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Response of vegetation to Lower Cretaceous paleoclimate variation in the Canadian Arctic

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The Sverdrup Basin is an east–west-trending extensional sedimentary basin underlying the northern Canadian Arctic Archipelago. The tectonic history of the basin began with Carboniferous to Early Permian rifting followed by a period of thermal subsidence with minor tectonism. Tectonic activity in the basin was rejuvenated in the Hauterivian–Aptian by renewed rifting and extension. The Isachsen Formation was deposited in marine, marginal marine/deltaic, and fluvial environments coeval with development of the adjacent Amerasia Basin. The Formation contains early post-rift deposits, the break-up unconformity, and late post-rift deposits of the Jurassic-Cretaceous rift succession of Sverdrup Basin and is contemporaneous with initiation of the High Arctic Large Igneous Province. The Isachsen Formation is thus of particular interest from a tectono-development perspective and an exceptionally well-exposed and constrained ∼500 m thick exposure at Glacier Fiord, Axel Heiberg Island, provides a window for better understanding Arctic paleoclimate during Cretaceous greenhouse conditions and a time of tectonic instability and associated volcanicism. Facies analysis and statistical palynology of the Glacier Fiord Isachsen Formation exposure are combined to test the hypothesis developed from an earlier study of the formation exposed on Ellef Ringnes Island that a brief warming episode during the Hauterivian punctuated otherwise relatively cool and moist Early Cretaceous climate and promoted expansion of hinterland coniferous communities in polar forests. Similar to the Ellef Ringnes Island material, coniferous palynomorphs dominate Glacier Fiord samples. Combined Q and R-mode cluster analysis delineate 4 clusters of samples that broadly reflect lithostratigraphy and 4 clusters of taxa that represent different vegetation communities that changed over time. Temporal trends in abundant bisaccate pollen are comparable to those observed on Ellef Ringnes Island: bisaccate pollen are relatively less abundant in the Valanginian – lower Hauterivian portions of the Paterson Island Member and peak in the late Hauterivian flood-plain facies of the upper part of the Member. The proportion of bisaccate pollen subsequently declines and remains low (∼10–20%) in marine mudstones of the Rondon Member (Barremian or early Aptian) and into the overlying Aptian Walker Island Member before recovering to abundances of near 50% in uppermost strata of that Member. Concurrent with the decline in bisaccate pollen is an increase in Gleicheniidites and Deltoidospora spores and Cycadopites and Cupressaceae-Taxaceae pollen. These trends are interpreted to reflect cool and moist climate during Valanginian and early Hauterivian time, warming throughout the Hauterivian that promoted expansion of hinterland coniferous communities surrounding Sverdrup Basin, and a return to relatively cool and moist conditions that promoted expansion of mixed lowland communities. Significant perturbations to global climate occurred during Valanginian to Aptian time when numerous cool excursions punctuated otherwise warm greenhouse conditions. Warming in the northern hemisphere during the Hauterivian is documented in a variety of paleoecological records and, using a multivariate statistical approach, we show that this event was manifested in the terrestrial realm in high northern latitudes of Canada by expansion of upland coniferous communities.