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Evidence for Timanian-age basement rocks in North Greenland as documented through U-Pb zircon dating of igneous xenoliths from the Midtkap volcanic centers

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ABSTRACT

Igneous xenoliths have been identified within the Paleozoic Midtkap volcanic centers of North Greenland that cut through Cambrian-Ordovician deep water trough sedimentary rocks that were subsequently deformed during the south-verging Ellesmerian Orogeny. The xenoliths were characterized geochemically and their zircons dated through the U-Pb technique. This provided ages ranging from 628 to 570 Ma, for xenoliths with granitic and monzonitic compositions, the former apparently older than the latter. These ages, coupled with the geochemical signature compatible with an arc setting, provide evidence for the presence of Timanian like basement in North Greenland. The structural setting suggests that the dated xenoliths belong to an allochthonous unit emplaced during the Caledonian Orogeny and deformed during the Ellesmerian Orogeny. Furthermore, this data provides new evidence for a northwestern extension (through continuation and/or through dispersal) of the late Neoproterozoic Timanide belt, from its type locality, in the Timan-Pechora region in Russia, through Svalbard, into North Greenland, to the Pearya Terrane on Ellesmere Island.

1. Introduction

The Neoproterozoic Timanide Orogen extends along the eastern margin of Baltica (Gee and Pease, 2004), from the southern Urals to Novaya Zemlya in the northeast and the Varanger Peninsula in the northwest (Fig. 1). The type areas of this orogen are located in the Timan-Pechora region (e.g. Gee and Pease, 2004; Kuznetsov et al., 2010). The main phase of the Timanian Orogeny in the Timanides *sensu stricto* was established at ca. 610–560 Ma (e.g. Gee et al., 2000; Larionov et al., 2004), but early magmatic and metamorphic events extend as far back as ca. 700–650 Ma (Andreichev, 1998; Kuznetsov et al., 2007).

The Timanide Orogen is traditionally thought to be an accretionary orogen that developed during west-directed subduction (beneath Baltica; e.g. Pease et al., 2004) and subsequent accretion of different outboard terranes. An alternative collisional hypothesis was presented by Kuznetsov et al. (2007 and references therein), who refer to the existence of a somewhat enigmatic paleocontinent, designated Arctida (Zonenshain et al., 1990), that collided with Baltica. This hypothesis is primarily based on the huge diversity of terranes incorporated into the Timanide Orogen. Of particular importance for this study is the northern extent of the Timanide Orogen whose presence remains a matter of debate. The northernmost Timanian magmatism, deformation and metamorphism in the type area have been documented by the deep drilling of the Pechora Basin (e.g. Kostyuchenko, 1994) and below the Phanerozoic sediments of the Barents Shelf (O'Leary et al., 2004). Farther northwest, the Timanides are truncated by the Caledonian Orogen (e.g. Gee and Tebenkov, 2004). However, Kuznetsov et al. (2007, 2010) suggested a northern extension of the Timanides towards the Svalbard Archipelago consistent with several lines of evidence for Timanian-like metamorphic ages from southern Svalbard (e.g. Majka et al., 2008, 2012, 2014). These complexes of ca. 640 Ma age are ubiquitously bordered by tectonic boundaries (e.g. Mazur et al., 2009; Majka et al., 2014). Mazur et al. (2009) and Kośmińska et al. (2014) suggested that large-scale, strike-slip faults dismembered the possible northwestern pre-Iapetian arm of the Timanides and juxtaposed them with Laurentian complexes during the Caledonian Orogeny. Majka et al. (2014) reported on the Tonian igneous suite being overprinted by the Torellian (local equivalent to the Timanian) metamorphic event, thus providing evidence for reworking of the typical Laurentian basement by a tectono-metamorphic

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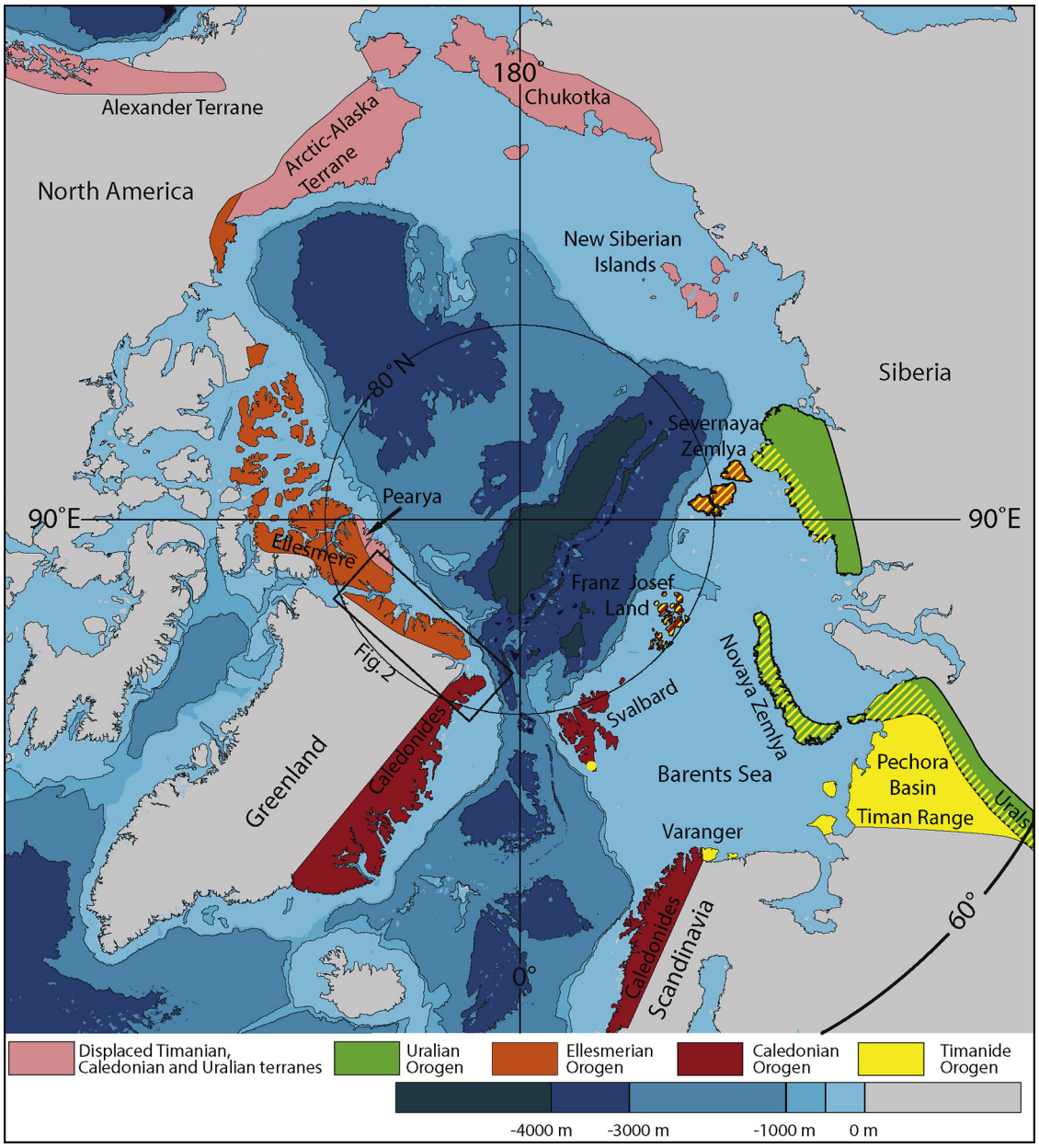

Fig. 1. Geography of the Arctic, illustrating localities and geological features discussed in the text. Area of Fig. 2 is highlighted with rectangle. Modified after Lorenz et al. (2013) and bathymetry is from Jakobsson et al. (2008).

event in the Late Neoproterozoic. This suggests that a common eastern Balto-Laurentian continental margin could have been involved in orogenic activity during the Late Neoproterozoic. A similar sequence of events has been documented in the northwestern part of Svalbard, where Tonian igneous rocks are intruded by Late Neoproterozoic agmatites (ca. 660–640 Ma, Peucat et al., 1989; Gromet and Gee, 1998). These agmatites were primarily interpreted as rift-related and associated with the opening of Iapetus. However, Majka et al. (2015) speculated that the aforementioned Tonian complexes, overprinted by the Torellian event known from southern and northern Svalbard, share a similar tectono-thermal history. Important information about the Late Neoproterozoic crystalline basement of northern Svalbard is also provided by the Quaternary volcanism of the Bockfjorden area. These volcanic rocks include large amounts of lower crustal granulitic xenoliths of intermediate and mafic composition. Zircons from these xenoliths yielded ages in the 630–500 Ma range (Griffin et al., 2012). Furthermore, the whole-rock Hf model age of one of the xenoliths provides an age of 560 Ma. Additionally, Griffin et al. (2012) have dated zircons from heavy mineral fractions from stream sediments in that area. Some of these zircons reveal possible metamorphic rims of ca. 550–520 Ma age. All these aforementioned dates fit the time span for the Timanian Orogeny.

Farther northwest, in the Pearya Terrane of northern Ellesmere Island, Tonian (ca. 960 Ma, e.g. Malone et al., 2014) orthogneisses and associated sediments and volcanics form a basement that is overlain by later Neoproterozoic sequences of sediments and volcanic rocks. These successions are in turn tectonically juxtaposed with an Early Ordovician island arc succession (e.g. Trettin, 1987). Although there is no record of Late Neoproterozoic metamorphism, recent evidence for ca. 540 Ma syenitic magmatism (Malone, 2014) also broadly fits the time-span of the Timanide (Torellian) Orogen. In addition, Neoproterozoic diamictites of Pearya that are commonly correlated with the diamictite units of Svalbard