Structure and Geochronology of the Alpine Schist, New Zealand

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STRUCTURE AND GEOCHRONOLOGY OF THE ALPINE SCHIST, NEW ZEALAND

STRUCTURE AND AGE OF THE ALPINE SCHIST FABRICS

ABSTRACT

The Alpine Schist is located on the eastern margin of the Alpine Fault, which accommodates oblique collision between the Pacific and Australian plates in New Zealand. Collision has been active since the Cenozoic and exhumation models predict that surface rocks were buried ~20km in the Pliocene. Despite this, fabrics of Mesozoic age are inferred to be preserved at the surface. In order to test the age of fabric formation, transects were conducted across the Alpine Schist to measure the foliation. Rock samples were collected to date the age of zircon and $^{40}$Ar/$^{39}$Ar age of muscovite in order to constrain the age of metamorphism and fabric formation within the Alpine Schist. The structural data displayed two populations of foliations: a dominant foliation tracking towards the orientation of the Alpine Fault and a minor shallower orientation. The geochronological data highlighted ages for the formation and deposition of the Alpine Schist protolith and metamorphism associated with the Rangitata Orogeny. Muscovite $^{40}$Ar/$^{39}$Ar data analysis yielded Pleistocene closure temperatures of the argon system. The heterogeneous foliation orientation and muscovite age suggested differential strain and fabric formation with the Alpine Schist during Pleistocene uplift along the Alpine Fault. The study of the active Southern Alps orogen and constraining the structural and geochronological features will enable more accurate interpretation of fossil orogens and their relationship with plate tectonics.

KEYWORDS

Geochronology, Structural, Alpine Schist, New Zealand, Southern Alps, Zircon, Muscovite
Structure and Age of the Alpine Schist Fabrics

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Figure 2 Geological map of the Central Southern Alps region surrounding the town of Franz Josef, showing variation in geology, general structural trend and schist units with decreasing metamorphic grade east of the Alpine Fault, modified after Cox and Barrell (2007).

Figure 3 Geological cross sections (no vertical exaggeration) across the Central Southern Alps region surrounding the town of Franz Josef. See figure 2 for location. A-A’ Waiho - Callery River, B-B’ Tatare Stream with annotated locations of muscovite samples for Ar/Ar dating, C-C’ Tommy Creek and D-D’ Hare Mare Creek – Waikukupa River. The transect cross sections display schist and mylonite units outcropping at the surface for their length. This is a simplification of the geology of the region to assist with visualisation as much of the surface is covered by a layer of Quaternary fluvio-glacial sediments that have not been mapped except for the Whataroa river channel. Surface fault expression from the work of Cox and Barrell (2007), fault trace in transect from the seismic interpretation of Davey et al. (1995).

Figure 4 Foliation and lineation readings collected from transects seen in figure 3. (a) Waiho River – Callery River transect (Poles to foliation, lineation, foliation trend), (b) Tatare Stream transect (Poles to foliation, lineation, foliation trend), (c) Tommy Creek transect (Poles to foliation, lineation, foliation trend, calculated fold axis), (d) Hare Mare Creek – Waikukupa River transect (Poles to foliation, lineation, foliation trend), (e) All lineation readings. Where there are discrete populations of foliation measurements these are identified by different colours on the stereonets.

Figure 5 CL imaging of zircons separated from Alpine Schist samples with laser spots annotated in red. (a) Sample NZ1310_Z5, growth zoning in typical crustal rocks, dark and bright zoning (a1 126.6 ± 1.8 Ma, a3 124.8 ± 1.8 Ma), (b) Sample NZ1310_Z15, homogenous xenocrystic core with polishing scratches, inner rim, evidence of metamorphic inner rim and bright outer rim, (b3 139.1 ± 3.3 Ma, b2 124.8 ± 3.3 Ma), (c) NZ1309_Z1 Growth zoning typical of crustal rocks, minor bright outer rim, (c1 265.9 ± 3.5 Ma), (d) NZ1310_Z25 metamorphic core with non homogenous outer rims, (683.1 ± 8.8 Ma), (e) NZ1210_Z24 well defined zones of core, bright and dark, with bright outer rim sections (e1 3345.4± 33.9 Ma, e2 3251.3 ± 33.9). Locations of concordant laser spots numbered for each zircon. All ages 238U/206Pb ages.

Figure 6: Concordia diagrams for zircon sampled from the Alpine Schist. (a) Sample NZ1309, (b) Sample NZ1310 and (c) Sample NZ1315.

Figure 7: U/Pb detrital zircon age relative probability plots for, a-b Alpine Schist (NZ1309, NZ1310, NZ1315), c-d NZ1309, e-f NZ1310, g-h NZ1315. Data at discordance <10% (a, c, e, g) and <5% (b, d, f, h) are used here for comparison. Prominent peak ages for the Cretaceous occur at 120 Ma and 140 Ma. The Triassic peak ages occur at 220 Ma and 240 Ma. Permian peak ages occur at 260 Ma and 270 Ma. Minor Silurian ages occur around 430 Ma. Singular Ordovician peak occurred at 470.1 Ma.

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~220 Ma and ~240 Ma. Permian peak ages occur at 260 Ma and 270 Ma. Minor Silurian ages occur around 430 Ma. A singular Ordovician peak occurred at ~470 Ma. All ages $^{238}\text{U}/^{206}\text{Pb}$ Age. 

Figure 9 $^{206}\text{Pb}$ detrital zircon age relative probability plots with kernel density plots following the method of Vermeesch (2012) for, (a-b) Rakaia subterrane (Torlesse terrane) from unpublished ages of (Acott 2013), (c-d) Alpine Schist (NZ1309, NZ1310, NZ1315) and (e-f) U/Pb detrital zircon age relative probability plots of Rakaia subterrane (Torlesse terrane-Haat Schist Transition Zone) sandstones (TAKA10) from Pickard et al. (2000). Relative probability plots show all data within discordance $<5\%$. Prominent populations are correlated between plots with grey vertical lines.

Figure 10 (a) $^{232}\text{Th}/^{238}\text{U}$ Ratio from Alpine Schist zircon samples plotted against $^{238}\text{U}/^{206}\text{Pb}$ Age for samples <500 Ma with annotated samples 10_5C at 124.6 Ma $^{232}\text{Th}/^{238}\text{U}$ 0.63, 10_1A at 130.2 Ma $^{232}\text{Th}/^{238}\text{U}$ 0.51, 10_20A at 139 Ma $^{232}\text{Th}/^{238}\text{U}$ 0.415, 10_17A at 139.1 Ma $^{232}\text{Th}/^{238}\text{U}$ 0.713, and NZ1310_33B at 187.5 ± 2.6 Ma ) $^{232}\text{Th}/^{238}\text{U}$ 0.17(b) Th/U Ratio from Rakaia Terrane Zircon Samples plotted against their $^{235}\text{U}/^{206}\text{Pb}$ Age for samples <500 Ma.

Figure 11 $^{40}\text{Ar}/^{39}\text{Ar}$ spectra with Mean Square Weighted Deviation (MSWD) and P values, from the Tatare Stream Transect in the Alpine Schist (see figure 2), (a) Sample NZ1306 closest to the Alpine Schist, (b) Duplicate of sample NZ1306, (c) Sample NZ1309, (d) Sample NZ1312 at the furthest extent of the Tatare transect from the Alpine Fault and (e) Duplicate of sample NZ1312.

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