Lithospheric flexural controls on landscape evolution of the western Canadian Arctic during incision of the Northwest Passages, Canada

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Lithospheric flexure in response to changing surface loads is an important control on surface topography and processes. The Northwest Passages, a series of waterways in the Canadian Arctic, consist of channels with depths of ~500 m in some areas, some of which are bounded by faultline scarps. These passages were deepened by recent glacial, and partially fluvial, incision through Cenozoic sediments. What is the effect of this incision on the adjacent Arctic Islands?

The Beaufort Formation is a Pliocene coastal plain deposit interpreted on the basis of paleoflow directions and upper and lower contacts to have stretched from the Northwest Territories to Ellesmere Island along the western Canadian Arctic before the incision of the passages. Despite having been deposited in a short period between 3.8 and 2.7 Ma these fluvial sediments and marine equivalents thicken toward the Canada Basin to as much as 3 km. While large straits may have existed previously among the islands, they were evidently sediment-filled during the Pliocene. A key question is whether the incised ribbonlike distribution of the Beaufort Formation and Arctic Islands' current topography can be explained by flexure of the Arctic lithosphere in response to: (1) post-Miocene sediment loading of the Arctic continental margin; and (2) Pleistocene incision of the passages. Elastic flexural sediment backstripping using gFlex is applied to Pleistocene and Pliocene strata offshore to estimate initial bathymetry and coastal topography at the Miocene-Pliocene transition. This allows the converse forward calculation of flexure owing to the sediment deposition. Model flexural downwarping by offshore sediment loading is sufficient to accommodate Beaufort Formation sediments, thereby explaining the ribbon-like distribution of the unit parallel to the coast. The effect of erosional flexural rebound by channel incision is then incorporated by iteratively removing sediment from the channels and replacing it with water until the current bathymetry is achieved. Model results indicate a 60 km lithospheric flexural thickness is suitable, but island uplift, of ~100s metres, is insufficient to match modern topography suggesting more incision in the channels and/or greater paleotopography than assumed in the model. The model results reinforce the interpreted need for a recent ice sheet over the Arctic Islands that was sufficiently thick to excavate the submarine channels without which there would be no navigable Northwest Passage in the western Canadian Arctic.

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