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Importance of Biological Loess Crusts for Loess Formation in Semi-Arid Environments

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The essential components for loess deposition are: material, atmospheric circulation and appropriate surface conditions for the trapping of aeolian material as well as the subsequent development of typical loess sedimentary structures. In spite of the world-wide distribution of loess deposits, knowledge of the processes of transformation from accumulated dust to mature loess sediment is still inadequate. Some recent studies highlight the potential importance of biologically crusted surfaces (BCS) in loess formation. BCS are highly specialized extremophile communities and generally play an important role in atmospheric dust trapping and erosion prevention. Our initial results indicate that cyanobacterial strains isolated from loess exhibit some specific morphological and ecophysiological characteristics that play a key role in loess formation, warranting adoption of the new term biological loess crusts (BLC).

We suggest that loessification is heavily influenced by the metabolic activity of BLC microorganisms mainly through polysaccharides. The sticky polysaccharide glue on the topographic surface, exuded mostly by cyanobacteria, can trap silty particles suspended in a dusty atmosphere. This collection of airborne loess forming particles is part of the life strategy of crust organisms in so far as they provide the necessary minerals for further growth of the BLC, which in turn provides protection from desiccation during dry periods. Simultaneously, polysaccharides secreted by crust organisms bind particles inside the BLC zone, forming a cohesive crust that resists both wind and water erosion during dry periods. Metabolized particles, exuded metabolites and unused airborne particles become the uppermost loess sediment covered with BLC. During moist periods, accumulation of dust and loess forming particles is very active. During the dry phases, the BLC becomes very stable and develops a resistant surface preventing wind and water erosion. The drying period induces polysaccharide production by cyanobacteria, serving to as protecting molecules from water stress. In the presence of water during a moist phase, polysacharides produced in the transition from wet to dry phases and accumulated during dry phases become a new sticky layer for dust accumulation and initiate a new cycle of loessification.

This model suggests that loess formation is intimately tied to BLC and cyanobacterial activity preferably combined with dry and wet environmental shifts. This scenario requires further detailed study in order to add it to the list of potential significant loess forming mechanisms that might describe not only particle generation, entrainment, transport and deposition, but also might shed light on loess granulometry, thickness, permeability, geographical zonality, adaption to the landscape and its changeability under human influence. Since BLC can be highly influenced by local changes of mineral and organic compounds, as well as moisture and temperature, this observation also raises questions about the importance of local environmental conditions for loess deposition.

Given that BLC is common on current loess surfaces that form the first stages of vegetation succession and also plays a key role in preventing wind and water erosion on disturbed soil, the proposed scenario about BLC dependent loessification should thus be seriously considered as one of the fundamental requirements for loess formation in semi-arid areas.