U-Pb constraints on high-pressure metamorphism in the southwestern Grenville orogen, Canada

J. W. F. Ketchum — Department of Earth Sciences, Memorial University, St. John's, Newfoundland, A1B 3X5, Canada

T. E. Krogh — Royal Ontario Museum, 100 Queen's Park, Toronto, Ontario, M5S 2C6, Canada

Garnet- and clinopyroxene-rich metabasites with mineralogical and textural evidence of eclogite-facies metamorphism are found in the 1.2–1.0 Ga Grenville orogen in central Ontario and western Quebec, Canada. Field and petrographic relationships indicate that this high-pressure event predated regional granulite- to amphibolite-facies metamorphism. Constraints on the timing of eclogite-facies metamorphism are critical for models of Grenvillian tectonic evolution.

The eclogitic metabasites, which are derived from mafic igneous precursors, are found in allochthonous lithotectonic domains of the Central Gneiss Belt (Fig. 1). These metabasites are rare and mainly occur as tectonized bodies within high-strain zones marking domain margins. Identical metabasite occurrences in domain interiors indicate that high-pressure equilibration was not confined to potentially exotic blocks within shear zones, but instead affected a large region of crust (Davidson, 1990). Comparable evidence for eclogite-facies metamorphism has not been documented in the adjacent parautochthon (Fig. 1). The metabasites typically contain some or all of garnet, clinopyroxene, plagioclase, orthopyroxene, amphibole, kyanite, corundum, sapphirine, rutile, and titanite, most of which represent younger metamorphic products after the inferred eclogite-facies assemblage omphacite-garnet-kyanite. Omphacite has only been documented in an eclogitic lense in western Quebec (Indares and Dunning 1997), but augite-plagioclase symplectite in the other bodies is interpreted as a breakdown product of omphacitic clinopyroxene (Grant 1989; Davidson 1990).

Seven bodies of variably retrogressed eclogite and one of associated anorthosite were sampled over a wide region for 'conventional' (ID-TIMS) U-Pb zircon dating. Our goal was to document both primary and secondary zircon growth ages in order to place constraints on the times of protolith crystallization and subsequent metamorphism. Only three samples provide information on protolith age, but all contain zircon interpreted as metamorphic and/or display discordance due to metamorphic resetting or mixing of igneous and metamorphic phases.

U-Pb Results

Four of seven eclogitic samples provide evidence of metamorphic zircon growth at 1095–1085 Ma. An eclogitic component of a metagabbro pluton in the interior of Go Home domain (Fig. 1) yields a 1469 ± 11 Ma upper intercept age (interpreted as the primary crystallization age), with metamorphic growth of low-U (<40 ppm) zircon at 1089 ± 2 Ma. A tectonic lense of garnet-clinopyroxene metabasite within a nearby shear zone contains similar low-U zircon dated at 1088 ± 2 Ma. One hundred km to the north, low-U zircons from an eclogitic body along the Britt-Shawanaga domain tectonic boundary are concordant at 1085 ± 3 Ma. A garnet-clinopyroxene metabasite from the same tectonic boundary along Georgian Bay provides a 1093 ± 2 Ma age based on three zircon fractions, with a fourth yielding a concordant older age of 1101 ± 4 Ma.

In addition to these results, four samples provide evidence of metamorphic zircon growth or resetting at other times. An eclogitic phase of the Frederic Inlet metagabbro at the margin of Shawanaga domain contains tiny colourless zircons of metamorphic aspect that crystallized at 1121^{+12}_{-10} Ma. Rare brown zircons in this sample formed at 997 ± 4 Ma and are likely related to amphibolite-facies retrogression. In Algonquin domain, the precursor to an eclogitic metagabbro crystallized at 1396^{+15}_{-13} Ma, with an imprecise lower intercept age of 1048 ± 30 Ma for metamorphic resetting. Sparse zircons from a meta-anorthosite in the Rosseau domain define a poorly constrained discordia line indicating igneous crystallization at ca. 1450 Ma. Excluding two imprecise, lower-U analyses, a 1063^{+35}_{-48} lower intercept age of metamorphism is indicated. This result is in

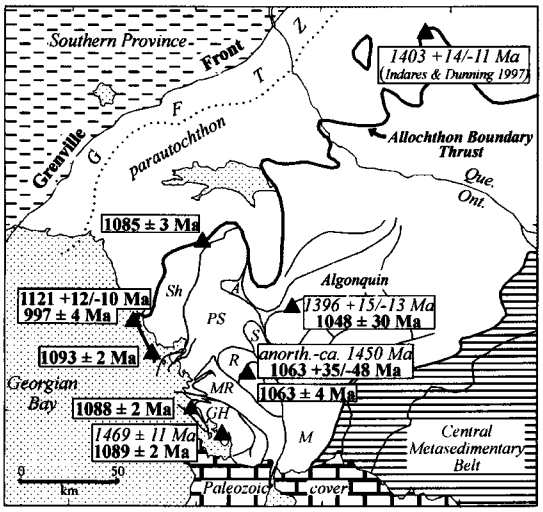

FIG. 1. Location of dated eclogitic metabasite occurrences in the Central Gneiss Belt, SW Grenville Province, Canada. All ages are from U-Pb zircon analyses. Italics - crystallization age of igneous protolith. Bold - metamorphic age(s). Results in the range 1089 ± 5 Ma are interpreted to record the time of high-pressure Grenvillian metamorphism.

agreement with two analyses of very low-U (<1 ppm) zircon from a nearby eclogite that indicate metamorphic growth at 1063 ± 4 (based on replicate $^{206}Pb/^{238}U$ ages). A third, weakly discordant, low-U fraction from this eclogite has a $^{206}Pb/^{238}U$ age of 1090 ± 3 Ma.

Interpretation

The U-Pb results indicate that igneous precursors of some eclogitic metabasites and the meta-anorthosite crystallized at ~1500–1400 Ma. The 1396 Ma igneous crystallization age of one body is in good agreement with a 1403^{+14}_{-11} Ma age for an eclogite protolith in western Quebec (Indares and Dunning 1997). Grenvillian metamorphism of these rocks is indicated at 1089 ± 5 Ma, the average age of metamorphic zircons in four widely-spaced bodies, with a fifth also containing one zircon fraction of this age. Previously reported U-Pb metamorphic ages from throughout the Central Gneiss Belt (with the exception of the Parry Sound domain) do not fall within this interval, indicating that the 1095–1085 Ma metamorphic zircons are unique to eclogitic metabasites and record high-pressure metamorphism rather than retrogression during later granulite- to amphibolite-facies regional metamorphism. We suggest that high-pressure metamorphism of allochthonous domains in the Central Gneiss Belt occurred during *c.* 1090 Ma overthrusting of the Central Metasedimentary Belt, with subsequent thrust transport and partial exhumation of these domains along a major regional detachment (allochthon boundary thrust; Fig. 1) that was likely active at *c.* 1080 Ma. Older, 1120 Ma zircons in the Frederic Inlet metagabbro indicate the possibility of an earlier high-pressure event in the Shawanaga domain, which is compatible with its inferred outboard setting during initial collision of the Central Metasedimentary Belt and Parry Sound domain (Culshaw *et al.*, 1997). Zircon growth and resetting at 1063 Ma in Rosseau domain samples may be related to a third high-pressure event or to retrogression of high-pressure assemblages. The extant field and geochronological data combined with these new results support a general tectonic model of thrust burial followed by partial thrust exhumation and thermal relaxation as the Grenville orogen propagated 'piggy-back' fashion towards its foreland.

References

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