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Counterclockwise Rotation of the Arctic Alaska Plate: Best Available Model or Untenable Hypothesis for the Opening of the Amerasia Basin

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THEME 13: The Amerasian Basin and Margins: New Developments and Results

Summary: For the past thirty years the most widely accepted model for the opening of Amerasia Basin of the Arctic Ocean has been that the basin opened by counterclockwise rotation of northern Alaska and adjacent Russia (Arctic Alaska plate) away from the Canadian Arctic Archipelago about a pole in the Mackenzie Delta region. Recently LANE (1997) has called this model into question. Thus it is worth reviewing the main data and arguments for and against the model to determine if indeed it is untenable as claimed by Lane, or is still the best available model.

The main evidence in favour of the model includes the alignment of diverse geological lineaments and the coincidence of Alaskan, Valanginian paleomagnetic poles with the cratonic one following plate restoration employing the rotation model. The odds of such restored matches occurring by chance are astronomic and thus such data provide very convincing evidence for the rotation hypothesis. Recent gravity and aeromagnetic data have allowed the interpretation of a former spreading centre with flanking anomalies. The orientation of these features is compatible with the rotation hypothesis, thus adding further support to the model.

A review of the various points raised by LANE (1997) against the rotation model reveals that some arguments are based on insufficient and inconclusive data, others are unsupported interpretations and still others are based on a selective marshalling of data. Overall it is assessed that none of Lane's points argue convincingly against the rotation model and that such a model is clearly the best available one for the opening of the Amerasia Basin.

INTRODUCTION

The origin of the Amerasian portion of the Arctic Ocean (Fig. 1) has been debated since CAREY (1955) first proposed that the entire Arctic Ocean formed by oroclinal bending (counterclockwise rotation) of Alaska and adjacent Russia away from the Canadian Arctic. Since this initial proposal was advanced, the Eurasian portion of the Arctic Ocean was shown to be a northward extension of the North Atlantic spreading system and to have opened in the Tertiary. However, the origin of the Amerasian portion has remained somewhat enigmatic and numerous hypotheses, including counterclockwise rotation of Alaska and adjacent Russia, have been proposed to explain its origin. All of these various models have been described and discussed by LAWVER & SCOTESE (1990) in a comprehensive review of the subject.

As discussed by LAWVER & SCOTESE (1990), most of the models have little support and some are clearly negated by the current geological and geophysical data bases from the Amerasia Basin and its margins. At the time when the LAWVER & SCOTESE (1990) review was published only the counterclockwise model seemed to provide a reasonable explanation of available paleomagnetic, paleogeographic and tectonic data from the margins and geophysical data from the basin (Grantz et al. 1979, HALGEDAHL & JARRARD 1987, EMBRY 1990, LAWVER et al. 1990).

Recently LANE (1997) challenged the counterclockwise rotation model and raised a number of points which he believed make the hypothesis untenable. LANE (1994, 1997) also proposed an alternative model which was a variation of that presented by VOGT et al. (1982).

It is important to realize that the question of the opening of the Amerasia Basin is a historical one and thus we can never know with absolute certainty if any given model is the correct one (the "truth"). The best we can do is to weigh the evidence for and against all the various hypotheses and accept the one which best fits the evidence as the best available model. This exercise must be repeated whenever new data which bear on the problem are produced. Thus, in this paper, the evidence for and against the rotation model are examined and discussed in terms of their robustness for supporting or negating the validity of the model. Also, important new data, recently published by GRANTZ et al. (1998) on the Chuckchi Borderland (Fig. 1), are used to evaluate the validity of the LANE (1994, 1997) model as well as the rotation one.

EVIDENCE IN FAVOUR OF THE COUNTERCLOCKWISE ROTATION MODEL

The clearest and most convincing evidence for understanding the evolution of an oceanic basin is derived from the identification of spreading centres, magnetic anomalies and fracture zones. Unfortunately such features are not readily definable in the Amerasia Basin although, as will be subsequently discussed, attempts have been made to decipher such elements.

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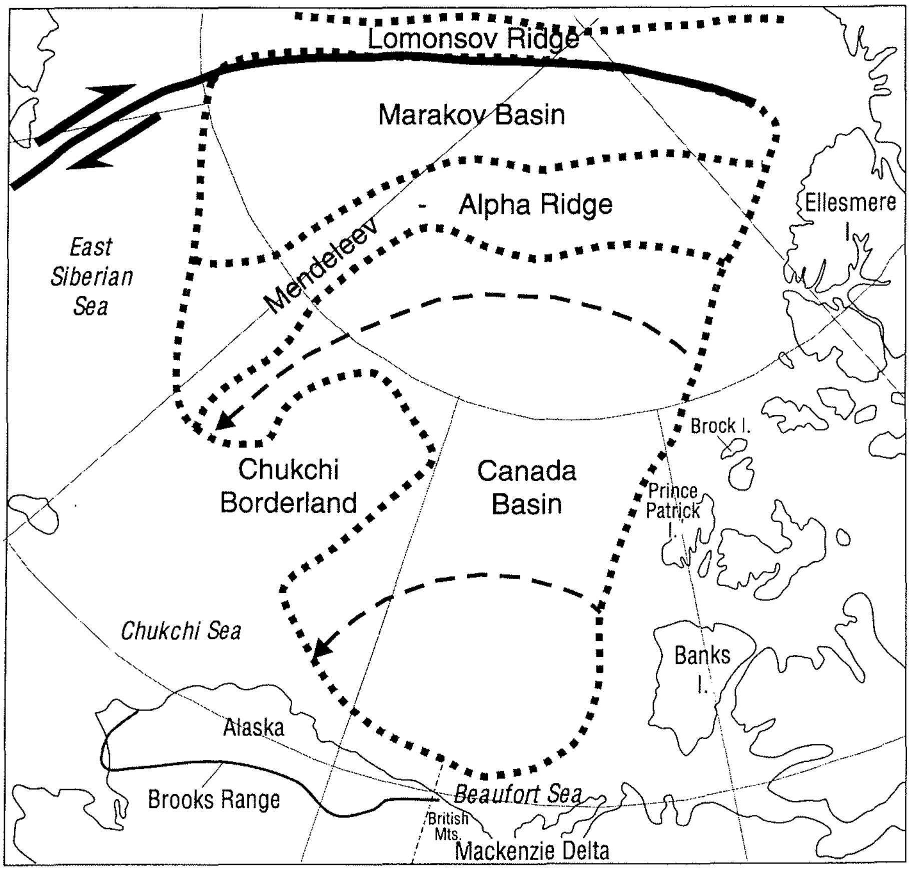

Fig. 1: The main geographic features of the Amerasia Basin and its margins. The counterclockwise rotation model for the opening of the basin proposes that the Arctic Alaska plate (northern Alaska and adjacent Russia) rotated counterclockwise about a pole in the vicinity of Mackenzie Delta. Such a model necessitates the existence of a major transform fault at the base of Lomonovsov Ridge.

Two other types of information also provide strong evidence for supporting a given plate reconstruction model. These are (1) a match of geological and/or geophysical lineaments and features on the juxtaposed margins of the pre-drift reconstruction and (2) a coincidence of paleomagnetic poles following plate restoration. These lines of evidence do not provide kinematic information but they do constrain the initial, pre-drift positions of the plates. Such positioning of course constrains possible subsequent movements which resulted in the current plate locations. Data which pertain to both of these methods are available for the Amerasia Basin and, as is demonstrated below, both provide robust support for the counterclockwise rotation model.

Paleomagnetic data

HALGEDAHL & JARRARD (1987) determined the paleomagnetic pole of a Valanginian sandstone (Kuparuk River Formation) from oriented cores from two wells on the north coast of Alaska. Notably the two determined poles were very similar and were over 1000 km southeast of the cratonic pole for the same age, indicating that their study area on northern Alaska had indeed moved in respect to cratonic North America. As clearly illustrated by HALGEDAHL & JARRARD (1987), a 66 degrees clockwise rotation of northern Alaska, which restores it snugly up against the Canadian Arctic Islands, results in the coincidence of the Alaska Valanginian poles with that of the craton. Thus the paleomagnetic data strongly support the counterclockwise rotation model.

LANE (1997) regards such evidence as "tentative" due to a lack of other sites and the possibility of errors due to steep inclinations and of remagnetization. LANE (1997) would have us believe it is quite possibly pure chance that the carefully determined poles from two locations end up coinciding with the cratonic pole after they are rotated 66° as required by the counterclockwise rotation model. Clearly the odds of such a chance coincidence of the poles, using a large amount of movement determined by a previously proposed model, are exceedingly high. Thus common sense dictates that the paleomagnetic results of HALGEDAHL & JARRARD (1987) must be regarded as persuasive evidence rather than as "tentative" data.

Geological lineaments and features

EMBRY (1990) compared a variety of geological lineaments and features along the rifted northern edge of the Alaska plate with those of the Canadian Arctic and showed that the plate restoration using the counterclockwise rotation model resulted in a number of reasonable and consistent continuities. Two well constrained lineaments which intersect the margins at a high angle are the Triassic basin axes and Triassic shorelines for both the Hanna Trough of offshore Alaska (GRANTZ & MAY 1987, THURSTON & THEISS 1987) and the Sverdrup Basin of the Canadian Arctic (EMBRY 1991). As demonstrated by EMBRY (1990) and shown in Figure 2, these two lineaments are closely aligned with a plate restoration which uses the counterclockwise model as its basis.

LANE (1997) dismissed the importance of these well constrained, aligned lineaments by noting that such information is not kinematic and that "they do not preclude other models". As noted earlier, they do not provide kinematic information but that is irrelevant to the argument at hand. The key point is that these identified lineaments can readily be aligned with a restoration of the Arctic Alaska plate up against the Canadian Arctic as proposed by the counterclockwise model. Furthermore, the odds of such a match being pure chance are so high that it is not reasonable to seriously consider such a possibility.

BURCHFIELD & ROYDEN 1985). In the Alaska-northern Yukon area the relationships between the foreland deposits and the hinterland are not as clear due to major Cretaceous-Tertiary deformation. In the northern Yukon the identified foreland deposits are Late Devonian in age (Imperial Formation) and they were deformed in latest Devonian-Early Carboniferous (BELL 1974). In northern Alaska there is some controversy as to the identification of foreland deposits. Most authors (e.g. NILSEN & MOORE 1982) have interpreted the thick fluvial deposits of the Upper Devonian Kanayut Formation as the foreland deposits. Notably this unit is the only possible candidate for foreland deposits within the Silurian-Devonian succession of the area because underlying deposits are shales and carbonates. MOORE et al. (1994) have suggested that the Upper Devonian fluvial strata are possibly passive margin deposits rather than syn-orogenic foreland deposits. Unfortunately they did not offer an explanation for the complete lack of foreland deposits for the Devonian orogenic belt of northern Alaska which would be the consequence of such an iconoclastic interpretation. MOORE et al. (1994) adopted the passive margin interpretation mainly because of the scattered occurrence of Middle-Upper Devonian clastic deposits in the hinterland but, as demonstrated in the Canadian Arctic, clastic deposits in the hinterland can be coeval with overall convergence and the bulk of the preserved deposits in the foreland basin. Thus it would appear that the Devonian geologic features of the Arctic Alaska plate are very similar to those of the Canadian Arctic with a highly deformed and intruded hinterland which experienced a succession of deformation events, including depositional episodes, from Silurian to earliest Carboniferous and an adjacent foreland with mainly Upper Devonian coarse clastics that were deformed in latest Devonian-earliest Carboniferous.

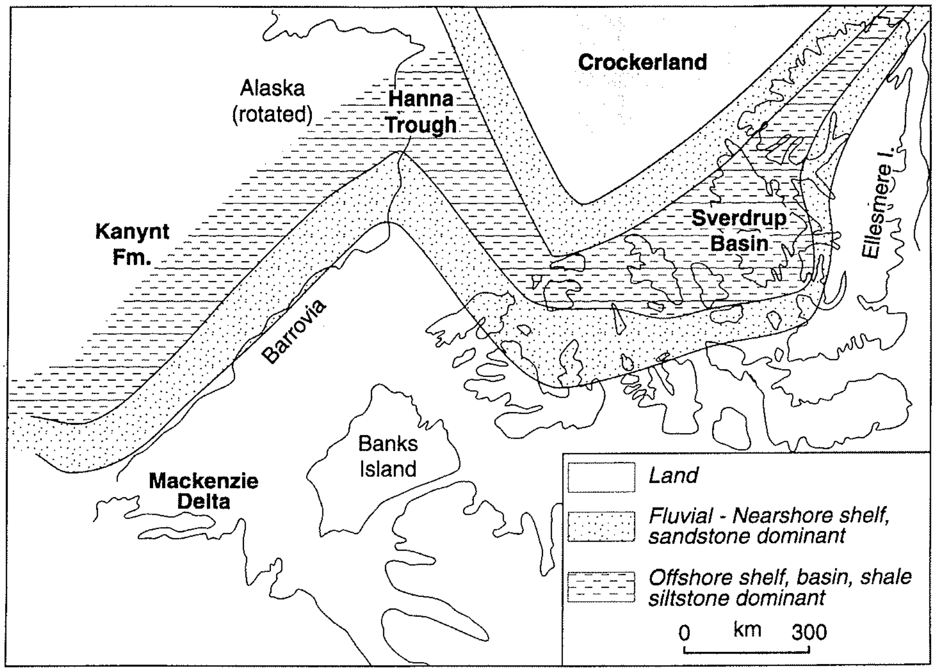

Fig. 2: Early Triassic paleogeography plotted on a plate restoration based on the rotation model. On this restoration well constrained lineaments such as Triassic shorelines and basin axes, recognized on both the Alaskan and Canadian margins, become perfectly aligned.

The other and more contentious geological features which were reconciled by the rotation model were related to the Devonian tectonic features of northern Alaska and the Canadian Arctic. As shown in Figure 3 and discussed in detail by EMBRY (1990), the rotation restoration resulted in a continuity of a Devonian orogenic belt and its associated foreland deposits. Notably, in both northern Alaska and the Canadian Arctic Islands, the highly deformed strata, which range in age from Proterozoic to earliest Devonian, are overlain by deposits of relatively undeformed Middle-Upper Devonian strata (Fig. 3). Thus in both areas the compressive deformation in the hinterland was mainly Early Devonian and older (TRETTIN 1991, MOORE et al. 1994) and deposition of clastic strata occurred during Middle-Late Devonian in scattered areas within the hinterland. Furthermore, granitic intrusions dated as near the Early-Middle Devonian boundary (~390 MA) are present in Alaska, northern Yukon and the Canadian Arctic Islands (TRETTIN 1991, MOORE et al. 1994, LANE 1997).

In the Canadian Arctic the preserved syn-orogenic foreland deposits are Middle-Upper Devonian and were folded and uplifted in latest Devonian-earliest Carboniferous (EMBRY 1988). This indicates that convergence and compression were coeval with sporatic deposition in the hinterland in Middle-Late Devonian, a phenonomen which is common in major orogenic belts (e.g.

LANE (1997) claimed that the Devonian features of the Arctic Alaska plate do not match those of the Canadian Arctic by

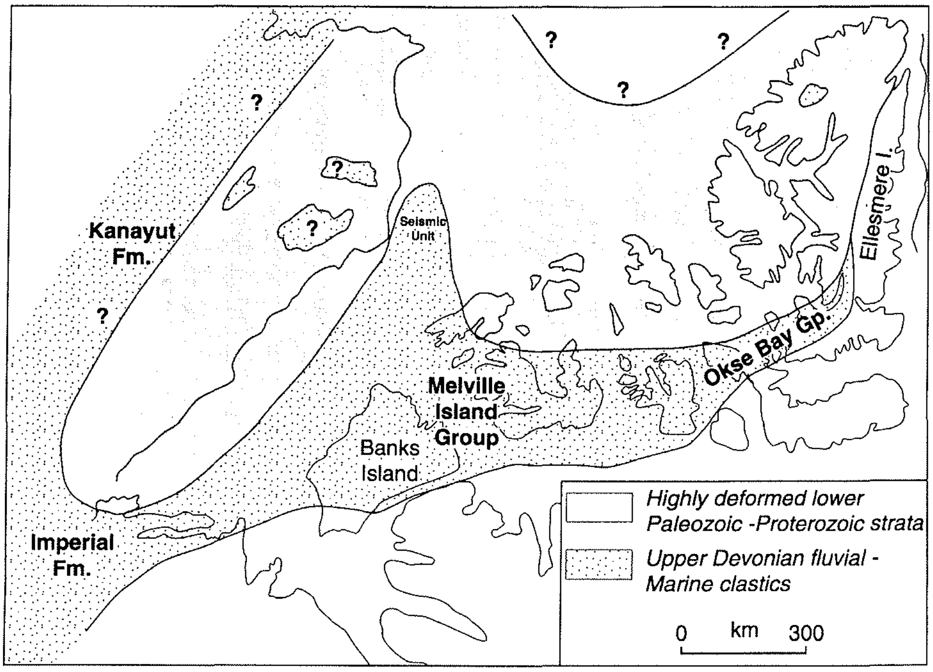

Fig. 3: Devonian-Early Carboniferous orogenic belts and associated foreland deposits plotted on a plate restoration based on the rotation model. Such a restoration results in a continuous orogenic belt from Ellesmere Island to northern Yukon. Note that isolated patches of relatively undeformed Middle-Upper Devonian clastic strata occur within the highly deformed hinterland area of both northern Alaska and the Canadian Arctic Islands.

focussing on the Middle-Upper Devonian deposition and presumed extension at scattered localities in the hinterland of northern Alaska and contrasting it with the latest Devonian-Early Carboniferous compression of the foreland in the Canadian Arctic. He claimed it was not reasonable to restore an area undergoing extension (Alaska) with one experiencing compression (Canadian Arctic). However, it is essential to realize that he ignored the Middle-Upper Devonian clastic deposits of the Canadian Arctic hinterland and the evidence for latest Devonian-Early Carboniferous compression in the foreland in northern Yukon. To strengthen his case he also cites Moore et al.'s (1994) speculative interpretation of the Upper Devonian fluvial strata of northern Alaska being passive margin deposits which, as indicated above, has little to recommend it. Thus Lane's (1997) selective comparison of Alaskan hinterland extensional tectonics with compressive tectonics of the foreland in the Canadian Arctic and consequent claim that they do not match is not a viable argument against the impressive similarities of the Devonian tectonic and sedimentological features of the two areas. The rotational model results in a satisfying reconstruction of a continuous Devonian orogenic belt and flanking foreland deposits which stretched from northeast Greenland to the northern Yukon. Such a reasonable restoration provides further support to the validity of the rotation model.

Potential Field Data

The gravity and magnetic data from the Amerasia Basin do not show a clear, unequivocal pattern which would allow the spreading history of the basin to be determined. Recently collected and analysed gravity and magnetic data from the southern part of the basin have allowed confirmation of the existence of a major, north-trending gravity low which bisects the basin and terminates in the Mackenzie Delta (Brozena et al. 1998). This has been interpreted as an extinct spreading centre and such an interpretation is compatible with the rotation model. Notably a bilaterally symmetric pattern of magnetic lineations some 300 km wide is centred over the gravity low (Brozena et al. 1998). As noted by Brozena et al. (1998), who have analyzed the latest potential field data collected from the basin, "the overall pattern remains consistent with the formation of the southern Canada Basin by rotation of the North Slope away from the Canadian Margin around a set of poles somewhere near the Mackenzie Delta".

When one considers that the potential field data indicate that the Amerasia Basin opened by counterclockwise rotation of the Arctic Alaska plate away from the Canadian Arctic Islands and that such a plate restoration results in a coincidence of prespreading paleomagnetic poles and the alignment of a variety of distinctive, well constrained geological lineaments, it is clear that the rotation model is exceedingly well supported by a diverse and robust data set.

EVIDENCE AGAINST THE COUNTERCLOCKWISE ROTATION MODEL

In this section the various points which Lane (1997) has advanced as evidence against the rotation model are briefly described and are then discussed as to their validity and their impact on the rotation model. Another line of evidence, which Dumoulin et al. (1998) have suggested as being problematic for the rotation hypothesis, is also reviewed.

Middle Paleozoic Tectonics.

Lane (1997) claimed that the rotation model juxtaposes an area which was undergoing extension in the Middle-Late Devonian (northern Alaska) with one which was undergoing compression

(Canadian Arctic). As previously discussed, the argument is based on a very selective marshalling of data. When all the data are considered from both the hinterland and the foreland of both areas, the Devonian tectonics of the two areas show remarkable similarities in terms of timing of deformation and intrusion, structural trends, depositional episodes, foreland development and foreland deformation. Thus this point argues strongly in favour of rotation rather than against it.

Rift-drift ages

Lane (1997) interpreted the age of the rift-drift transition of the northern Alaska margin to be about 130 ma and that of the Canadian margin to be 100 ma. He thus claimed that the two margins could not have been juxtaposed.

The major fallacy in this argument is that there are no reliable data to determine with any confidence the age of the start of drift for the Canadian margin. Lane (1997) based his interpretation for this margin partly on an outdated seismic interpretation by Meneley et al. (1975) which postulated that faulted Lower Cretaceous strata lay beneath unfaulted Upper Cretaceous strata on northernmost Ellef Ringnes Island (see Lane, Fig. 9). It was established many years ago that the youngest strata beneath the Upper Cretaceous in this area are Early Jurassic rather than Early Cretaceous in age and this was published by Dixon et al. (1990). Thus such data do not allow the age of breakup to be determined.

The information from both Meighen and Prince Patrick islands, which Lane (1997) cites to support his interpretation, is also not precise enough to allow the age of breakup to be determined. Meighen Island data (Brent & Embry 1995) have no age constraints beyond Upper Cretaceous strata unconformably overlying Upper Triassic strata. The Prince Patrick Island area has faulted Neogene strata resting on faulted Albian strata (Harrison et al. 1988). Lane (1997) also appeals to the subsidence history of the Sverdrup Basin to support his interpretation but such data have no obvious linkage to Amerasian events and circular reasoning becomes a problem. Finally it should be noted that Lane (1997) assumes an earliest Cretaceous age (125 Ma) for rift-drift transition of the margin adjacent to the Arctic Islands in his model (Lane 1997, Figs. 15, 16). This is inconsistent with his claim that the rift-drift transition is 100 Ma (Lane 1997, Fig. 7) but is consistent with the rotation hypothesis.

It should also be mentioned that all the basins in the Arctic were affected by a tectonic episode during the Cenomanian (~95 MA) and this event may well have been global in extent. Currently there are no data or reasonable arguments which tie this episode to the rift-drift transition for the Arctic Islands continental margin.

Beaufort Sea Margin Offset

On the basis of potential field data and deep seismic reflection surveys, Stephenson et al. (1994) interpreted the existence of a spur in the continent-ocean boundary in the southwestern Beaufort Sea (Fig. 4). Lane (1997) *a priori* interpreted the eastern side of the "spur" as a fracture zone (Fig. 4B) and claimed that the orientation of such a fracture zone was not compatible with the rotation hypothesis. However one can just as easily interpret (speculate) that the eastern flank of the spur is an extensional margin and that the west-facing margin is a fracture zone (Fig. 4A). Such an interpretation would be compatible with the rotation hypothesis. In summary the nature of the boundaries of the interpreted spur in the continent-ocean boundary is equivocal and thus does not bear on the validity of the rotation hypothesis.

Northern Yukon Tectonics

The British Mountains of the northern Yukon are the eastward continuation of the Brooks Range of northern Alaska (Fig. 1). Lane (1997) has interpreted that, because the pivot for the rotation hypothesis is in the adjacent Mackenzie Delta, the Brit-

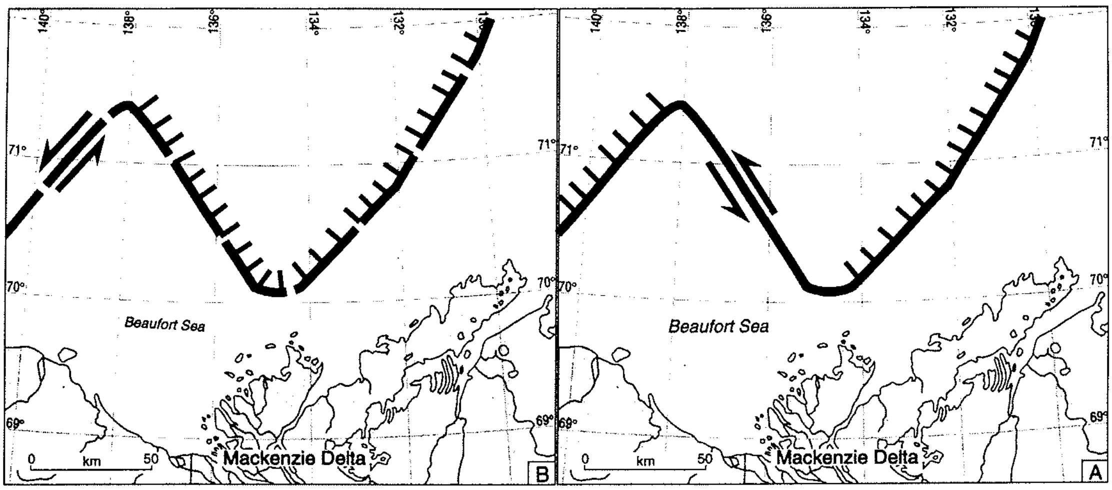

Fig. 4: The spur in the continent-ocean boundary which has been identified by Stephenson et al. (1994). (A) The east-facing flank of the spur interpreted as a rifted margin. (B) Lane (1997) interpreted the east facing flank as a fracture zone.

ish Mountain area should have experienced compression during the Early Cretaceous when the Arctic Alaska plate was rotating. LANE (1997) claimed that all the deformation in this area is no older than latest Cretaceous.

This argument against rotation carries little weight for several reasons. First of all the structural geology of the British Mountains is still known only on a reconnaissance scale and published maps (1:250,000 scale) are based mainly on airphoto interpretation (Lane, pers. comm. 1998). Furthermore, it is well established that deformation in the Brooks Range of adjacent Alaska began in Late Jurassic and substantial deformation occurred throughout the Early Cretaceous as well as later in the Late Cretaceous and Tertiary (MOORE et al. 1994). Thus it seems unreasonable that all pre-Late Cretaceous tectonic activity in this mountain range abruptly stopped at a political (Alaska-Yukon) border. Finally it should be noted that the location of the pole of rotation is not fixed and may well have been south of the Mackenzie Delta (A. Grantz, pers. comm., 1998). This would have resulted in little compression in the northern Yukon region during Early Cretaceous. Overall this argument has little to recommend it and does not support the proposition that the rotation model is not tenable.

Lomonosov Transform

Lane (1997) noted that the rotation model demands the existence of a major transform fault along the base of the Lomonosov Ridge (Fig. 1) and that there is no evidence for its existence. Both of these points are correct and more importantly there are no data which indicate that it does not exist. Thus, this point is of no value until evidence is obtained which support or deny the existence of such a fault

It is worthwhile noting that recently COAKLEY & COCHRAN (1998) collected gravity and bathymetric data from the flank of the Lomonosov Ridge. Their preliminary interpretation is that "the Greenland end of the Lomonosov Ridge is a transform margin and that the Siberian portion of the Lomonosov Ridge is an oblique sheared margin". As noted by the authors, such an interpretation is "compatible with the rotation model".

Margin Geometry

LANE (1997) reiterated the frequently cited argument that the rotational model is not valid because there is substantial overlap of the Chukchi Borderland and the east Siberian Shelf onto the Canadian landmass when the Arctic Alaska plate is rotated 66° counterclockwise. This issue has been dealt with by previous authors (e.g. GRANTZ et al. 1979) and most of the overlap of the Siberian Shelf can be accounted for by crustal extension which occurred during rifting. The Chukchi Borderland is a marginal plateau, a type of appendage which seems to characterize many continental margins (e.g. Flemish Cap on the Atlantic margin). As postulated by GRANTZ et al. (1979), it likely originated by extension of the Siberian margin and may possibly consist of a number of displaced blocks (GRANTZ et al. 1998).

An alternative hypothesis to explain the noted overlap is a slightly modified rotational model which postulates major transform faults occur on the eastern and western margins of the Chukchi Borderland and which requires spreading rates and directions to have varied somewhat for the three different major segments of the Amerasia Basin (Fig. 5). It must be noted that this model is very speculative.

In summary the presence of a marginal plateau does not constitute a major failing of the rotation hypothesis and the origin of such a plateau can be easily accommodated within the model.

Mantle Anisotropy

MAIR & LYONS (1981) interpreted a seismic P-wave velocity anisotropy of 3 % for the upper mantle in the southern Amerasia Basin with the maximum velocity having an orientation of 346°. It has been hypothesized that the maximum velocity direction is parallel to mantle flow and thus is a good kinematic indication of direction of spreading (HESS 1964). As was noted by MAIR & LYONS (1981), the recorded direction is about 50° from the spreading direction predicted by the rotation model for this locality.

The MAIR & LYONS (1981) result is not readily compatible with the rotation hypothesis. Interestingly it is not compatible with any proposed model for the opening of the Amerasia Basin including that of LANE (1994, 1997). With the current data base it is impossible to evaluate the robustness of this single data point. Until more maximum P velocity directions are obtained from various areas of the basin, this one value must remain an interesting curiosity whose meaning is obscure.

Lower Paleozoic Fauna and Facies

DUMOULIN et al. (1998) recently compared the facies and fauna (mainly conodonts) of the Ordovician and Silurian strata of the Brooks Range of northern Alaska with those found in the Canadian Arctic Islands. They found substantial differences in both facies patterns and faunal affinities with the Alaskan strata having both Siberian and North American affinities and the Canadian Arctic strata having only North American affinities. They interpreted these differences as evidence against the rotation model.

DUMOULIN et al. (1998) appear not to have considered the palinspastic location of the Lower Paleozoic strata of the Brooks Range when they compared the strata with those of Arctic Islands areas. When northern Alaska is juxtaposed against the Canadian Arctic Islands the present position of the Brooks Range is about 400 km from the Arctic Islands. However it is critical to realize that the Ordovician-Silurian strata have been translated to this relatively nearby position by two major post-Silurian orogenies, the Devonian-Early Carboniferous

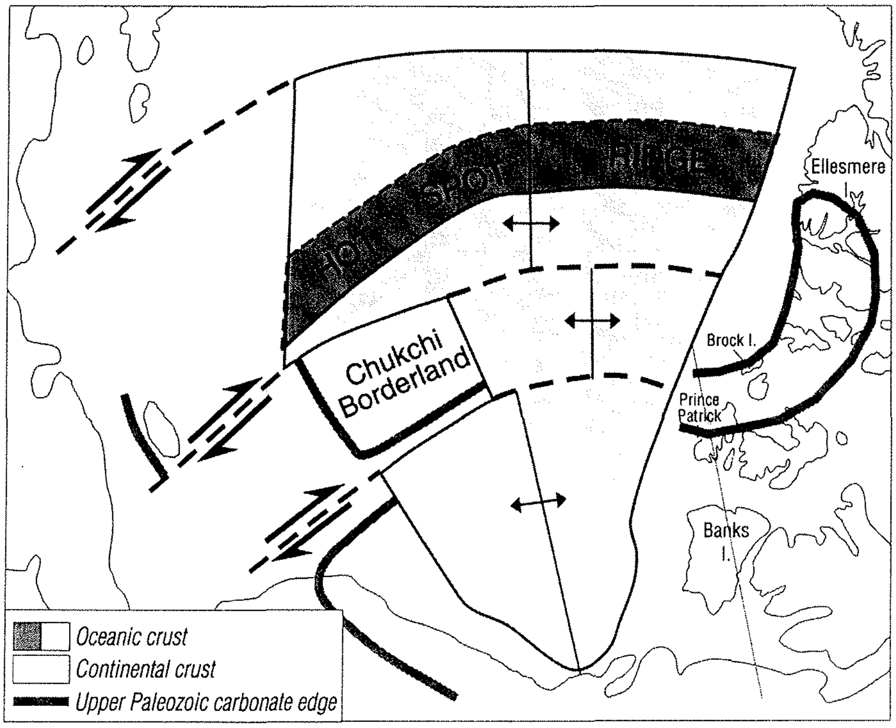

Fig. 5: A schematic representation of a slightly modified rotation model with three main segments of spreading separated by major transform faults. Slower spreading in the middle segment would result in a marginal plateau, the Chukchi Borderland.

Ellesmerian Orogeny and the Late Jurassic-Tertiary Brookian Orogeny (MOORE et al. 1994). The shortening connected with both these orogenies is large. It has been estimated that the Brooks Range strata were translated up to 1000 km northward in the Late Jurassic-Tertiary (MOORE et al. 1994, MAYFIELD et al. 1988). Shortening connected with the earlier Ellesmerian Orogeny is very difficult to estimate but, given the near vertical orientation of the strata in many areas and the sizeable width of the deformed belt (300 km+) (Fig. 3), shortening was at least 500 km and may well have approached 1000 km. Thus the Ordovician-Silurian strata could have been as much as 2000 km away from equivalent strata of the Canadian Arctic and were probably on a separate tectonic plate. Thus it is not surprising that facies and faunal differences occur between two widely separated areas and consequently such differences have no bearing on the question of the validity of the rotation model.

Summary

The geological and geophysical data presented by LANE (1997) and DUMOULIN et al. (1998) which supposedly are not compatible with a rotation model, are irrelevant to the debate, are too incomplete to evaluate or, in fact, are supportive of the model. Thus it would appear that there are currently no data which negate the rotation model or even indicate that it is unlikely.

EVALUATING THE ROTATION AND LANE MODELS WITH NEW DATA

As mentioned in the introduction, new data from the Amerasia Basin and its margins allow the validity of various models to be further tested. Recently GRANTZ et al. (1998) recovered bedrock samples from the eastern flank of the Chukchi Borderland (Northwind Ridge) and these have been dated and assigned to general environments of deposition. Because some of these samples are pre-Jurassic in age, such data provide important new constraints on the position of the Chukchi Borderland before the opening of the Amerasia Basin. For any proposed model, the pre-drift location of Chukchi Borderland should be in a position such that facies now identified on the Borderland fit with the established regional facies patterns on the margins of the Amerasia Basin.

As described earlier, in the rotational model, the Chukchi Borderland has not moved far, if at all, from its present position outboard of the Chukchi Sea which contains the Hanna Trough. In contrast, the LANE (1994, 1997) model postulates that the Chukchi Borderland was translated to its current position about 600 km from an original position in the southeastern corner of the Amerasia Basin offshore of Tuktoyaktuk Peninsula and Banks Island (see LANE 1997, fig. 15). The samples collected and analyzed by GRANTZ et al. (1998) allow an evaluation of the reasonableness of each of these postulated locations.

For such an evaluation critical samples include Lower Triassic deep water shales and sandstones and Permian shelf carbonates which were among the bedrock samples obtained from Chukchi Borderland. In the rotation hypothesis Chukchi borderland remains adjacent to Hanna Trough in the Chukchi Sea and also becomes juxtaposed with the southwestern portion of the Sverdrup Basin in the vicinity of Brock Island (Fig. 2). Deep water Lower Triassic strata and Permian carbonates occur in both areas (DAVIES & NASSICHUK 1991, EMBRY 1991, THURSTON & THEISS 1987) and, as shown on Figure 6, this postulated position of Chukchi Borderland is very compatible with established regional facies trends.

The LANE (1994, 1997) model places Chukchi Borderland adjacent to the Arctic Platform on which Upper Jurassic-Cretaceous strata everywhere unconformably overlie Devonian and older strata (Fig. 6). The closest occurrences of Lower Triassic deep water shales and sandstones are in the Brock Island area, 700 km to the north (EMBRY 1991) and the eastern Brooks Range, 700 km to the west (MOORE et al. 1994). Furthermore, regional facies trends indicate that Lower Triassic sediments were never deposited anywhere near the position postulated by LANE (1994, 1997) (Fig. 2). Thus it would appear that the Lane model does not provide a reasonable Lower Triassic facies reconstruction and this severely downgrades its plausibility.

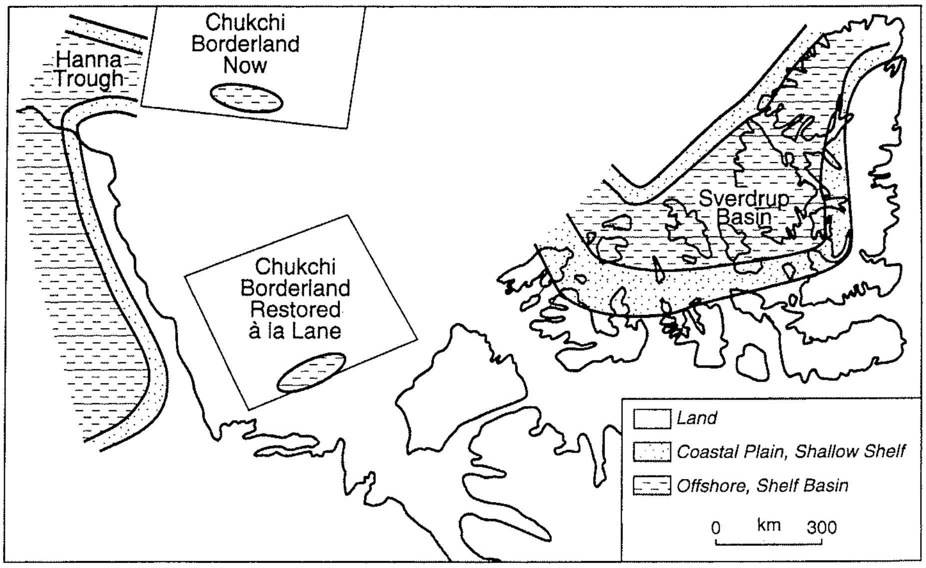

Fig. 6: An evaluation of postulated pre-drift positions of the Chukchi Borderland using Lower Triassic facies distribution (EMBRY 1990). A pre-drift position which coincides with its current position, as advocated by the rotation model, is completely compatible with the regional Lower Triassic facies pattern. A position in the southeastern corner of the Amerasia Basin, as postulated by VOGT et al. (1982) and LANE (1994, 1997), is not compatible with the regional Lower Triassic facies pattern in the Arctic.

CONCLUSIONS

The available geological and geophysical evidence for the Amerasia Basin and its margins are compatible with the counterclockwise rotation of the Arctic Alaska plate model. Such a restoration results in the coincidence of earliest Cretaceous paleomagnetic poles from northern Alaska and the craton and the alignment of distinctive and well constrained geological lineaments. Furthermore, a possible spreading centre and flanking magnetic anomalies which have been delineated on recently obtained gravity and magnetic data support such a model for the opening of the basin. Recently raised objections to the model are inconsequential and have little or no bearing on its validity. Bedrock samples recently collected from the eastern flank of the Chukchi Borderland indicate that it has not moved very far from its present position near Hanna Trough, as predicted by the rotation model. Models which have postulated that the Chukchi Borderland was originally positioned in the southeast corner of the Amerasia Basin are not consistent with the occurrence of Upper Paleozoic carbonates and Triassic shales on the eastern flank of the Borderland and are thus best regarded as implausible.

The hypothesis that the Amerasia Basin opened by the counterclockwise rotation of northern Alaska and adjacent Russia away from the Canadian Arctic Islands is currently the best available model for the origin of that portion of the Arctic Ocean.

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