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Triassic river systems and the paleo-Pacific margin of northwestern Pangea

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ABSTRACT

Detrital zircon U–Pb ages from Triassic strata exposed in the circum-Arctic, analyzed by LA-ICP-MS and SHRIMP-RG, are compared at the regional scale to better understand the paleogeography of northern Pangea and help restore rift opening of the Arctic. Data sets are compared based on their zircon age distributions, cumulative age probability plots, and the K–S test. Three major source regions are characterized. These fed clastic material to transcontinental river systems that transported material from the highlands of northwestern Pangea to its once continuous paleo-Pacific continental margin. The paleo-Lena River System was fed from sources in the Baikalian and Altay-Sayan mountainous regions of Siberia. Zircon populations are characterized by a limited number of Precambrian zircons (~1.8–2.0 Ga with fewer ~2.5–3.0 Ga), lack of 0.9–1.8 Ga zircons, and a dominant 480–500 Ma and 290–300 Ma age population. The paleo-Taimyr River System was sourced from the Uralian orogenic belt region and deposited along a rifted portion of the Siberia–Baltica margin beginning in the Permo–Triassic. Precambrian zircon populations are similar to those of the paleo-Lena system, and samples closest to Siberia have similar populations in the 480–500 Ma and 290–300 Ma age ranges. Chukotka, Wrangel Island and Lisburne Hills, Alaska, have sparse ages between 900 and 1800 Ma, Ordovician ages are younger (~440–450 Ma), and, along with abundant ~300 Ma ages, they contain ~250–260 Ma and lesser ~215–235 Ma zircons, interpreted as derived from silicic volcanic centers associated with Permo–Triassic to Triassic continental flood basalt provinces in Siberia, Taimyr and Kara Sea region. The trans-Laurentian River System was likely fed by rift-related uplift along the proto North Atlantic/Arctic margin and delivered sediment to the Cordilleran margin of Pangea. These samples have no significant upper Paleozoic zircons and have a much broader age range of Precambrian zircons.

1. Introduction

Northern Pangea was fully assembled in the Early Permian after Siberia joined Baltica and Laurentia along the Uralian suture (Fig. 1) (e.g. Ziegler, 1988; Nikishin et al., 1996; Lawver et al., 2002). Its stability, however, was short-lived. The eruption of the Siberian traps and rifting along the western flank of the earlier Uralian suture created a broad aborted rift zone (the West Siberian Basin) that extended oceanward into inferred paleo-Pacific back-arc basins (Fig. 1; e.g. Nikishin et al., 2002; Reichow et al., 2009). In the North Atlantic/Artic region, the site of the older Caledonian orogenic belt also experienced rift-related uplift and formation of fault-bound basins beginning as early as the Permian and continuing into the Triassic. Rifting eventually led to continental break-up and formation of the North Atlantic later in the Cretaceous (Fig. 1; e.g. Ziegler, 1988; Nikishin et al., 2002).

This overall paleogeography (Fig. 1) dictated source regions for Triassic depositional systems and controlled the location and configuration of major river systems that carried clastic material to Pangea's northern paleo-Pacific continental margin (Fig. 1). Today, these siliciclastic deposits crop out in younger fold belts or remain deeply buried in basins (Fig. 2). Rifting and plate motions associated with the formation of the Cretaceous and Tertiary Arctic Ocean basins have severed many of these deposits from their original sources, making it more difficult to decipher their ancient Triassic paleogeography (Fig. 2).

U–Pb detrital zircon geochronology is a rapidly evolving and powerful tool for determining the provenance and maximum depositional age of clastic strata. The increased availability and speed of data collection by the laser ablation-ICP-mass spectrometers have generated increasingly larger data sets of this sort (e.g. Davis et al., 2003; Kostler and Sylvester, 2003; Gehrels, 2012). This method is effective

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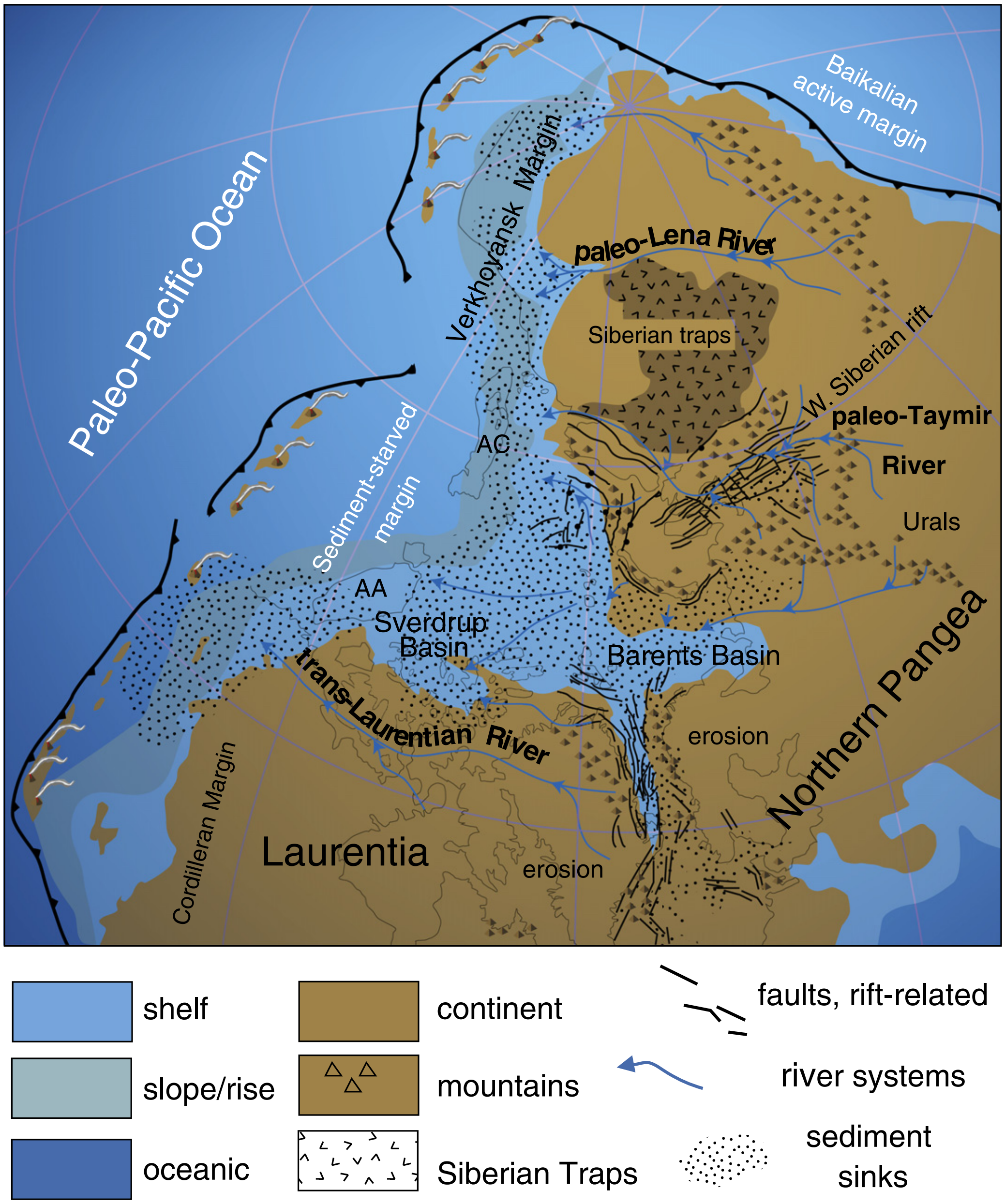

Fig 1. Simplified paleogeography of northern Pangea in the Permo–Triassic to Early Triassic based on Lawver et al.'s (2002) Middle (240 Ma) to Late (210 Ma) reconstruction. Areas of shelf and continents, rift-related faults and mountains after Nikishin et al. (1996) and Ziegler (1988). Arctic Alaska (AA) restored following Lawver et al. (2002). The general region of Chukotka (AC) is restored after Miller et al. (2006, 2010, this paper). Proposed river systems of northern Pangea and offshore depositional "sinks" are portrayed in highly schematic form. Offshore island arcs and subduction zones are inferred. For discussion see text.

at testing and establishing the first-order coherency and source regions of large clastic depositional systems, enabling us to reconstruct ancient paleogeographies and tectonic events now obscured by younger deformational events and plate motions (e.g. Rino et al., 2008; Condie et al., 2009; Dickinson and Gehrels, 2010; Nebel-Jacobsen et al., 2011; Babinski et al., 2012).

This study of Triassic strata and their detrital zircon populations was initiated to determine how effective this approach might be in elucidating the rift opening geometry and history of the Arctic Ocean basins (e.g. Miller et al., 2006). Additional published data (Miller et al., 2010) and new results (this paper), when added to a growing number of regional studies (e.g. Beranek et al., 2010; Omma et al., 2011), provide a clearer and broader view of what was once the paleogeography of northern Pangea in the Triassic. Increased interest in the geology and natural resources of the Arctic has led to a series of new models for the plate tectonic evolution of the Arctic Ocean's Amerasia Basin (Fig. 2) (e.g. Kuzmichev, 2009; Miller et al., 2010; Colpron and Nelson, 2011; Golonka, 2011; Grantz et al., 2011; Lawver et al., 2011). The combined data set discussed here and the conclusions drawn from this data, although evolving, provide a solid basis for building and testing paleogeographic models and plate tectonic reconstructions of the Arctic.

2. Analytical methods and data analysis

The locations of the samples analyzed and discussed are shown in Fig. 2 and their exact locations and ages are listed in Appendix 1A. Most samples were collected from paleontologically dated Triassic stratigraphic successions (e.g. Sosunov et al., 1982; Harrison et al., 2008; Appendix 1A). Triassic strata in the New Siberian Islands

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