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Stone pavements and vesicular soil structure: System-wide order from local interactions

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The concept of self-organisation sets a different research focus than traditional geomorphological research that tends to concentrate on the interaction between a given geomorphic system and its framework conditions. Self-organisation, in contrast, focuses on internal interactions and offers a systemic and comprehensive understanding of different geomorphic phenomena, and especially those phenomena that seem to elude determination by environmental conditions. One such geomorphic phenomenon is that of stone pavements in arid regions that are typically associated with vesicular soil structure. Our literature review on the formation of the vesicular structure of dryland soils covered by stone pavements indicates that the concept of self-organisation might offer a deeper understanding of the internal mechanisms that lead to the apparent association of stone pavements with vesicular soil structure. These internal mechanisms are characterised by negative and positive feedback loops that interact and limit each other, so that local processes eventually lead to the typical system-wide co-evolution of stone pavement and vesicles. The essential mechanism for vesicle formation that finally also leads to the re-formation of a stone pavement is a process chain of displacement of air from soil pores due to infiltrating water, and vesicle formation leading to material sorting due to the lifting of stones. This process chain interacts with another process chain: with continuing accretion of aeolian material, a given zone of vesicles eventually flattens and collapses due to increasing sediment overburden, while the zone of active vesicle formation grades into higher parts of the section.
The detailed conceptual framework for the study and understanding of local interactions leading to the system-wide order of stone pavements and the vesicular structure of soils is presented for discussion in the broader scientific community. Subsequent field work, laboratory experiments and numeric modelling will aim at quantifying internal thresholds and limiting factors of vesicle and pavement formation.