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Detrital Zircon Constraints on the Chronology of the Nuvvuagittuq Greenstone Belt

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Reconstructing Earth's earliest history is hindered by the scarcity of pre-3.5 Ga rocks, with rare Hadean detrital zircons providing valuable but incomplete insights into early crustal processes because their source rocks no longer exist. The Nuvvuagittuq Greenstone Belt (NGB), in the Northeastern Superior Craton, may instead preserve remnants of this early crust.

The NGB is crosscut by 3.77 Ga trondhjemites, providing a well-established minimum age. Mafic metavolcanic rocks have yielded ^{142}Nd isotopic compositions consistent with formation at ~4.3 Ga, while gabbroic intrusions define ~4.16 Ga isochrons from coupled long- and short-lived Nd systems, consistent with Hadean crystallization and representing the oldest known preserved rocks. Uncertainty persists, however, due to quartz-rich horizons interpreted as detrital metasediments proposed to record sedimentary deposition at ~3.78 Ga and, if these are conformable within the volcanic sequence, they would challenge the Hadean age for the mafic units. Determining whether these quartz-rich rocks provide robust chronological constraints on the mafic basement is therefore critical.

Here we investigate several quartz-rich fuchsitic horizons interpreted as detrital metasediments to constrain their zircon ages and assess implications for the NGB chronology. These are composed primarily of recrystallized quartz (40–70%) and lack primary sedimentary textures, instead displaying strong metamorphic fabrics. Additional phases include feldspar, biotite, amphibole, and sillimanite, with some samples containing 15–30% fuchsite. Zircons from all samples predominantly display oscillatory zoning, Th/U ratios of 0.3–1.1, and rare earth element patterns consistent with a magmatic origin. U–Pb geochronology reveals heterogeneous age populations despite close stratigraphic proximity. Some samples are dominated by a ~3750 Ma zircon population with subordinate concordant ^{207}Pb/^{206}Pb ages of 3500–3600 Ma, whereas others contain substantial populations younger than 3700 Ma, clustering at ~3500 Ma and ~3000 Ma. Although some of these quartz-rich units are dominated by Eoarchean zircons, all contain concordant Paleo- to Mesoarchean magmatic grains, younger than the 3.77 Ga intrusive minimum age of the NGB. These metasediments therefore postdate trondhjemite emplacement and our new data suggest unconformable deposition onto an older mafic volcanic basement. Accordingly, the detrital units do not impose meaningful age constraints on the mafic rocks nor preclude a Hadean origin for the NGB.