Geochemistry of Precambrian Basement Beneath the Williston Basin, Trans-Hudson Foldbelt/Superior Craton Boundary zone, Oliver County, North Dakota USA

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Abstract

Two cores were recently cut through the Williston Basin into the proposed underlying Precambrian age Trans-Hudson foldbelt and Superior craton boundary zone. NDIC cores #37672 and #37380 intersected basement at 2969.7 m (9,743 ft) and 3132.9 m (10,278.5 ft) respectively, collecting 7 m (23 ft) and 23 m (75 ft) of ~4-inch diameter drill core. The top two meters of 37672 are bleached, porous, foliated gneiss and thin intruded granitoid, both heavily altered as verified by FMW weathering plot and elevated K_2O ~ 11 wt.%. Unaltered granitic gneiss is composed of alternating bands of biotite/chlorite and elongated quartz, plus feldspars and trace muscovite, titanite, zircon, and pyrite. Core 37380 is primarily fine to course foliated hornblende-plagioclase-biotite amphibolite. Accessory minerals include minor epidote, biotite/actinolite, opaque minerals (magnetite and pyrite), zircon, and apatite. The unit contains thin ptygmatic quartz veins, calcite veins, high angle altered fractures, and intrusions of medium grained to pegmatitic granite which range from a few cm to 60 cm wide. The unweathered granitoids, and gneiss of 37672, plot in the TAS granite field and as subalkaline, while the unweathered gneiss of 37380 with SiO_2 = 50.42 wt.%, plots as alkaline gabbro. CaO contents of the granitoids range from 0.84-1.6 wt.% consistent with an evolved granitic composition. Unweathered samples are peraluminous and, with the exception of gneiss in 37672, have CIPW normative corundum 0.85 - 1.67, which may indicate S-type affinities. Granitoids plot in the volcanic arc field on trace element tectonic discrimination diagrams. They are relatively enriched in large ion lithophile elements (LILE) and light rare earth elements (LREE) compared to chondrite, but depleted in Nb, Ta, and Ti, as in arc granitoids, while the mafic gneiss shows less enrichment. Core 38672 LaN/YbN ratios are 59-70 with Eu/Eu* = 0.75-0.98. The 37380 gneiss is distinct and has La_N/Yb_N= 41 and Eu/Eu*=1.58, but also has a negative Nb-Ta anomaly when normalized to MORB. Single zircon age dates and Hf and Nd isotope results indicate the 37672 host rock crystallized at ~2.67 Ga from a juvenile, Neoarchean mantle source within an arc-continent collisional zone, which may represent a piece of the western edge of the Superior Craton. The 37380 meta-basic host rock crystallized at ~1.83 Ga from a juvenile, Paleoproterozoic mantle source within potentially an arc-continent collisional zone, likely associated with the Trans-Hudson orogeny. The host rocks of both cores were intruded at ~1.78 Ga by medium crystalline granite, followed closely by intrusion of granitic pegmatite within #37380. All the intrusive granitoids originated from a mixture of juvenile, Paleoproterozoic mantle and Neoarchean (~2.7 Ga), likely Superior Craton, crustal sources that formed within an arc-continent collisional setting.