity across bedrocks with wide ranging ages and subtle but systematic variation within slope profiles. Modelling surface development and maintenance can consider the surfaces as a cellular system, in which individual clasts interact and have the potential to derive emergent properties, such as patterned ground. A cellular automata model is presented in which the interaction of surface and clast characteristics reflect variability observed in the field. This is used to explore the conditions and controls that lead to the development of spatial order from an initially random state. Order in the surface is assessed as a function of the final spatial pattern, but also the dynamic condition of the surface when steady state behavior has been achieved. Downslope variations in order coincide with subtle variations in both individual and collective clast characteristics. We observe that clast configuration acts to moderate the downslope flux of clasts, whereby slope acts as a topographic sieve promoting out-migration of more mobile clast fractions. Given the interactions between clasts at sufficient ground cover densities, travel distances are limited not by an ability to initiate movement, but rather by the geometrical restriction on travel distance, inhibited by locking. The presence of order can be related directly to the precise geometry of interactions between clasts, which from field observations is linked to bedrock geology, ground cover, and slope controlled process activity. The emergent pattern has some geomorphological significance, enhancing flow retardation, maintaining dispersion, and encouraging sedimentation and infiltration. The results of the modelling raise a set of new questions on the process dynamics and evolution of clast-mantled desert surfaces.