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Lower Paleozoic Rocks around Today's Arctic Ocean: Two Ancestral Continents and Associated Plates; Alaskan Rotation Unnecessary and Unlikely

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THEME 14: Circum-Arctic Margins: The Search for Fits and Matches

Summary: Much of the present day Lower Paleozoic strata around the Arctic Ocean can be tied either to the ancestral Laurentian continent or to the ancestral Siberian continent. Correlated with Laurentia (Arctic Laurentian Assemblage) are the Canadian Arctic Islands, northern Alaska and northern Chukotka, including Wrangel Island. Correlated with ancestral Siberia (Arctic Siberian Assemblage) are the Verkhoyansk and Taimyr fold belts on the north and east of the Siberian Plateau, Omolon microcontinent bordered by the Kolyma fold belt on the west, the New Siberian Islands and Omulevka blocks. The New Siberian Islands and elongate Omulevka block appear to have been pieces of Siberia rifted away during the Middle Devonian. The Omolon microcontinent has also been postulated to have rifted away from Siberia during the Devonian but the existence of the Kolyma fold-belt with Phanerozoic and Proterozoic supracrustal strata facing Siberia suggests an older time of separation.

Both the Arctic Laurentian and Arctic Siberian assemblages had miogeoclines that opened into ancestral ocean basins towards the modern day Arctic Ocean. Within the Arctic Laurentian Assemblage the Canadian Arctic Islands joined to Alaska-Chukotka at an obtuse angle across a Paleozoic aulacogen (Richardson Trough). In the aulacogen is a thick succession of carbonate-dominated Lower Paleozoic basin facies, while to the northwest on the eastern Arctic Alaskan Plate, equivalent strata are very thin chert and shale miogeoclinal basin facies. The present day angular relationships, are similar to those expected for a triple-rift system with an ocean basin on the north formed from a rift approximately paralleling the modern ocean margin of the Canadian Arctic Islands, and a second rift paralleling the modern coast of northern Alaska-Chukotka. The aulacogen would have been a failed rift. This indicates that there was an ancestral ocean in the position of Canada Basin in the Lower Paleozoic. This paleogeography differs from the popular rotationist plate reconstruction that shows Alaska and Chukotka against the Canadian Arctic Islands in the Paleozoic. In this scenario a narrow trough or ocean would have had to extend from the Richardson Trough north between pre-rotation Alaska and the Canadian Arctic Islands. The present day facies pattern suggests a northward transition from trough to open miogeocline rather than a continuous trough or closed ocean.

INTRODUCTION

Canada Basin in the Arctic Ocean is bordered by the ancestral continents of Baltica, Siberia and Laurentia (TORSVIK et al. 1995), which are now parts of the Asian and North American cratons. There are many hypotheses concerning the creation of Canada Basin in the Cretaceous following the amalgamation of Laurentia, Siberia and Baltica. One of the more popular is the proposal that the Arctic Alaskan-Chukotkan plate rotated anticlockwise some 66o around a pivot point in northwestern Canada. This theory has been disputed recently by LANE (1997) who proposes a simple rift-drift model with little rotation about a northerly trending spreading center in Canada Basin.

Most of the debate centers on data from Cretaceous and younger rocks. However, an important constraint on these models is the arrangement of components in the Canada Basin area before the Cretaceous. A very important component is the initial position and history of the Alaskan-Chukotkan part of the Laurentian continent.

In this paper we will give a preliminary review of what we understand of Lower Paleozoic miogeoclines that fringed the northern ancestral cratons of Siberia and Laurentia as working information for constraining the early history of the Arctic region.

LOWER PALEOZOIC STRATA AROUND TODAY'S ARCTIC OCEAN

Lower Paleozoic strata are preserved in the more rugged inland areas of continental margins surrounding the Arctic Ocean (Fig. 1). Continental shelves surrounding the Arctic Ocean are mainly covered in thick Mesozoic and Tertiary strata, thus little is known about Paleozoic strata here. This is particularly a problem in the East Siberian and Chukchi seas where the continental shelves are up to 800 km wide. Fortunately, some islands in these seas have Paleozoic exposures (Wrangel Island, New Siberian Islands, Bennet Island; Fig. 1).

In the Lower Paleozoic, most rocks now found around Canada Basin were parts of two major separate ancestral continents Laurentia and Siberia (TORSVIK et al. 1995). In addition, there were discrete microcontinents (Omolon-Kolyma-Prikolyma and Omulevka) which now lie in Mesozoic fold belts between the Arctic portion of these two continents (Fig. 1).

Facies patterns in Lower Paleozoic rocks preserved in the Arctic, generally show a transition from shallow-water platform carbonates to deeper-water shales typical of outer miogeoclines in the direction of the Arctic Ocean (Canadian Arctic, Northern Alaska, New Siberian Islands and Bennet Island, north and south Verkhoyansk and Taimyr Peninsula; Figs. 1,2,3). This means that the ancestral Siberian and Laurentian

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continents faced Paleozoic oceans in the present day direction of the Arctic Ocean as illustrated in reconstructions of TORSVIK et al. (1995).

ANCESTRAL LAURENTIAN ASSEMBLAGE

Correlated with Laurentia (Arctic Laurentian Assemblage) are the Canadian Arctic Islands, northern Alaska and northern Chukotka, including Wrangel Island (KOS'KO et al. 1993). In northern Alaska there are outboard shallow water platforms which may be outer highs, continental fragments, or rifted pieces of a shallow-water margin from elsewhere around the Arctic.

The Canadian Arctic Islands preserve Lower Paleozoic shallow-water strata in the southeast and basinal miogeoclinal strata in the northwest (Figs. 2,3; TRETTIN 1991). This pattern is possibly broken in the southwest where platform strata could extend to the edge of the modern continental shelf and basinal strata would be missing. This is a key area because isolated platform carbonate occurrences like Nanook et al. 1986) or hypothetical NE Chukchi (found on seismic lines in THURSTON & THEISS 1987) or hypothetical Northwind Ridge Lower Paleozoic platform strata (GRANTZ et al. 1998) could be restored back to the margin. Restoration can be achieved in many ways including rotation or simple strike-slip.

Northern Alaska has Lower Paleozoic platform carbonates and some basinal facies running along the Brooks Range on the south and miogeoclinal basin facies with the isolated platforms noted above on the north (HARRIS et al. 1995, MOORE et al. 1994). Chukchi and Seward Peninsulas (TILL & DUMOULIN 1994) are correlated with northern Alaska as is Wrangel Island (KOS'KO et al. 1993).

Between the Canadian Arctic Islands and northern Alaska is the Richardson Trough (Fig. 4). The Richardson trough is interpreted to be an aulocogen or failed arm of a triple-rift system. Strata deposited within it are regionally distinct. Two km

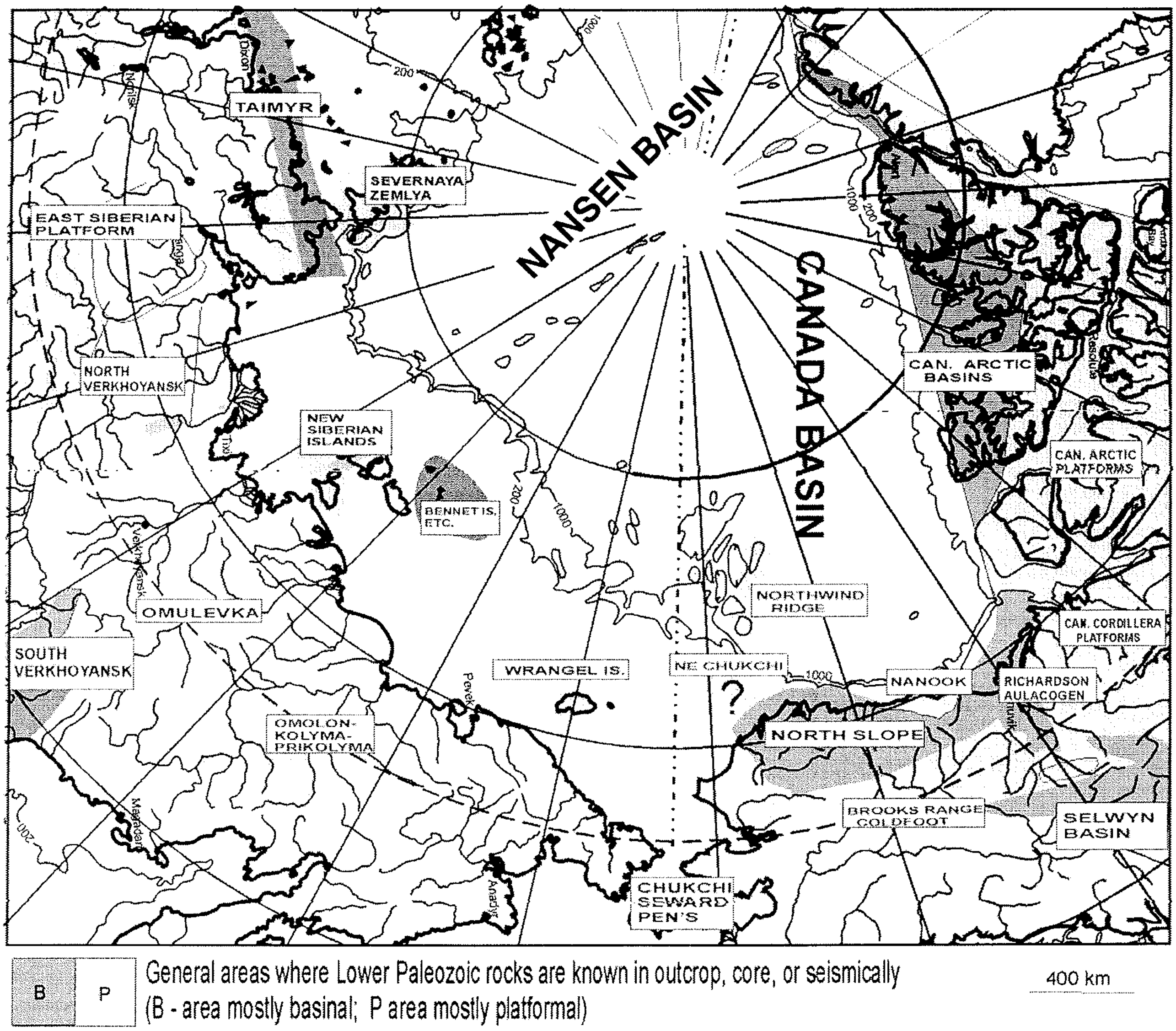

Fig. 1: Location of known Lower Paleozoic rocks around Canada Basin.

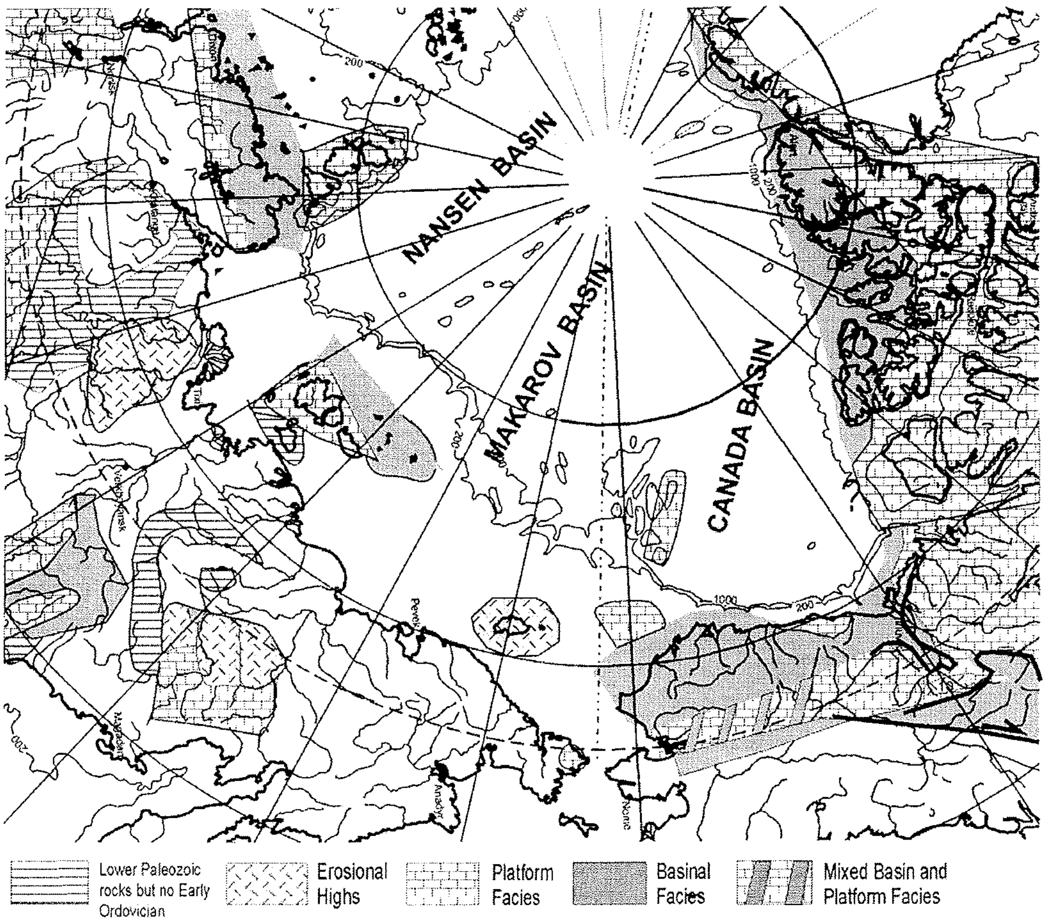

Fig. 2: General distribution of Early Ordovician facies around Canada Basin. Basinal areas generally represent outer miogeolines (ancestral continental shelves). See text for sources of data.

of thin bedded Upper Cambrian- Lower Ordovician limestone are followed by a few hundred meters of cherts interstratified with thin beds and very thick units of limestone and clastic limestone. Limestone strata include major debris flow and slope breccia units. These strata clearly have the signature of a trough filled by carbonate debris from flanking carbonate platforms, known in the subsurface east and west of the trough. These trough strata are 2-5 times thicker than miogeoclinal strata of the northwest Yukon where limestones are minor lithologies.

This configuration supports the concept that the northern margin of Laurentia in the Paleozoic was similar to what it is today. That is, it formed from a triple-rift system. The Richardson Trough (aulacogen) failed to open and the two other rifts opened to form the northern margin of Laurentia, one trending to the northeast from the Richardson Trough and the other to the west along northern Alaska. If this is correct, then it is unlikely that Alaska and the Canadian Arctic Islands were ever closely juxtaposed making a 66° counterclockwise rotation unnecessary. This configuration is also supported by DUMOLIN et al. (2000) who found that Lower Paleozoic biogeographic patterns, facies and depositional environments between northwestern and north-central Alaska and the Canadian Arctic Islands are strikingly dissimilar.

ANCESTRAL SIBERIAN ASSEMBLAGE

Correlated with ancestral Siberia (Arctic Siberian Assemblage) are the Verkhoyansk and Taimyr fold belts, on the north and east of the East Siberian Plateau, the Omolon microcontinent bordered by the Kolyma fold belt on the west, the New Siberian Islands and Omulevka blocks.

Two sides of the ancestral Siberia craton now face the Arctic (Figs. 2, 3). The northern margin is preserved as a platform-to-basin miogeoclinal facies pair in the Taimyr fold belt (KABAN'KOV et al. 1997, MALICH et al. 1987, POGREBITSKY 1971, TESAKOV 1995, VERNIKOVSKI 1996). The eastern margin is preserved in the Verkhoyansk fold belt and is well exposed in the south and partly exposed in the north. It also shows a miogeocline with platform carbonates on the Siberian craton and basin facies to the northeast (BULGAKOVA 1996, KOREN et al. 1983, ORADOVSKAYA 1988).

The central portion of the Verkhoyansk is covered in post-Lower Paleozoic strata and although platform strata of the Siberian craton are known in the subsurface, miogeoclinal basin facies are hidden, if present. However, the Omulevka block which sits some distance east of the Verkhoyansk block is dominated by a succession of Paleozoic platformal strata some of

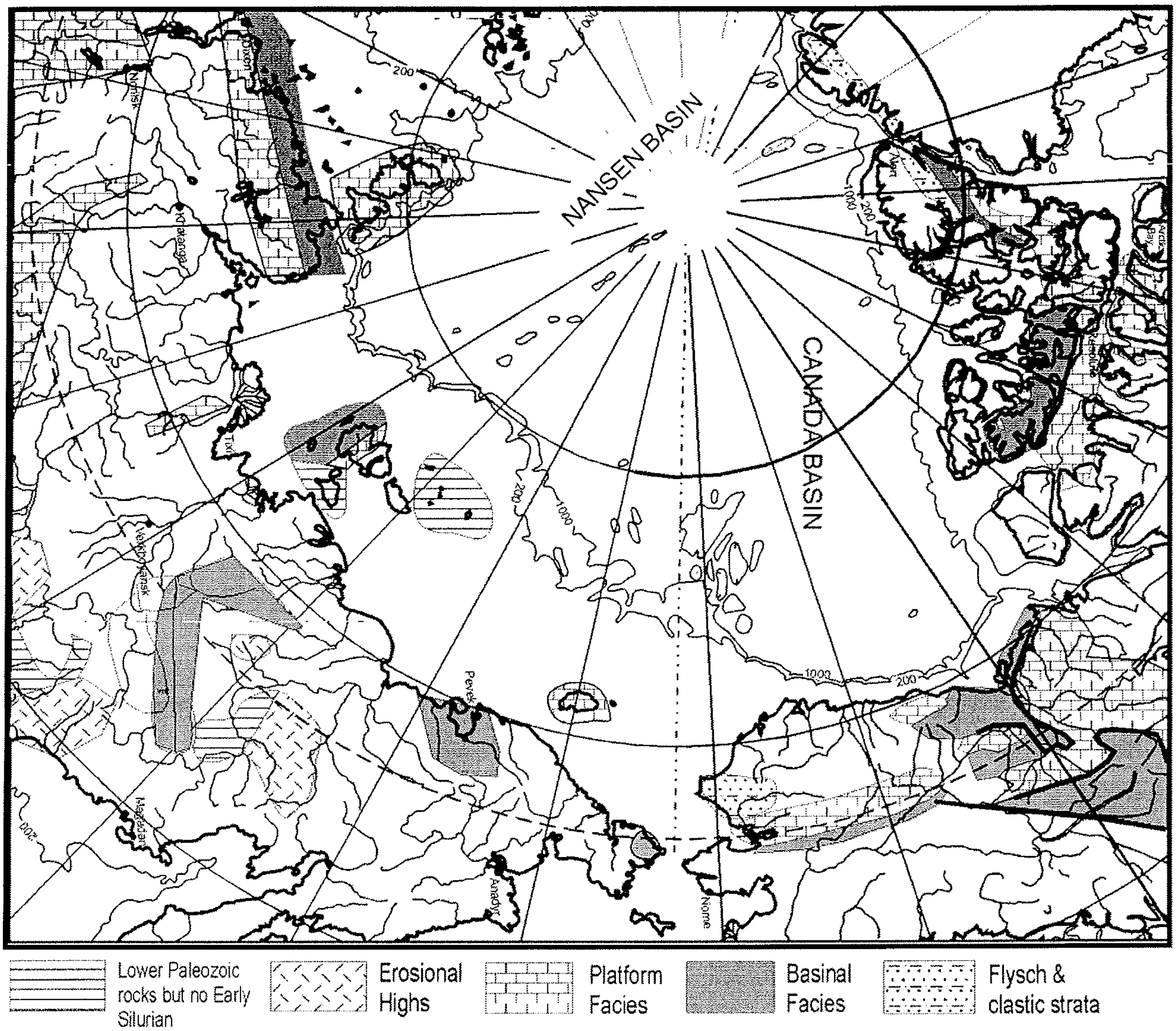

Fig. 3: General distribution of Early Silurian facies around Canada Basin. Basinal areas generally represent outer miogeoclines (ancestral continental shelves). See text for sources of data.

which are eastwardly transitional to basin facies in the north. The shape of the block suggest a good fit back into the central Verkhoyansk area and PARFENOV (1993) has suggested it rifted from there in the Devonian.

The New Siberian Islands and Bennett Island represent additional platform and miogeocline facies (KOS'KO et al. 1990) of uncertain connection to the Siberian Platform. Like the Omulevka block they may be pieces rifted away from the craton in Devonian or later time.

The Omolon massif is a large round area of crustal rocks overlain by Paleozoic platform carbonates and Devonian volcanics. The crustal component has been tied to the Siberian craton (PARFENOV 1993). However, it must have been relatively independent well before the Paleozoic because the Prikolyma fold belt on its western margin is a typically miogeoclinal succession dating back into the Proterozoic (TKACHENKO 1989).

Severnaya Zemlya is a large area of platform strata of unknown affinity.

CONCLUSIONS

The Lower Paleozoic margins of ancestral Siberia and Laurentia are preserved and exposed in northern North America and northeastern Asia. Several blocks with Paleozic strata found in Mesozoic foldbelts between the two can be associated with one or the other, with the exeception of Severnaya Zemlya. The configuration of northern Laurentia in the Lower Paleozoic appears to be very similar to its present day geometric configuration making counterclockwise rotation of Alaska unlikely and unnecessary.

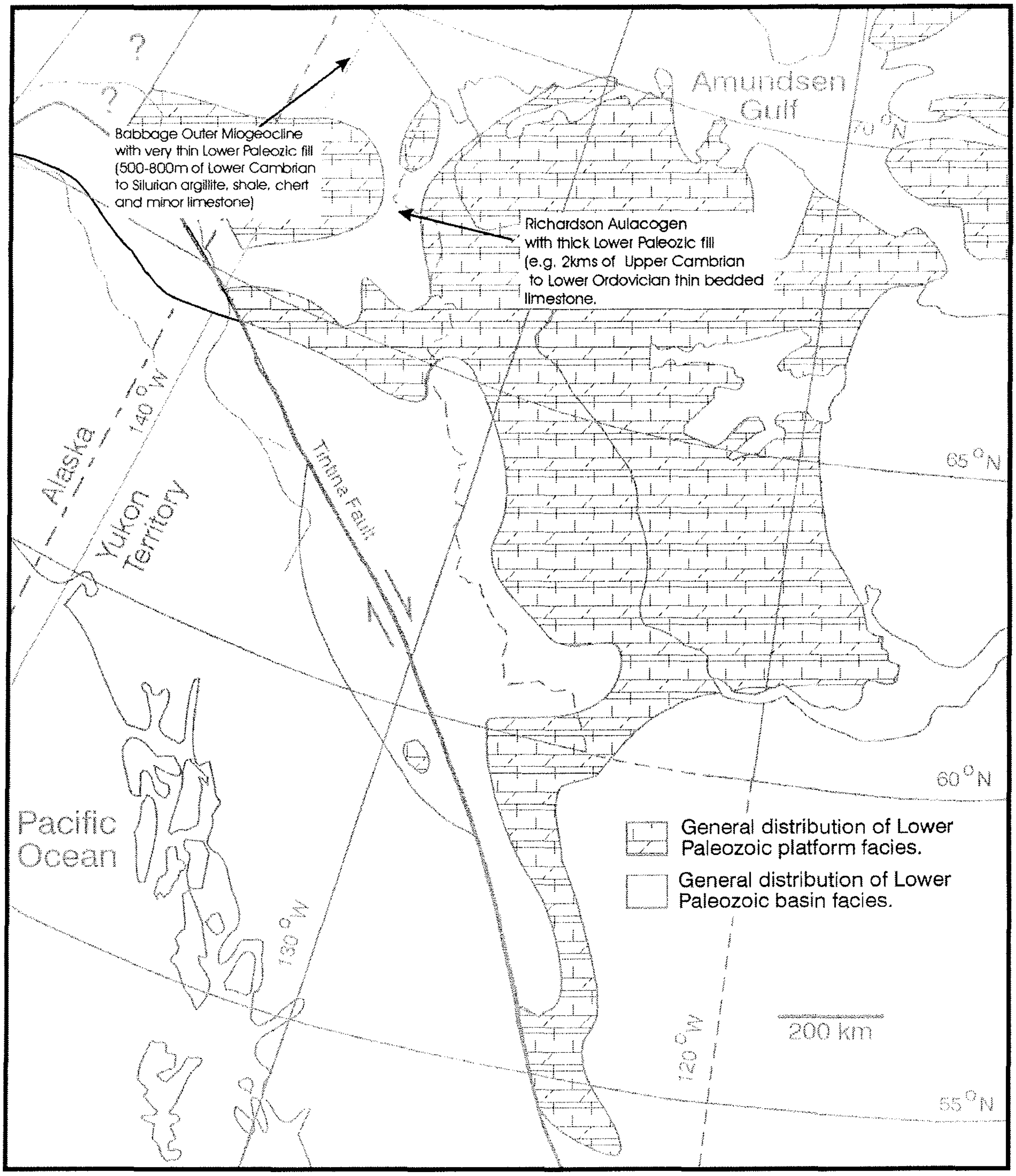

Fig. 4: Paleogeography of the Northern Canadian Cordillera highlighting facies variations from Richardson Trough (aulacogen) northwest into Babbage Basin (miogeocline); adapted from CECILE & NORFORD 1993. If Alaska had rotated away from the Canadian Arctic we would expect to see facies typical of a narrow trough extending along northern Alaska. Instead we see a transition from trough to open miogeocline supporting the hypothesis that the configuration of Alaska in the Lower Paleozoic was much like it is now and rotation is neither needed nor likely.

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