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Desert Stone Mantles: Quantification and Significance of Self-Organisation

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Desert stone mantles exhibit sorting patterns which are evidence of self-organisation. Previous investigations of stone mantles developed on Late Tertiary and Quaternary basalts in arid northeastern Jordan, revealed distinct variations in the nature of stone cover both downslope and between lithologies of different age. However, manual field measurements of clast size and shape did not preserve information about the spatial configuration of the stone surface. Improved digital image capture and analysis techniques, including using a kite-based platform for vertical photography of the surface, has permitted the nature of stone mantles to be examined and modelled in greater detail. Image analysis has been assisted by the strong contrast in colour between the basalt clasts and the underlying surface enabling a binary classification of images, from which data on size, shape and position of clasts can be readily acquired. Quantification of self-organisation through a box-counting technique for measuring fractal dimension and a procedure using Thiessen polygons to determine 'locking structures' indicates a general increase in organisation of the stone mantle downslope. Recognition of emergent behaviour requires an explanation in terms of positive feedback between controlling process and the influence of surface form. A series of rainfall simulation and infiltration experiments have been undertaken on plots to assess the variation in surface hydrology as a response to variations in ground surface and slope profile form. The relative contribution of runoff events of varying size and the degree to which the ground surface configuration accelerates or restricts modification of the surface influences the overall evolution of slope profiles via the erosion, transfer and deposition of both surface clasts and the underlying fine grained sediments. Critical to this modification is the interplay between the surface configuration, rainfall and runoff. The experiments presented here are also the first attempt to quantify the influence of clast surface coverage on rainfall partitioning and sediment mobilisation. Results suggest that a close synergy exists between surface character, whole slope form and hydrological response to rainfall. Characteristics resulting from self-regulating behaviour, including emergent spatial structures, non-linear spatial variations in surface character and negative feedbacks between form and process action are evident. Runoff response is damped at slope positions where clast patterning is most developed. Questions arise with regard to the degree to which processes of surface modification represent a self-regulating system through time.