Peak metamorphic and geochronological constraints from Lu-Hf garnet dating at the Borden gold deposit, Chapleau, ON

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Located at the southern margin of the Kapuskasing Structural Zone (KSZ), the Borden gold deposit hosts low-grade gold mineralization within upper amphibolite to granulite facies garnet-biotite gneisses (±sillimanite). The metamorphic history of the gold-hosting lithologies is critical to the timing of mineralization at this unusual new discovery. To compliment metamorphic parameters and determine metamorphic geochronology, we conducted Lu-Hf geochronology of garnet owing to the strong partitioning of Lu in garnet. This radiometric dating method has become increasingly useful to constrain metamorphic ages of high-grade metamorphic assemblages. The garnet is almandine-rich, chemically unzoned and contains inclusions of quartz and less abundant biotite. Garnet-biotite geothermometry yields temperatures ranging from 475°C to 800°C ±50°C. Although garnet compositions are fairly consistent, biotite compositions vary from inclusions in garnet cores to inclusions in garnet rims and to biotite in the groundmass, yielding temperatures that increase from the garnet core towards the rim. These results indicate that prograde metamorphism from upper amphibolite to granulite facies is recorded during garnet growth. The elimination of chemical zoning in garnet is likely due to intracrystalline diffusion at peak metamorphic temperatures. Garnets were separated from a gneissic unit and were dated using the ^{176}Lu-^{176}Hf radiochronometer (half-life of about 37 billion years) at University of Western Ontario. The Lu-Hf isotopic analyses from two hand-picked garnet splits of about 100 milligrams and corresponding whole-rock splits (with and without dissolving zircons) yield a precise internal isochron age at 2629.0 ± 4.3 Ma (with an initial ^{176}Hf/^{177}Hf 0.281210 ±0.000010 and MSWD = 0.66) with 5 data points. This age is within error of the Lu-Hf isochron age of 2630.4 ± 4.7 Ma (with an initial ^{176}Hf/^{177}Hf =0.281204 ± 0.000013 and MSWD = 0.16) when the whole-rock dissolved with zircons is not included in the age calculation. The initial Hf isotopic composition of this gneiss is εHf =+4.1 (epsilon unit is the deviation in parts per 10,000 relative to Chondrite Uniform Reservoir at 2629 Ma) which indicates that the protolith of this rock was derived from a long-term depleted (high Lu/Hf) mantle reservoir. Our new results suggest that peak granulite facies metamorphism associated with garnet growth took place ca. 2629 Ma. This is consistent with earlier estimates of the age of granulite facies metamorphism. Retrograde metamorphism of these lithologies is critical to the structural control of mineralization at this deposit. Lenses of relict granulite facies rock were more competent than surrounding retrograde amphibolite facies lithologies, producing the requisite conditions for localized brittle deformation and mineralization during dominantly ductile shear-zone deformation.