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P–T evolution of contemporary high-T eclogite and high-P omphacite granulite from the lower crust, Fiordland, New Zealand

M. C. De Paoli (1) and G. L. Clarke (2)

(1) Institute of Geochemistry and Petrology, ETH Zürich, Clausiusstrasse 25, CH-8092, Zürich, Switzerland (matthew.depaoli@erdw.ethz.ch), (2) School of Geosciences, FO9, University of Sydney, Sydney, NSW, 2006, Australia.

The Breaksea Orthogneiss, a high–pressure (P) component of the c. 126–116 Ma Western Fiordland Orthogneiss, comprises interleaved dioritic and gabbroic orthogneiss that experienced peak high-P omphacite granulite and eclogite facies conditions. High-grade metamorphism preceded isothermal decompression, followed by cooling and hydration at high-P amphibolite facies conditions. Mineral equilibria modeling using calculated P–temperature (T) and P–MH_2O phase equilibria diagrams in the model system NCKFMASHTO (Na2O-CaO-K2O-FeO-MgO-$Al2O_3$-SiO_2-H_2O-TiO_2-O) are used to constrain the relative timing of tectonic amalgamation/ entrainment (P–T–D–t evolution) of omphacite granulite and eclogite. Quantitative P–T and bulk chemical constraints on the development and preservation of characteristic granulite and eclogite facies mineral assemblages such as omphacite-garnet-rutile-plagioclase-quartz-ternary feldspar (antiperthite)-kyanite (granulite) and omphacite-garnet-rutile $\pm$ orthopyroxene (eclogite) are assessed with reference to the calculated phase diagrams. Results of the phase equilibria modelling are validated in the context of natural assemblages from the Breaksea Orthogneiss, where contemporary dioritic granulite and gabbroic eclogite formed at P$\approx$1.8 GPa and T$\approx$850°C. They also illustrate the dependence of granulite and high-T eclogite assemblages on whole-rock composition from mid- through to overthickened-crustal conditions ($\approx$60 km). Peak assemblages together subsequent replacement textures and in combination with mineral compositional and modal data reflect diagnostic segments of peak to retrograde P–T evolution on the calculated phase equilibria diagrams. The scarcity of omphacite-bearing granulite and orthopyroxene-bearing eclogite assemblages in rocks from the granulite–eclogite transition reflects the influence of whole-rock composition on phase diagram topology. The Breaksea Orthogneiss extends the thickness of the Cretaceous Fiordland island arc developed off the Eastern Gondwana margin to $\approx$60 km, close to the thickest of known Andean–style margins.