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Crustal provenance of the "Timanide" detrital zircon geochronology signature in the circum-Arctic stratigraphic record

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Understanding the geologic history of the Arctic Ocean basins and surrounding landmasses is one of the great remaining challenges of global plate tectonic studies. The fact that three globally significant Phanerozoic age orogens (Caledonian, Uralian, Cordilleran) become untraceable as they trend into the Arctic underscores this challenge. Numerous geological studies have been carried out on the landmasses surrounding the Arctic Ocean using a "terrane approach" to establish tectonostratigraphic correlations for plate tectonic reconstructions. Detrital zircon (DZ) geochronology-based correlations and provenance interpretations of siliciclastic strata are widely used across the circum-Arctic region and offer the possibility of correlating crustal fragments sampled from the marine and terrestrial realms. Potentially the greatest leverage in Arctic DZ studies is the ability to test integrative paleogeographic/plate tectonic models using geochronology data as a correlation tool between basins and zircon source regions (either primary or recycled) that have been geographically fragmented by post-depositional plate motions and/or deformed ± metamorphosed by tectonic processes. Thus, the rapidly growing body of geochronology data becoming available in the Arctic offers great promise towards elucidating its complex plate tectonic history, but has also revealed new challenges in tectonic interpretation of DZ results.

Over the last decade, arguably the most salient data signal that has been identified and discussed in Arctic geochronology is the occurrence of ~750-540 Ma zircon ages. These ages have been collectively and informally grouped in the literature as the "Timanide" signature because igneous rocks that span this age range are found near and within the Timanian orogen that affected northeastern Baltica (although much of the age range pre- or post-dates the timing of deformation). Other circum-Arctic regions with at least some ~750-540 Ma igneous rocks include Novaya Zemlya, Taimyr, the Arctic Alaska Chukotka microplate (AAC), and the Finnmark Caledonides, whereas these ages are notably absent from most of the northern margin of Laurentia (with the exception of the ca. 720 Ma Franklin igneous event in northern Canada). The rifting of Laurentia from Baltica to form the Iapetus Ocean occurred in latest Neoproterozoic and Cambrian time [1], thus isolating Laurentia from the Timanides until the Caledonian orogeny. The presence of "Timanide" age detrital zircons in Silurian-age Caledonian flysch in the deepwater facies of the Franklinian basin [2] and in Devonian clastic wedge strata [3] along the Arctic margin of Canada illustrates the provenance of these depositional systems includes a source region containing "Timanide" age zircons. Uncertainty about the tectonic setting and paleogeography of "Timanide" age magmatism in crust that is not part of the Timanides is a significant issue that has received little attention. Whether sedimentary sources are related to Baltica and/or Laurentia is heavily weighted to observation of "Timanide" ages in DZ data, potentially implying erroneous paleogeographic constraints if the paradigm of ~750-540 Ma ages being a Baltican signature in the Arctic is not universally valid. For example, the Laurentian affinity Kalak Nappe Complex of the Finnmark Caledonides contains 570-560 Ma rift-related intrusions [4], coeval to syn-orogenic magmatism in the Timanides, and thus exemplifies peri-Laurentian crust that was uplifted and contributed DZ ages atypical of Laurentian sources to the stratigraphic record. A further complication in using “Timanide” ages as diagnostic of source terranes is the analytical challenge presented by datasets containing younger apparent ages than the crystallization age due to minor (therefore imperceptible in typical DZ methods) discordance of zircons in this age range.

References:

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[3] Anfinson et al. (2012) GSA Bulletin 124: 415-430

[4] Roberts et al. (2006) Geological Magazine 143: 887-903