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Arctic-Alaska Rotation Hypothesis Revisited

Kurzfassung

Unterschiede im prä-mississippischen Gestein jenseits der Grenze zwischen Alaska und Kanada können erklärt werden, wenn die arktische Zone von Alaska in die Nähe von Ellesmere Island und Grönland zur Zeit des Altpaläozoikums gerückt wird. Vom Obersilur bis zum Unterdevon kann dieses Gebiet eines von vielen gewesen sein, das an den nördlichsten Teil von Ellesmere Island andockte. Vom Spätdevon bis zur frühmississippischen Epoche könnte es sich um 1500 km oder mehr entlang der Polarzone des Laurentischen Massivs verschoben haben, als Sibirien mit dem heutigen nordöstlichen Nordamerika zusammenstieß.

Abstract

Differences in pre-Mississippian rocks across the restored boundary between Alaska and Canada can he explained if the Arctic-Alaska terrane is placed near Ellesmere Island and Greenland in early Paleozoic time. In the late Silurian to early Devonian, this terrane may have been one of many that docked with northernmost Ellesmere Island. Then, in late Devonian to early Mississippian time, it may have been sinistrally displaced 1500 km or more along the polar margin of Laurentia when Siberia collided with what is now northeastern North America.

Résumé

Les différences dans la roche prémississippienne au-delà de la frontière entre l'Alaska et le Canada peuvent être expliquées si l'on place la zone arctique de l'Alaska à proximité d'Ellesmere Island et du Groenland à l'époque prépaléozoïque. De l'époque silurienne jusqu'à l'époque prédévonienne cette région peut avoir été une parmi plusieurs qui se sont rattachées à la partie la plus au nord d'Ellesmere Island. De l'époque dévonienne jusqu'à l'époque mississippienne cette région pourrait s'être déplacée de 1500 km ou plus le long de la zone polaire du Massif Laurentique, quand la Sibérie est entrée en collision avec la partie nord-est de l'Amérique du Nord actuelle.

Keywords

Arctic Tectonics, Canada Basin

1. Introduction

During the last half of the 20th century the north polar region, until then a place of mystery, folklore and high stakes exploration, became a place of science. S. W. CAREY was slightly ahead of his time in the mid 1950's when he applied his orocline, or mountain bending concept to the creation of the Arctic Ocean (CAREY, 1956; Fig. 1). It would be more than another decade before mobile continents and spreading sea-floors became conventional geoscientific wisdom.

Since the 1950's, nearly half a century of measurements have drastically reduced the size of Carey's rotated block and have constrained the time of rotation to the Cretaceous Period between about 125 and 85 Ma (Fig. 2).

2. Rotation Hypothesis – Discussion

Principal support for rotation is the close similarity of Mississippian through Early Cretaceous thickness and facies trends plus sediment source directions across the restored Alaska-Canada boundary (BALKWILL 1978; BALKWILL et al. 1983; GRANTZ et al. 1979; Fig. 3). There are also paleomagnetic measurements showing a Hauterivian or younger (< 130 Ma) rotation of at least part of northernmost Alaska by about 66 degrees anticlockwise relative to the North American craton (HARBERT et al. 1990), and

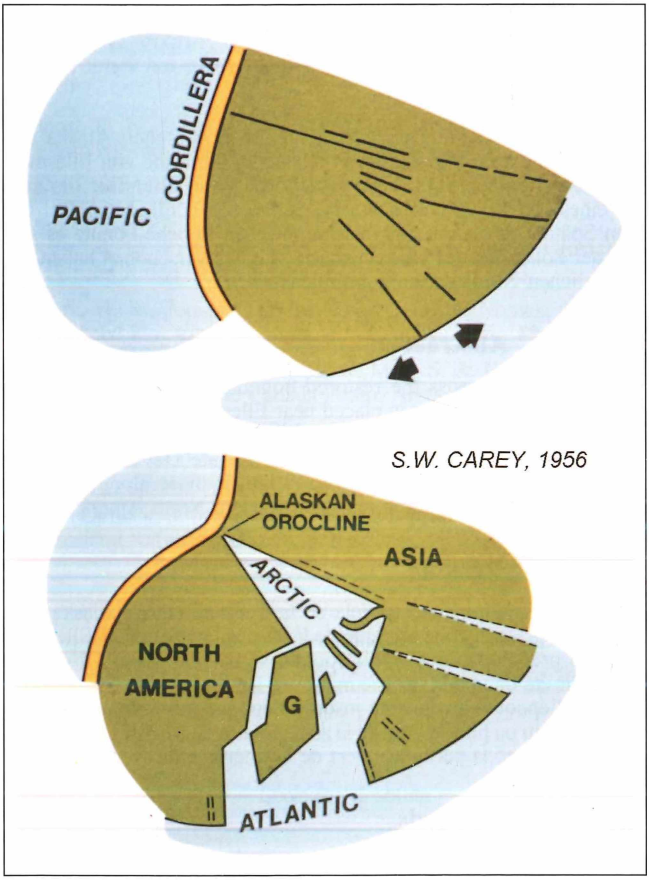


Fig. 1: The orocline concept applied to the Arctic region (CAREY, 1956).

tentative evidence from satellite-derived gravity measurements of an extinct spreading axis extending north from the Mackenzie Delta and bisecting southern Canada Basin (LAXON & MCADOO 1994, 1998).

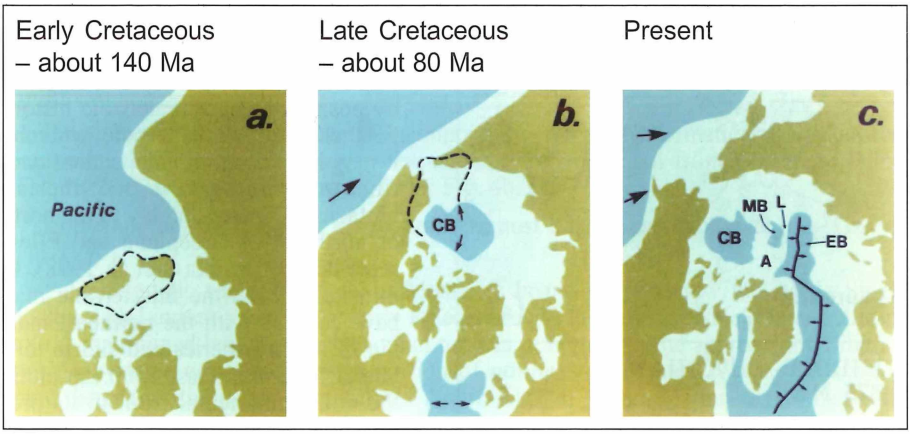


Fig. 2: Rotation model. Dashed outline is Arctic-Alaska terrane (NEWMAN et al. 1979; FUJITA & COOK 1990).

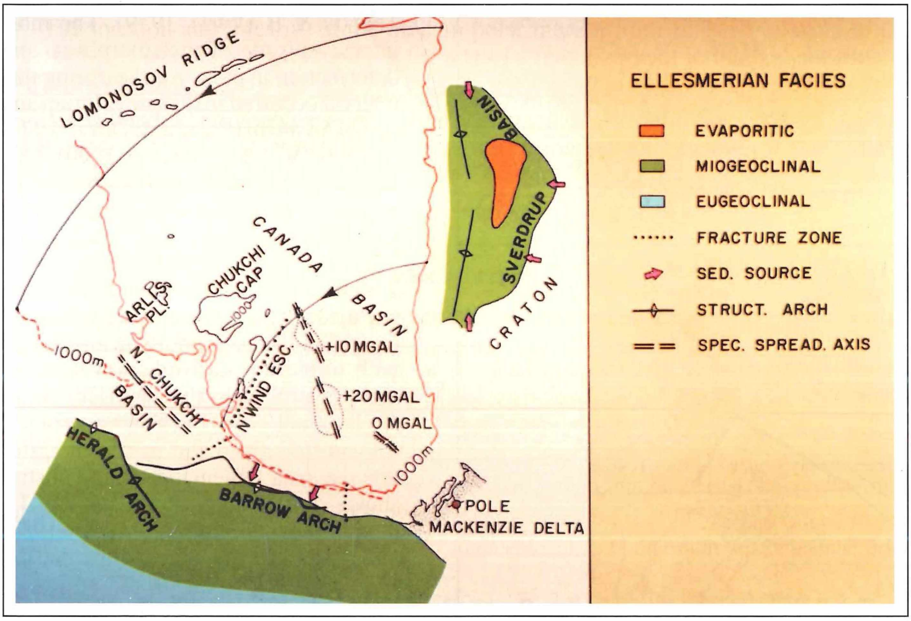
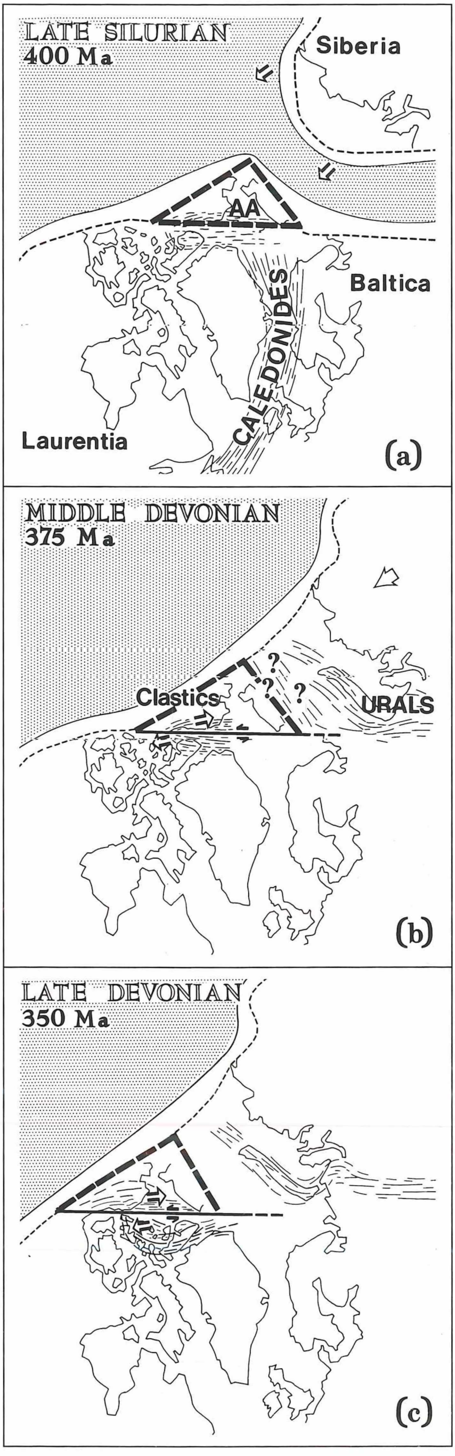


Fig. 3: Ellesmerian (Mississippian to early Cretaceous) facies. When rotation restored about indicated pole, close matchup of opposing margins indicated by dashed Canadian bathymetry north of Alaska (from GRANTZ et al. 1979).



Difficulty arises when Devonian and older rocks are compared across the restored boundary. Deformed igneous and metamorphic rocks in polar Alaska (e.g. GRANTZ et al. 1987) lie against contemporary pristine sedimentary units on much of the Canadian side (e.g. DIXON & DIETRICH 1990) (Fig. 4c). This difficulty can be resolved by positing an early Paleozoic history for the Arctic-Alaska terrane, whereby it may have been an independent continental fragment with Siberian biofacies affinities that lay to the north or northeast of Greenland and Ellesmere Island (DUMOULIN et al. 1998). In mid-Paleozoic time this terrane may have collided with the northeast margin of North America and slid in left-lateral fashion at least 1500 km along the polar continental front to its pre-rotated position near what is now the Mackenzie Delta (SWEENEY 1982).

Many lines of evidence tie northernmost Alaska to the polar regions of Greenland and Ellesmere Island during mid-Paleozoic time (GRANTZ et al. 1990; TRETTIN & BALKWILL 1979). The most intense episode of metamorphism and deformation in polar Alaska during this interval occurred in the late Silurian and early Devonian (BROSGE & DUTRO 1973; CHURKIN 1973; GRANTZ et al. 1990). This is matched by contemporary metamorphism and deformation on northernmost Ellesmere and Axel Heiberg islands (TRETTIN & BALKWILL 1979; TRETTIN 1987). At this same time a deep water trough across northernmost Greenland was inundated and filled with turbidities derived from the Caledonian orogen to the east (HENRIKSEN & HIGGINS 1998). The Pearya terranes, transported from the northern Caledonides past Greenland along sinistral shears, were sutured to Ellesmere Island in the late Silurian (TRETTIN 1987, 1991). Suturing was accompanied by

Fig. 4: Proposed mid-Paleozoic development of Arctic. Large arrows in b and c show expected directions of tectonic transport, small arrows show offset along proposed shear zone (from SWEENEY 1982).

major compressional deformation, including southwest-directed thrusting on Ellesmere Island (TRETTIN et al. 1987). Arctic-Alaska may have moved with the Pearya terranes at this time, remaining nearby or attached to the north (Fig. 4a).

Early Devonian sediments beneath coastal polar Alaska today coarsen to the west (BROSGE & DUTRO 1973). In a pre-rotated Arctic-Alaska this becomes a northeasterly coarsening, in agreement with the textural trend noted in contemporary clastics on northern Ellesmere Island and Greenland (TRETTIN & BALKWILL 1979; HENRIKSEN & HIGGINS 1998) which, in mid-Paleozoic time, are presumed here to have been adjacent landmasses.

In late Devonian through early Mississippian time, major deformation in northeastem Laurentia, the Ellesmerian orogeny, expanded west and south from Ellesmere Island (TRETTIN & BALKWILL 1979; TRETTIN 1998; Fig. 4b, c).

Contemporary deformation across northernmost Alaska was moderate (e.g. GRANTZ et al. 1990).

Paleomagnetic reconstructions of MOREL & IRVING (1978) show the Baltic Shield closing with Laurentia during the early Paleozoic with the Siberian Shield later colliding with the combined landmass in Devonian time as in Figure 4. The approaching Siberian block may have crashed against a portion of northeast Laurentia, causing severe tectonic disruption there, and remobilized Arctic-Alaska, pushing it further to the southwest along the polar front of Laurentia (Fig. 4b, c). By early Mississippian time, Arctic-Alaska apparently came to rest against a region that included the MacKenzie Delta area.

This scheme can explain mid-Paleozoic geological and tectonic similarities between now distant regions and, when rotation is restored, it accounts for differing tectonic histories between northern Alaska and the area northeast of the MacKenzie Delta in pre-Mississippian time.

The location and linearity of the modem polar margin from Ellesmere Island to the Mackenzie Delta are also explained as the site of a major zone of left lateral shearing in the mid-Paleozoic.

A few hundred million years later, in early Cretaceous time, the Arctic-Alaska terrane mobilized once more in anticlockwise rotation to initiate the opening of the modem Canada Basin.

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