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Timing of Cretaceous Shelf Margins in the Colville Basin, Arctic Alaska

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ABSTRACT

Cretaceous clinothems on the Alaska North Slope hold significant undiscovered oil potential, as attested to by three recent, large oil discoveries in the Torok and Nanushuk Formations clinothem. A quantitative understanding of clinothem timing has been hindered by relatively imprecise biostratigraphy with large uncertainties >5â€“10 m.y. We integrate new zircon U/Pb geochronology with seismic stratigraphy to illuminate the timing and relationship between the Torok-Nanushuk and Seabee-Tuluvak clinothems. Maximum depositional ages are defined by young detrital zircon U/Pb age populations, likely derived from coeval volcanism in Russian Chukotka or south of the Brooks Range. The Torok-Nanushuk clinothem stretches from the Chukchi Sea to the Arctic National Wildlife Refuge and represents the world's most voluminous (1.2 million km3) and highest relief (>1 km thick) foreland clinothem. Clinoform dip directions and detrital zircon provenance indicate that sediment was derived primarily from Chukotka during longitudinal, eastward sediment dispersal. Estimated depositional ages (n=13 sites) reveal a progradational surge between ca. 115 and 105 Ma when the shelf margin prograded more than 450 km in a supply-dominated system. Progradation slowed after 105 Ma when seismic stratigraphy shows a shift to aggradational shelf-margin trajectories. The shelf margin prograded only another 125 km eastward to the ultimate shelf margin at 97.9-97.8 Ma (Â±0.7-1.1 Ma; n=3). We estimate ~400 k.y. periodicity for Torok-Nanushuk depositional sequences, which is equivalent to the Milankovitch long eccentricity cycle. We detect a curious ~2 m.y. hiatus in deposition on the shelf between the Torok-Nanushuk ultimate shelf margin at 97.9-97.8 Ma and a sequence-bounding retrogradation at the base of the overlying Seabee-Tuluvak sequence at 95.7-95.4 Ma (Â±0.4-1.0 Ma; n=3; Ninuluk sandstone). Enigmatic deepwater deposits such as the Juniper sandstone and Arctic Creek unit have been recognized extending >200 km east of the Torok-Nanushuk ultimate shelf margin, but with an uncertain relationship to clinothem sequences west of that ultimate shelf margin. New geochronology indicates that these deepwater deposits young upward from 98.2-97.5 Ma (Â±0.8-1.3 Ma; n=2) at the base to 96.1-95.5 Ma (Â±1.1-1.2 Ma; n=2) at the top, suggesting deposition during a lowstand coeval with the hiatus recognized on the shelf. Deposition renewed on the shelf after 95 Ma and includes progradation of the Seabee-Tuluvak clinothem at 93.8-92.1 Ma (Â±0.3-0.7 Ma; n=3). Notable differences between the Torok-Nanushuk and Seabee-Tuluvak clinothems include a change from Chukotkan to Brooks Range provenance and significant reductions in both sediment flux and clinoform relief. These new geochronologic data confirm previous interpretations of a Juniper-Arctic Creek-(Gilead?) lowstand systems tract comprising basin-floor fan deposits that post-dates the Torok-Nanushuk ultimate shelf margin, and of the Ninuluk and basal Seabee as a transgressive systems tract that reflects drowning of the relict Torok-Nanushuk shelf during the late Cenomanian. The data also constrain the age of progradation of the Seabee-Tuluvak highstand systems tract across the relict shelf. This study demonstrates the potential to correlate specific lowstand shelf margins with quantitative geochronology, providing improved constraints for understanding hydrocarbon systems in Cretaceous clinothems on the Alaska North Slope.