V41A
3061

The P-T-t history of the Alpine Schist, New Zealand: Constraining tectonic processes during the late stages of Gondwana breakup

Sophie Briggs[1], John Cottle[1], Matthijs Smit[2], Graham Hagen-Peter[3]

[1]Department of Earth Science, University of California Santa Barbara
sbriggs@umail.ucsb.edu
cottle@geol.ucsb.edu

[2]Pacific Center for Isotope and Geochemical Research, Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia, Vancouver, Canada. msmit@eos.ubc.ca
[3]St Olaf College, Northfield, MN. ghagenpe@gmail.com

Summary

The microcontinent Zealandia is composed of terranes accreted at the margin of west Gondwana during late Paleozoic – Mesozoic Pacific Plate subduction. Separation of Zealandia from west Antarctica in the Late Cretaceous marked the final stage in the breakup of Gondwana. Two contrasting ideas for the rifting have been proposed:

1) Subduction ceased by ~100 Ma, followed by a rapid transition to extension, culminating in sea-floor spreading from ~83 Ma separating Zealandia and Australia-Antarctica (e.g. Tulloch et al., 2009).

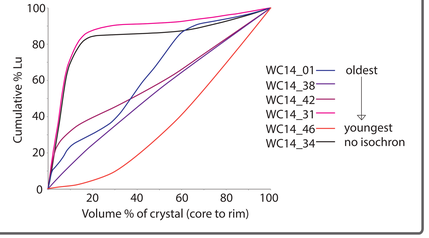
2) Convergence continued simultaneously with back-arc extension along a portion of Zealandia until ~85 Ma. This hypothesis is based on Late Cretaceous Sm-Nd and Lu-Hf ages from a zoned garnet porphyroblast (Vry et al., 2004) from the Alpine Schist, a metamorphosed accretionary complex.

This study addresses the problem of garnet growth (a prograde metamorphic process) during a time period thought to be dominated by extension and lithospheric thinning in Zealandia. Garnet-bearing Alpine Schist was dated by Lu-Hf geochronology throughout the Southern Alps orogen. Isochron ages vary from 97.3 ± 0.28 in the southern Alpine Schist to 75.4 ± 1.3 in the north. Compositional zoning in garnet aids age interpretation and is consistent with prolonged garnet growth throughout the Alpine Schist.

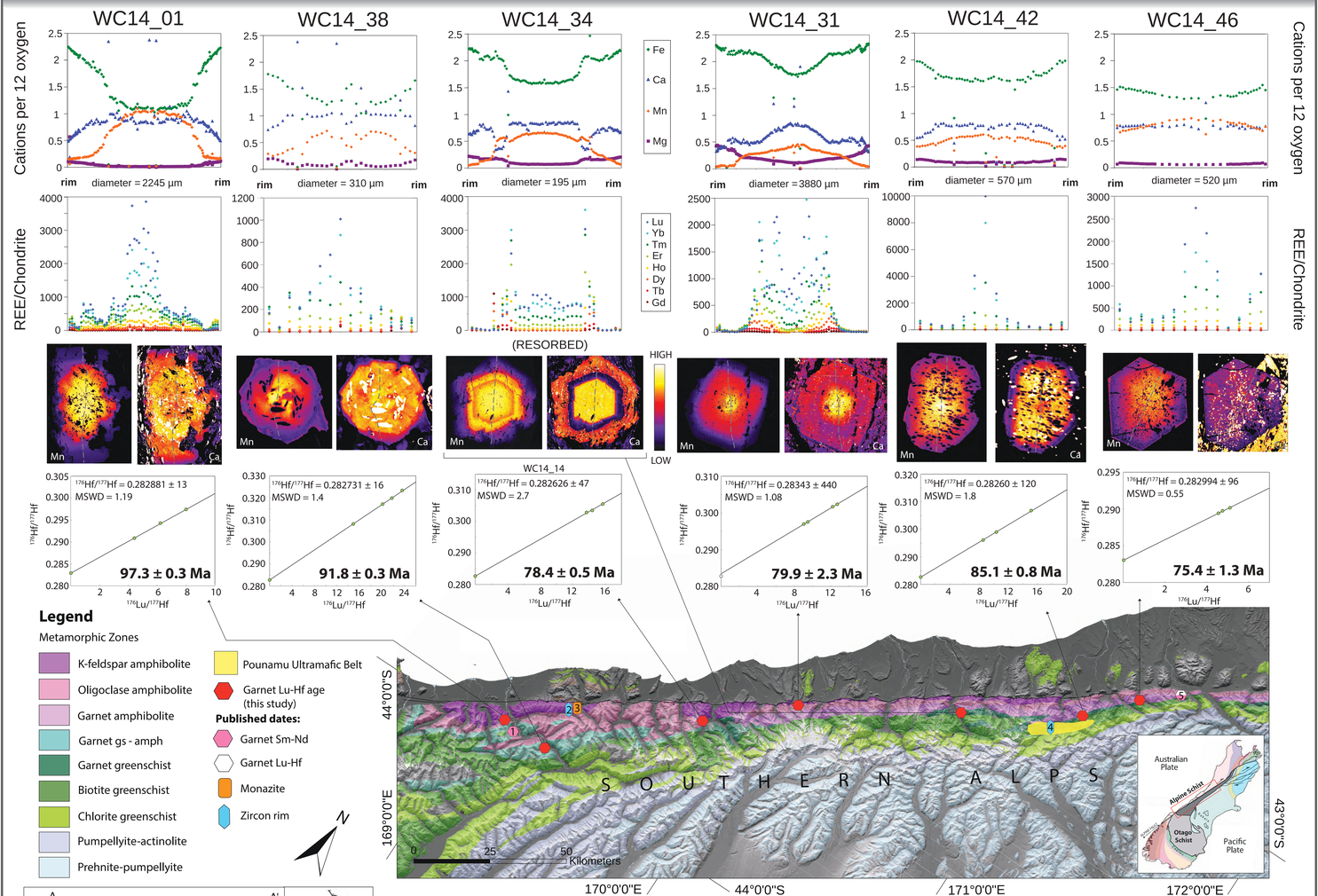
Phase equilibria modelling and P-T path construction will reveal if garnet grew on a prograde path (convergence) or during isobaric heating or decompression (transition from convergence to extension). Coupled with garnet ages, a P-T-t evaluation of the Alpine Schist will elucidate the tectonic processes that occurred during the final stage in the breakup of Gondwana.

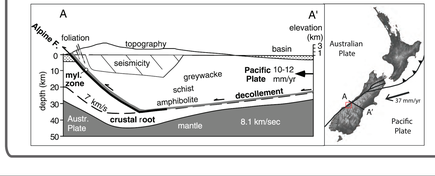
Lu-Hf garnet geochronology

Lu-Hf garnet geochronology involves analysis of multi-grain garnet aliquots by isotope dilution methods, resulting in a 'bulk age'. The distribution of the parent isotope ^{176}Lu throughout the volume of the garnet grain will determine if this age represents a mean age for the time period over which garnet grew, or if the age is bias toward the timing of core or rim growth. In Alpine Schist garnet Lu distribution versus volume % garnet is variable but does not correlate with isochron age, indicating that core-rim age bias is not responsible for the observed age heterogeneity.



Results





Legend

Metamorphic Zones

- K-feldspar amphibolite
- Oligoclase amphibolite
- Garnet amphibolite
- Garnet gs - amph
- Garnet greenschist
- Biotite greenschist
- Chlorite greenschist
- Pumpellyite-actinolite
- Prehnite-pumpellyite
- Pounamu Ultramafic Belt
- Garnet Lu-Hf age (this study)

Published dates:

- Garnet Sm-Nd
- Garnet Lu-Hf
- Monazite
- Zircon rim

Map shows Alpine Schist metamorphic field gradient and location of samples analyzed. Inset shows basement terranes of the South Island and the extent of the Otago and Alpine Schist metamorphic overprints. Metamorphic zones from http://data.gns.cri.nz/ based on the QMAP Geological Map of New Zealand (Rattenbury and Isaac, 2012). Cross section shows dip of Alpine Fault and uplift of Pacific Plate crust along lower crustal decollement (modified from Vry et al., 2004).

Previously published dates from the Alpine Schist are numbered on the map as follows:

1) 100 ± 12 Ma, Sm-Nd mineral – whole rock isochron (Mortimer and Cooper, 2004)
2) 71 – 64 Ma from U-Pb zircon rim ages (Cooper and Ireland, 2013b)
3) 71 ± 2, U-Pb monazite (Mortimer and Cooper, 2004)
   79.6 ± 0.3 Ma to 50.5 ± 0.3 Ma, monazite (Briggs unpublished data)
4) 72 ± 2 Ma U-Pb from zircon rims (Cooper and Ireland, 2013a)
5) 98 ± 8 Ma, Sm-Nd mineral – whole rock isochron (Vry et al., 2004)
   86 ± 0.2 Ma, Lu-Hf garnet rim – whole-rock isochron (Vry et al., 2004)

Age Interpretation

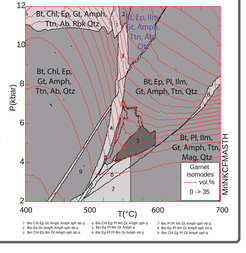
Representative garnet grains for each sample, characterized using elemental X-ray maps of manganese and calcium. Rim-rim transects shown as gray dashed lines indicate major element measurements by electron microprobe analysis (EPMA) and trace element measurements by laser-ablation inductively coupled plasma-mass spectrometry (LA-ICP-MS).

Major element cation and chondrite normalized HREE abundances generally reflect normal Rayleigh fractionation during garnet growth. Small increases in HREE (and in some cases Mn) abundance at rims could represent a decrease in growth rate and simultaneous increase in matrix diffusion during increasing temperature (e.g. Smit et al., 2013), or alternatively, diffusive re-uptake of Lu as a result of garnet resorption (e.g. Kelly et al., 2011). Retention of Lu and loss of Hf during resorption can create spuriously young Lu-Hf garnet ages, especially if the Lu budget is weighted toward garnet rims.

Garnet resorption has clearly occurred in WC14_34, evidenced by spikes in compositional zoning (particularly HREE) which likely represent redistribution of HREE back into the core during resoprtion. The resorbed core is rimmed by later garnet growth. WC14_34 does not form an isochron (isochron below WC14_34 is from WC14_14).

Continuing work: Thermobarometry

Example pseudosection constructed for WC14_46 using Perple_X_6.7.2 (Connolly 1990, 2009). Garnet isomodes demonstrate the feasibility of garnet growth during isobaric heating or decompression, while isopleths will allow a comparison of the conditions of garnet core and rim growth.
Variations in the conditions of initial garnet growth between samples with different bulk compositions will contribute to age variation.



Implications

Garnet growth in the Alpine Schist persisted during late Cretaceous extension. Collision of the Hikurangi Plateau LIP fragment may have driven late convergence at the Pacific-Gondwana margin. Alternatively garnet grew during extension and lithospheric thinning associated with western Gondwana breakup. P-T-t paths will resolve the tectonic processes responsible for late garnet growth.