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Compositional Variability of the Mantle beneath West Antarctica and its Relationship to Terrane Tectonics: Evidence from Mantle Xenoliths

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This work examines the petrography and mineral chemistry of sixteen previously undescribed mantle xenoliths suites from the West Antarctic Peninsula. The xenoliths are from the Jones Mountains (a Palaeozoic volcanic arc terrane on the margin of Gondwana), Adelaide Island (a Mesozoic volcanic arc terrane) and Alexander Island (an accretionary complex). They were entrained by subduction and rift-related magmatism, including 50 Ma calc-alkaline lamprophyres (Adelaide Island) and 10–5 Ma alkali basalts (Alexander Island and Jones Mountains). The xenoliths range in composition from pyroxenites (Adelaide Island) to spinel peridotites (Alexander Island and Jones Mountains). At Alexander Island, the spinel peridotites occur as both ‘fertile’ lherzolites and ‘depleted’ harzburgites. The xenoliths show a wide variation in mineral chemistry, for example olivine varies from Fo91.5 in the harzburgites to Fo71 in the pyroxenites. Significant variations have also been observed in the major-element chemistry of the pyroxenes. Those in the spinel peridotites are Cr-diopsides whereas those in the pyroxenites are Al-augites.

Rare-earth element patterns of clinopyroxenes and Cr/(Cr+Al) ratios of spinels provide information on the origin of the xenoliths. We conclude that the harzburgites experienced a complex evolution involving extraction of up to 20% melt, perhaps in the mantle wedge, followed by accretion on to the base of the lithosphere and enrichment in Cr by large degree hydrous melts (boninites). There is also evidence of enrichment in strongly incompatible trace elements by carbonate melts and fluids from the subducted Phoenix plate. However, some of the spinel lherzolites from Alexander Island, and also those from the Jones Mountains, have compositions that are similar to fertile mantle and have not been subjected to large scale melting. The pyroxenites from Adelaide Island are believed to represent samples of veined lithospheric mantle caused by percolation and reaction of small-fraction carbonate-rich melts, most likely from the subducted slab, into the overlying lithosphere.

These findings confirm the complex nature of the terranes that comprise the Antarctic Peninsula. This is a first step towards integrating the geophysical and geochemical data on the continental lithosphere of this area. Importantly, the xenoliths provide new information on how the composition of the lithosphere at a continental margin has evolved in response to mantle melting and enrichment associated with a subducting oceanic plate. Further samples from these localities are currently being studied in greater depth at the University of Cambridge.