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Pre-3750 Ma supracrustal rocks from the Nuvvuagittuq supracrustal belt, northern Québec

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Abstract

Geochemistry and U-Pb ion microprobe zircon geochronology guided by high-resolution mapping (1:50 scale) was used to define a minimum age of ca. 3750 Ma for supracrustal rocks from the *Nuvvuagittuq supracrustal belt* (NSB) in the northern Superior Province, Québec (Canada). Mineralogy and geochemistry of critical field relationships preserved at the Porpoise Cove locality describe a supracrustal succession of (mafic) amphibolites and ultramafic rocks, finely banded quartz-magnetite units with intermixed coarse-grained ferruginous quartz-pyroxene rocks and quartz-biotite schists that superficially resemble polymict metaconglomerates with large (up to 10 cm) deformed polycrystalline quartz and mafic clasts. All units in the mapped outcrop have sharp lithological contacts. Narrow (dominantly trondhjemitic) orthogneiss sheets locally preserve intrusive contact relationships to the supracrustals. The total extent of the supracrustal enclave is ~8 km^2; it is strongly deformed and the full deformation history appears to be shared by all units with later modifications from leucogranitoid intrusions. The quartz-biotite schists record complex zircon growth at ~3500 and ~2800 Ma, interpreted to reflect metamorphic events. Zircons separated from orthogneisses in the enclave – including one sheet that transects a banded quartz-pyroxene (±magnetite) unit – yield magmatic $^{207}Pb/^{206}Pb$ ages of ca. 3750 Ma. These ages are slightly younger than earlier provisional reports for an NSB orthogneiss from Porpoise Cove. The Nuvvuagittuq supracrustals are the oldest rocks thus far reported for the Minto Block, they overlap in age with the ca. 3.70–3.83 Ga *Isua supracrustal belt* and *Akilia association* rocks in West Greenland, and they represent an important new area for exploration of the early Earth.

Keywords: Archean; geochronology; geochemistry; Superior Province; supracrustal; Nuvvuagittuq

1. Introduction

In the course of regional isotope geochronology and mapping of the Inukjuak domain, Eoarchean (>3.6 Ga) rocks were discovered in the northern Superior Province (Ungava Peninsula, Canada) by the Ministère des Resources naturelles du Québec [1] (Fig. 1). Reconnaissance geochronology by standard isotope dilution techniques and thermal ionization mass spectrometry (TIMS) on whole zircons reported by David et al. [2] showed that an orthogneiss unit at the Porpoise Cove locality of the *Nuvvuagittuq supracrustal belt* (*NSB*) ~27 km southeast of the town of Inukjuak contains zircons with U-Pb ages up to 3825±16 Ma. However, because that report was preliminary, published accounts that detail the U-Pb isotope systematics of the *NSB*

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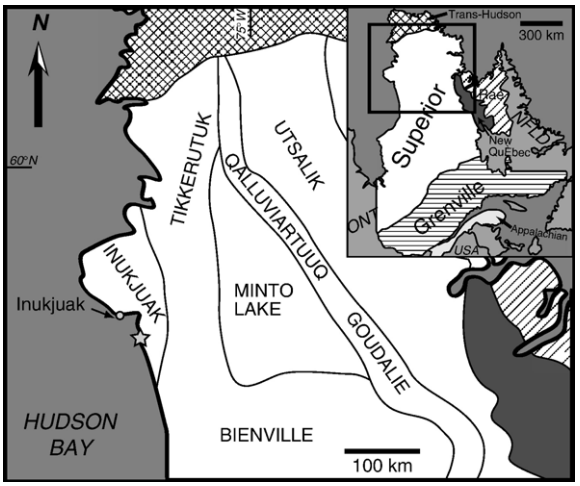

Fig. 1. Lithotectonic domains of the Superior Province in northern Québec (modified after [1,17,20]). Inset shows location of geologic provinces within Québec, Canada. Location of the Nuvvuagittuq belt (and Porpoise Cove locality) indicated by a star.

zircons were unavailable. Stevenson and Bizzarro reported negative initial εNd and εHf for these rocks with model ages of ca. 3900 Ma [3], which provides supporting evidence for ancient crust in the *NSB*. Prior to the work in the Minto Block, documented results from U-Pb studies of detrital zircons and Nd model ages for rocks collected near the western margin of the Superior Province within the *Assean Lake crustal complex* (Manitoba) and the *Northern Superior super terrane* (northern Ontario) were interpreted to indicate that recycled early Archean crust is present in the vicinity [4–6]. If detailed mapping to guide sampling for ion microprobe U-Pb zircon geochronology can be used to confirm an Eoarchean age for the *NSB*, then it would represent the first evidence of preserved supracrustals of such antiquity in the Superior Province. Therefore, the pioneering work by Simard et al. [1] and David et al. [2] on the *NSB* deserves to be followed by further detailed geochronological and geochemical analyses on a wider suite of lithologies guided by high-resolution mapping.

The Nuvvuagittuq rocks are deformed and appear to record a complex metamorphic history that may have involved multiple Pb-loss events or zircon inheritance, or both. Maps at the adequate detail to investigate possible cross-cutting relations between the orthogneisses and supracrustal rocks (and thereby minimum ages for the *NSB* successions) were not previously available and protolith assignments to the various units in the enclave have hitherto been provisional. We chose to explore these rocks in more detail since pre-3.7 Ga supracrustal sequences are extremely rare and each new discovery has the potential to greatly expand our knowledge of conditions on the early Earth. Such rocks provide the only direct window into surface processes that governed the planet at the time of life's emergence [7].

Because the oldest rocks are complicated by protracted histories of metamorphism, much of the controversy that surrounds the geology of ancient supracrustal sequences at other localities – such as at the *Isua supracrustal belt* (*ISB*) and *Akilia association* (*AA*) in southern West Greenland – has been fueled in part by the reconnaissance-scale "sketch maps" that have historically accompanied those studies [8–11 c.f. 12,13]. To overcome issues which have traditionally plagued that work, our new analysis used an integrated approach to (i) construct detailed maps to guide sample collection of critical field relations that may be used to establish (minimum) ages of candidate sedimentary units in the *NSB*; (ii) investigate the possibility for (older) zircon inheritance in the orthogneisses and candidate paragneisses; (iii) gain insight into the metamorphic history of the units; and (iv) place geochemical constraints on possible protoliths to the supracrustal assemblage. Here, we report the results of large-scale (1:50) mapping to guide sampling for high-resolution U-Pb zircon geochronology and other geochemical studies [14]. In the present work, the within-grain analytical capacity of the UCLA Cameca *ims*1270 ion microprobe, e.g., [15], was applied to U-Pb analyses of zircons extracted from four *NSB* orthogneiss samples, including two from the same unit previously investigated by David et al. [2], as well as two quartz-biotite schists of putative detrital sedimentary origin.

2. Geologic background

The Minto block within the northeastern Superior Province is composed of several Archean terranes dominated by granitoid gneisses with subordinate supracrustal units arranged in a north-northwestern regional structural trend as distinguished by strong aeromagnetic anomalies [16]. The current prevailing model for the origin of the Minto Block is that it comprises the batholitic roots of plate-margin and intra-oceanic arcs with rare preservation of supracrustal sequences that were amalgamated through a series of collisions ca. 2.7 Ga [17,18]. The *Inukjuak* domain is the westernmost terrane within the Minto block and is distinguished from the neighboring *Tikkerutuk* based on aeromagnetic contrasts [16]. Recent isotopic work has found a corresponding decrease in εNd within the