Combined U-Th-Pb monazite and Lu-Hf garnet ages from the Alpine Schist: Implications for the timing and duration of Barrovian metamorphism in the Southern Alps, New Zealand

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Introduction and objectives
The Alpine Fault plate boundary in New Zealand has exposed a cross-section through greenschist- to amphibolite-facies Alpine Schist that extends for over 230 km along the Southern Alps (Fig. 1). The Alpine Schist offers an ideal location to investigate the timescales of Barrovian-type metamorphism and terrane accretion at the eastern Gondwana subduction margin. Existing ages of metamorphic minerals in Alpine Schist are scarce and range from 100 – 70 Ma (Fig. 1). We combine monazite LA-ICP-MS (laser ablation split-stream) geochronology with Lu-Hf garnet geochronology from samples distributed along the Alpine Fault. Prograde garnet metamorphism and terrane accretion at the eastern Gondwana subduction margin.

Implications and discussion points
1. Preliminary Lu-Hf garnet ages (Fig. 2) are consistent with a published Sm-Nd mineral – whole-rock age from the Matakete Range area (Mortimer and Cooper, 2004).
2. Monazite and xenotime ages are significantly younger than new and published Sm-Nd and Lu-Hf garnet – whole-rock ages (Vry et al., 2004).

Three possible explanations are:
1. 70 Ma signature records the timing of peak temperature mineral growth.
2. Fluid influx associated with pegmatite intrusion in the Matakete Range area resulted in fluid-assisted mineral growth at ~70 Ma (Fig. 3).
3. The garnet-bearing rocks and monazite-bearing rocks underwent different P-T paths. High Lu/Hf garnet may mask younger, low Lu/Hf garnet growth stages.

4. Monazite U-Th-Pb ages are not disturbed by monazite alteration to apatite + allanite + REE-epidote.

Fig. 1: Map of the Alpine Schist showing sample locations

Fig. 2: Garnet chemistry and Lu-Hf garnet geochronology from two garnet-epidote facies schists (MR13-01, MR13-10). Major element data were measured by EMPA. REE data were measured by LA-ICPMS. MR13-10 garnet shows typical progressive zoning in major elements with HREE concentration in the core of the grain. Garnet separates were not categorized by grain size or inclusion density. Whole-rock fractions include both pressure diagenetic (boobm) and Sadelix-digested fractions. Garnet – whole-rock isochrons have high MSWD values due to the unusually high 176Lu/177Hf of metabasites. Two point garnet – whole-rock isochrons demonstrate some variation between the garnet points, which brackets the multi-point isochron age.

Fig. 3: Monazite and xenotime LASS-ICP-MS data from a quartz-feldspathic gneiss (MR13-28, Qz-Pi-Ksp-Qtz-Ms-IIm). Monazite occurs 1) altered to apatite – allanite – REE-epidote coronas in biotite and 2) as unaltered grains in quartz/plagioclase. Th is concentration as thorite inclusions in apatite and Y is concentrated in the REE-epidote rim. Unaltered monazite has higher Th/U but similar REE profiles as altered monazite. Geochronology shows that U-Th-Pb systematics are not disturbed by monazite alteration processes.

Fig. 4: Anatectic pegmatites from the Matakete Range intrude quartz-feldspathic gneiss host rock. MR13-28 was collected ~50 m from pegmatite outcrops within the zone of highest pegmatite abundance. Pegmatites yield a monazite 176Th/177Hf-Th age distribution which envelopes that of the monazite bearing quartz-feldspathic gneiss (MR13-28, Fig. 3). Monazite REE profiles reflect modal garnet abundance.