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The formation of the Alleghenian Isthmus triggered the Bashkirian glaciation: Constraints from warm-water benthic foraminifera

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ABSTRACT

The timing of the final collision of Laurentia and Gondwana as well as the disappearance of the gateway between the Rheic and Tethyan oceans are quite controversial and poorly established. Accurate constraints on the gateway closure are vitally important for the understanding of global sea-level fluctuations, ocean circulation, regional and global environments, salinity and reorganization of the thermohaline circulation in the western Tethys, the Bashkirian glacial episode and the overall decline of atmospheric CO_2 concentrations. Here we present a new approach by applying warm-water benthic foraminifera (WWBF) data to precisely constrain the Rheic-Tethys gateway (RTG) closure, utilizing taxonomic and statistical methods. The link to the RTG closure and the profound biotic transformations in the oceans, sea-level, and expansion of the Gondwana ice sheet are discussed herein. The WWBF records in the studied regions constrain the timing of the RTG disappearance and support a linkage between the appearance of the Alleghenian Isthmus and the onset of the Bashkirian glaciation.

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1. Introduction

The collision between the Laurentian and Gondwanan plates and its associated orogeny are among the most important episodes in Earth's history. The orogenic belts that developed during the collision extended for a distance of thousands of kilometers, from southern Mexico and the Appalachian Basin through Africa and to Bohemia in Central Europe. The collision developed from approximately the Middle-Late Devonian to the Permian and produced several orogenic phases at different times. The different parts of the belt possessed their own names: Alleghenian belt in North America, the Mauritanide belt in Northwest Africa, the Variscan belt in Europe and North Africa. The timing of the disappearance of a gateway between the Rheic and Tethyan oceans, which gave rise to the belts, is controversial and poorly established. According to some paleogeographic and tectonic models, orogenic belts and high mountains between Gondwana and Laurentia developed during the Late Devonian, with no connection between the Rheic and Tethys oceans throughout the late Paleozoic (Kroner and von Romer, 2013; Stampfli et al., 2013; Scotese, 2015; Díez Fernández et al., 2016). Other models proposed the existence of the RTG until the Early Permian (Vai, 2003; Walsh et al., 2007; Domeier et al., 2012). The majority of scientists, though, believe that the RTG only existed until Moscovian or Kasimovian times when the connection was finally cut off (Cavazza et al., 2004; Cocks and Torsvik, 2011; Lawver et al., 2011; Blakey, 2013). The establishment of a Gondwanan Late Paleozoic ice sheet is associated with the larger suite of global climatic and environmental reorganizations that occurred within the Serpukhovian–Moscovian interval, between 330.9 and 307.0 Myr ago (Grossman et al., 2008; Montañez and Poulsen, 2013; Mory et al., 2008). Declining atmospheric CO_2 concentrations have been cited as a major trigger of this climatic change, with various opinions on the significance of the RTG closure (Montañez and Poulsen, 2013 and references therein). An important input into the closure problem came from carbon isotopic studies where significant interoceanic water variability was documented by the magnitude of the $\delta^{13}C$ shift at the Mississippian-Pennsylvanian transition (Grossman et al., 1993; Mii et al., 1999, 2001; Saltzman, 2003). The differences in the $\delta^{13}C$ of the Panthalassan and Paleotethyan water masses were proposed to coincide with the mid-Carboniferous boundary, presumably marking the circulation changes that are hypothetically associated with the closure of the RTG (Grossman et al., 2008).

The closure of the Rheic Seaway has also been linked to the onset of early Serpukhovian (middle Chesterian) glaciation, because of an abrupt three-fold increase in the amplitude of fourth-order (400 kyr) eustatic cycles in the Midcontinent (Smith and Read, 2000). Later on,

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