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Petrogenetic overview of the rifted, Southern Victoria Land lithospheric mantle, Antarctica

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The stretched and thinned lithosphere underlying the Ross Sea in the Southern Victoria Land segment of the West Antarctic Rift System sits adjacent to the up-thrown Transantarctic Mountains, providing over 5 km of relief. The Cenozoic, alkalic McMurdo Volcanic Group rocks were erupted through continental crust that varies in thickness from c. 17-25 km beneath Ross Island to c. 40 km in the foothills of the Transantarctic Mountains. Basanites contain numerous mantle and crustal xenoliths. The peridotite types include spinel lherzolites, harzburgites and rare dunites, and rare plagioclase-bearing spinel lherzolites, which are thought to form via metamorphic reaction and refertilisation processes. Garnet is never observed, but is inferred from symplectite textures. A wide variety of pyroxenite xenoliths are present, though subordinate to peridotites, with glimmerite-type found at Foster Crater. Crustal xenoliths are common, and from their study a possible trans-lithospheric basement suture has been suggested. Peridotite and crustal xenolith geothermometry record an atypically hot geotherm of 50-100 °C/km in Southern Victoria Land, which may be caused by advective heat transfer from melt refertilisation over the past 24 Ma or more. Melt extraction has been interpreted to occur in the mantle garnet facies or the spinel facies, and has been attributed to mantle pluming or decompression melting.

A deca-kilometre-scale mantle H_2O, trace element and Sr-Nd-Pb isotopic heterogeneity has been demonstrated for the region, and numerous detailed studies have revealed a complex history of partial melting, refertilisation and metasomatism involving carbonatite, N-MORB and alkalic melts. Erebus lavas record an end-member HIMU mantle component on U/Th and $^{230}Th/^{232}Th$ versus Pb isotope plots, an enriched mantle component is evident at White Island and Mount Morning (EMI and EMII) and some pyroxenites at Mount Morning share trace element and isotopic characteristics with eclogite. Despite this complex regional history, oxygen fugacity $\Delta\log fO_2$ values averaging -1 FMQ at Mount Morning (from Mössbauer spectroscopic measurements), overlap with the global median in rifted settings (-0.9 FMQ). Primitive lava and peridotite isotopic ratios tend to lie along a mixing trajectory between mantle end-member components DMM and HIMU, a characteristic that is shared across a geographically wide area referred to as the diffuse alkaline magmatic province (DAMP): these areas were once contiguously assembled in Gondwana.

The depleted element budget of harzburgites in the region overlaps with the field for Archaean mantle, and those of lherzolite with Proterozoic and Phanerozoic mantle, whose timing is in agreement with initial aluminachron stabilization ages. The timing of some pyroxenite formation in the region has been dated at c. 439 Ma, in Northern Victoria Land eclogite samples are dated at c. 500 Ma and crustal xenoliths beneath Mount Morning at c. 540 Ma: the latter two ages overlapping with subduction of the Palaeo-Pacific plate beneath Gondwana during Ross orogenesis. It appears likely that pyroxenite formed from fluids derived from (or modified by) melting of the subducting eclogitic oceanic crustal plate percolating through peridotite of the lithospheric mantle. Subsequent melting of pyroxenite veins has contributed to the enriched trace element and isotope signatures in DAMP rocks. Despite the knowledge advances made in the past two decades, there is still significant research to be undertaken in Southern Victoria Land.