Paleoproterozoic eclogite from the Snowbird tectonic zone, western Canadian Shield

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The Snowbird tectonic zone shows up as a dramatic regional positive linear gravity anomaly at the boundary between the Archean Rae and Hearne Provinces of the western Canadian Shield. Since originally being defined and interpreted as a Proterozoic suture, this enigmatic structure has variously been interpreted as a Proterozoic escape structure, an Archean suture with Proterozoic reactivation, and an Archean suture with Archean reactivation. The zone is clearly a fundamental lithospheric-scale structure, but its significance for the architecture and history of Laurentia has remained a matter of considerable controversy for more than a decade.

Where well exposed in northern Saskatchewan, the Snowbird tectonic zone consists of lower crustal granulite facies mylonites, including high pressure granulite and eclogite facies rocks. Minimum P-T conditions of 1.5–1.9 GPa and 900–1000˚C have been determined for some of the gneisses and mafic granulites, and pressures up to 2.0 GPa for the eclogites, conditions consistent with burial to mantle depths. Dating the HP metamorphism has proved to be very difficult however. When first discovered the eclogites were considered to be Archean, based on age measurements on the host felsic gneisses that revealed a complex metamorphic history spanning the period 2.6–1.9 Ga. This conclusion was reinforced by the dating of nearby syn-tectonic granite at ~2.6 Ga and evidence for a protracted granulite facies event starting at 2.62 Ga, with metamorphic zircon growth at ~2.55 Ga.

The recent discovery of zircon in the eclogites has provided the opportunity to define the age of HP metamorphism precisely and to help resolve the controversy over the tectonic significance of the Snowbird zone. The zircon occurs mostly as rare, small, rounded, sector-zoned grains, some containing inclusions of high-pressure minerals (e.g. garnet, kyanite, corundum and quartz), and some in a close textural association with such minerals. Much of the zircon is therefore interpreted to have grown during the HP metamorphism.

Initial high precision U-Pb isotope dilution analyses of individual separated zircon grains showed that not all the zircon was the same age, however. There was a well-defined single population at ~1.9 Ga in one sample and an array of apparent ages between 1.90 and 2.54 Ga in another. It was unclear whether the ~1.9 Ga population recorded the HP metamorphism or a later overprint that had nearly destroyed the isotopic evidence for HP metamorphism at ~2.5 Ga. The question was answered by locating some zircon in thin section that could be demonstrated, from its textural setting, to have formed during the HP metamorphism, then measuring its age *in situ* using the SHRIMP ion microprobe. The zircon chosen was an agglomeration of irregularly-shaped zoned zircon grains within a large crystal of omphacitic clinopyroxene (Figure 1). The morphology and large number of free surfaces in the cluster were consistent with the zircon forming first, then being included in the clinopyroxene as it grew during the eclogite facies metamorphism. Two small isolated zircon grains included elsewhere in the clinopyroxene also were dated.

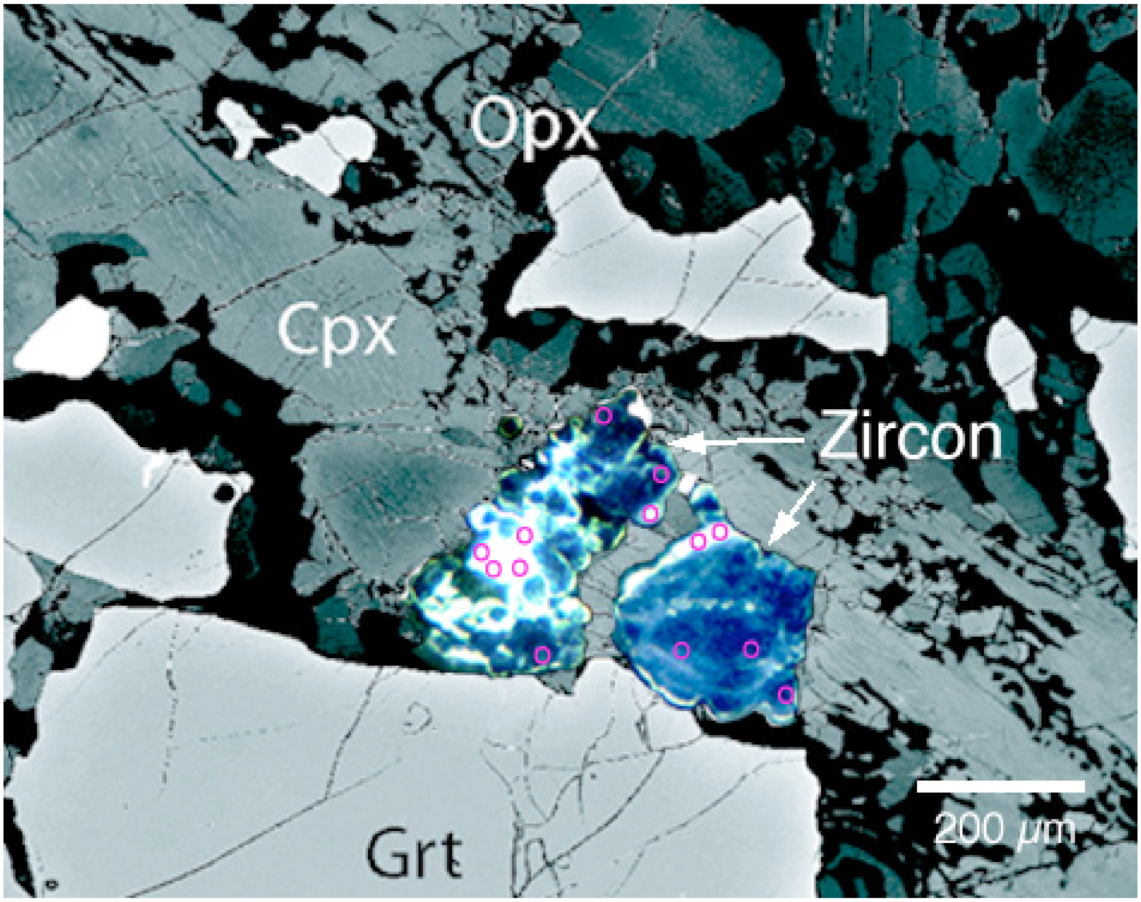

Figure 1: *Image of zircon in a thin section of eclogite from the Snowbird tectonic zone. A colour cathodoluminescence image of a cluster of zoned zircon grains is superimposed upon a backscattered electron image of the enclosing minerals, showing the inclusion of the zircon within high pressure omphacitic clinopyroxene. Circles mark the locations of 13 areas dated by the SHRIMP. Both cores and rims yielded the same age within analytical uncertainty, 1905 ± 19 Ma.*

Despite having a wide range of U content, the cores and rims of the zircon cluster, and the isolated grains, all yielded the same concordant U-Pb age within analytical uncertainty, 1905 ± 19 Ma, proving that the HP metamorphism was Paleoproterozoic, not Archean. Once this was established, the isotope dilution analyses of several individual ~1.9 Ga zircon grains were used to determine the age of metamorphism with much higher precision as 1904.0 ± 0.3 Ma.

This age measurement places the high pressure metamorphism within a major period of assembly of the micro-continents forming Laurentia. It falls exactly in between the ages of bounding orogens in the adjacent cratons, the Taltson-Thelon (2.0–1.9 Ga) and the Trans-Hudson (1.9–1.8 Ga). A major mafic dyke swarm nearby is only ~10 m.y. younger. It appears that Paleoproterozoic micro-continental collision during the assembly of Laurentia buried Archean crustal rocks and gabbros trapped in the collision zone to mantle depths, from which they were then rapidly exhumed to mid crustal levels, possibly as a result of delamination of the continental lithosphere, which also triggered asthenospheric upwelling and mafic magmatism.