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Kinneyia-type wrinkle structures—Critical review and model of formation

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ABSTRACT

Kinneyia structures are among the most typical wrinkle structures observed on ancient siliciclastic sediment surfaces since the Archean. Recently, Kinneyia structures have been grouped together with other microbially induced, crinkly decorations on ancient bedding surfaces as wrinkle structures. They are mainly preserved on upper surfaces of ancient siliciclastic-event deposits and are characterized by millimeter-scale, winding, flat-topped crests separated by equally sized round-bottomed troughs and pits. The structure resembles small-scale interference ripples including crest-dominated linear and pit-dominated honeycomb-like patterns. The steep slopes of the crests, however, exclude their formation at the air or water-sediment interface. Thin sections across Kinneyia structures reveal their formation beneath microbial mats. They formed at an early stage and do not arise from loading and other processes related to burial. Based on the close relationship to event deposits, a genetic model considering the specific hydraulic conditions on siliciclastic tidal flats after storms or floods is proposed. Numerical calculations show that, after microbial mats have been reestablished on the new sediment surface and groundwater is still flowing downslope, the top portion of the sediment confined beneath mats may be liquefied, thus allowing grains to move with the groundwater. Oscillations of groundwater flow owing to periodic reversals of flow direction at rising tides, and a tidal signal of oscillating pore pressure may enhance formation of ripplelike structures along the boundary with the overlying mat. The model applies primarily to Kinneyia structures presumed to be formed beneath cohesive microbial mats in peritidal zones.