The Initiation of the Rift Phase of the Amerasia Basin (Arctic Ocean)

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Summary

The timing of the initiation of the rift phase of the Amerasia Basin of the Arctic Ocean has been debated for many years. To help constrain the age of this event, ages of detrital zircons from Triassic-earliest Cretaceous sandstones from northern Sverdrup Basin have been compiled. Pre-Rhaetian sediment supply from a land area to the north of Sverdrup Basin was relatively high and included numerous zircons with a near depositional age. Such zircons indicate that the pre-Rhaetian sediments were in part derived from a distal, active margin and that a large integrated drainage system was present over the northern land area upon which the Amerasia Basin subsequently formed.

Following early Rhaetian uplift, sediment supply from the north was greatly reduced and the detrital zircons are all substantially older than the depositional age of the strata in which they occur. These data suggest that starting in early Rhaetian the northern land area was dissected by rift valleys and only local drainage from a rift shoulder reached northern Sverdrup Basin. Thus we interpret that the rift phase of the Amerasia Basin started in earliest Rhaetian.

Introduction

The Arctic Ocean is divided into two main basins, Eurasia and Amerasia. The Eurasia Basin has long been accepted to have opened in the Cenozoic by sea floor spreading as a northward continuation of the North Atlantic Ocean Basin. In contrast, the origin of the Amerasia Basin has been debated for the past 45 years.

Favoured Model

The favoured model for the opening of the Amerasia Basin is counterclockwise rotation of northern Alaska and adjacent NE Russia away from the Canadian Arctic Archipelago in Jurassic and Early Cretaceous (Grantz et al, 2011). This geometric model is well supported by the restored alignment of various linear geological features. These features include Late Paleozoic- Mesozoic basin axes, Triassic facies boundaries, Late Paleozoic to Triassic erosional edges, and Devonian structural and depositional trends (Embry, 2000). Additional strong support for the model is provided by matching magnetic anomalies which flank a well defined, extinct spreading ridge which in turn bisects the basin as predicted by the model (Grantz et al, 2011).

The opening of the Amerasia Basin included both a rift phase and a sea floor spreading phase. Grantz et al (2011) have interpreted that much of the Amerasia Basin is underlain by transitional, hyper-extended, continental crust and exhumed mantle which formed during the rift phase of basin formation. Only the central portion of the basin is interpreted to be underlain by oceanic crust formed by sea floor spreading. This crustal model is corroborated by recent seismic refraction data collected in the southern portion of the basin (Mosher et al, 2012). There is widespread consensus that the sea floor spreading phase of opening began in the early Hauterivian (Early Cretaceous) and this event is marked by a major unconformity in basins around the margins of the Amerasia Basin (Embry and Dixon, 1994). However, the timing of the start of the earlier rift phase of basin formation has remained uncertain with various ages having been proposed over the last 30 years.

Previous Interpretations

Grantz and May (1983) offered the first, reasonably well documented interpretation for the initiation of rifting of the Amerasia Basin. They recognized a major graben structure (Dinkum Graben) on seismic data from the continental shelf north of Alaska. The master fault of the graben paralleled the margin of the Amerasia Basin and consequently Grantz and May (1983) interpreted the start of rifting to be age equivalent to the strata at the base of the graben-fill. The strata are not been penetrated by the drill but were interpreted to be earliest Jurassic on the basis of correlations to wells to the south. These Jurassic strata (Kingak Fm) are underlain by a widespread unconformity with the youngest strata beneath the unconformity being late Norian (Late Triassic) in age (Houseknecht and Bird, 2004).

Embry and Dixon (1994) offered an alternative interpretation for the initiation of rifting on the basis of stratigraphic and structural studies in the southwestern portion of Sverdrup Basin, Canadian Arctic Archipelago. In this area, numerous normal faults which parallel the Amerasia margin are present and the oldest graben-fill is early Middle Jurassic (Bajocian) in age (Harrison and Brent, 2005). A major unconformity of early Bajocian age and of tectonic origin occurs at the base of the strata and can be correlated over much of Sverdrup Basin (Embry, 2011). It is also present on Svalbard, in the Mackenzie Delta region and in northern Alaska (Worsley, 2008; Poulton et al, 1982; Houseknecht and Bird, 2004). Thus, this widespread and significant tectonic event became a reasonable candidate for marking the initiation of rifting of Amerasia Basin

Earliest Rhaetian Unconformity

Studies in the Sverdrup Basin demonstrated the presence of a major, tectonic unconformity of earliest Rhaetian age (latest Triassic) and that Norian strata were significantly truncated beneath the unconformity (Embry and Johannessen, 1993; Embry, 2011). This unconformity occupied the same stratigraphic position of the base Kingak unconformity of Alaska as well as that at the base of the Jurassic succession in the Mackenzie delta region and on Svalbard. Notably, in all four areas, the youngest strata beneath the unconformity are Norian but the oldest transgressive strata directly overlying the unconformity range in age from as old as early Rhaetian in the Sverdrup Basin to as young as mid- Sinemurian in the Mackenzie delta region. Thus the Sverdrup Basin data provided the most precise age date (early Rhaetian) for the

earliest uplift associated with this unconformity which is also solid candidate for the tectonic event which marked the start of the rift phase.

Determining the Initiation of Rifting

To decide which unconformity best approximated the initiation of rifting, the ages of detrital zircons from Early Triassic to earliest Cretaceous sandstones from northern Sverdrup Basin were compiled. It has been established that substantial amounts of Norian and older Triassic strata in the northern Sverdrup Basin were sourced from Crockerland, an extensive land area which lay north of the basin (Embry, 1993, 2011) and upon which the Amerasia Basin subsequently developed. Notably, these strata contain zircons which are close to the depositional age of the strata in which they occur, indicating that Crockerland had an active margin on its distant, Pacific-facing border. It was hypothesized that, as soon as rifting began (either early Rhaetian or early Bajocian), Crockerland would have been dissected by rift valleys, thus greatly reducing sediment supply to the northern Sverdrup Basin as well as cutting off access to the distant active margin and the supply of young zircons.

It has been found that sediment supply from the north was greatly reduced following the earliest Rhaetian unconformity and that the Rhaetian to Aalenian (i.e. pre-Bajocian) sandstones contain no zircons younger that Norian (i.e. no zircons close to depositional age). Furthermore, zircons from post early Bajocian sandstones (Bathonian, Berriasian) are no younger that Devonian and are mainly Precambrian in age.

These data lend strong support to the interpretation that the rift phase of the Amerasia Basin began in earliest Rhaetian rather than in earliest Bajocian. The data also suggest that the earliest Bajocian unconformity records a major rift event which extended normal faulting further inland of the previous rift margin and which significantly reduced the extent of the rift shoulder source region to the north of the Sverdrup Basin. Furthermore, it appears that continuing uplift of the rift shoulder exposed strata possibly as old as Precambrian by earliest Cretaceous.

Petroleum Implications

This analysis leads to the prediction that substantial latest Triassic-early Middle Jurassic (Rhaetian-Aalenian) strata are likely present at the base of grabens which initially developed during the rift phase of the Amerasia Basin. Both reservoir and source strata can be envisioned to be present in this succession in such grabens.

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