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Authigenesis in vertebrate fossils on a marine sequence boundary in the Upper Cretaceous Judith River Formation of north-central Montana, U.S.A.

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The richly fossiliferous Campanian Judith River Formation (JRF) is widely exposed across much of north-central Montana. Vertebrate fossils in the marine portion of the JRF are locally concentrated on discontinuity surfaces that formed during transgressive events. Because bones include abundant primary void spaces that can readily accommodate authigenic mineralization, fossil bone derived from JRF marine facies provides a unique opportunity to study early diagenesis within a sequence-stratigraphic framework. This study seeks to (1) compare authigenic signatures in skeletal material from a variety of depositional environments (coastal and marine), and (2) characterize authigenesis on a fourth-order marine sequence boundary.

The $\sim$180 m thick JRF comprises the distal reaches of an eastward-thinning clastic tongue that accumulated on the western margin of the Western Interior Seaway. The unit is a heterolithic composite of silty claystones, siltstones and fine- to medium-grained sandstones of fluvial, tidal, and shallow marine origin. This study focuses on a discontinuity surface at the base of a back-stepping fourth-order sequence that merges landward with a concave, erosional ravinement surface. This bounding surface is extremely fossiliferous with regard to vertebrate hardparts. Local meter-scale scours that mark the surface yield abundant shark teeth, bones of marine reptiles, fish, and rare terrestrial taxa (e.g., dinosaurs). The surface can be traced for $\sim$17 km along depositional strike (N-S), to the limits of available exposure.

Authigenic cements filling cracks and primary voids in $\sim$50 bone specimens mantling the marine sequence boundary were compared with $\sim$60 bones collected from two nonmarine sites intercalated in associated paralic facies. Bones were examined in thin section using both polarized light microscopy and SEM-EDS. Fossil material associated with the sequence boundary exhibits a complex history of authigenic minernalization. Authigenic phosphate is present in most bones, and on occasion fills entire voids to the exclusion of other authigenic cements. Pyrite is abundant as a void fill and also replaces bone tissue. Calcite is abundant, and fills entire voids when present. Fossil material from terrestrial localities tends to show less extensive cementation, with one terrestrial assemblage virtually devoid of authigenic cements. Bones from terrestrial localities also do not show the extensive phosphatization seen in marine fossils, and calcite and pyrite are present to a limited extent in only one of the sampled nonmarine localities. This variation in authigenic cements is likely due to variation in pore water chemistry during early diagenesis, with marine environments being more acidic and reducing.

Authigenic cements in the JRF record track environments and allow for correlation between fossil bones and depositional settings. Moreover, cements in fossil bone provide a novel means of characterizing authigenesis associated with a marine sequence boundary. To determine whether the authigenic signature of the sequence boundary is distinct from the background marine signature, it will be necessary to characterize authigenesis in contemporaneous fossil material not associated with the discontinuity surface. This in turn will yield critical insights into the formative history of the surface (e.g., degree of exhumation/reworking).