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# The oxidation state of the sub-arc lithospheric mantle: New data and models

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It has long been recognised that arc-related peridotites are more oxidised than those in other tectonic settings [1]. However, the samples studied to date were frequently small, heterogeneous and altered, while it remains unclear whether these are all melting residues formed in the mantle wedge of subduction zones or not. Recent field studies have allowed recovering exceptional suites of large, homogeneous and serpentine-free sub-arc mantle spinel harzburgites at Avacha (Kamchatka arc, Russia) [2] and Ritter (Western Bismarck arc, Papua New Guinea) [3] volcanoes. Here we present a $^{57}Fe$ Mössbauer study of spinel in Avacha and Ritter peridotites; the results are used to re-evaluate the oxidation state of the sub-arc mantle and discuss its origin and evolution with new petrogenetic models [3].

The two peridotite suites were sampled in recent eruptive products; respectively low-K andesitic tephras (Avacha) and submarine picrite-boninite cinder cones (Ritter). All peridotites display the same textural and major and trace element features, which indicate that they are mantle residues produced by 25-40% of melting at 1-3 GPa [2, 3]. As reported for other sub-arc mantle xenolith suites, Avacha and Ritter peridotites are enriched in $SiO_2$ and orthopyroxene (opx) at a given melting degree in comparison with melting residues of fertile primitive mantle [3]. This enrichment is attributable to the effects of fluxed-melting by $SiO_2$- and volatile-rich, subduction-derived agents in the mantle wedge [3]. Euhedral and homogeneous Cr-rich spinels were selected in alteration-free peridotites and analysed for their $Fe^{3+}/\sum Fe$ by Mössbauer spectroscopy. The range in $Fe^{3+}/\sum Fe$ for most Avacha samples is relatively limited (0.23-0.30) as are their modal opx contents (19-30 wt%). In contrast, spinel in the Ritter samples has $Fe^{3+}/\sum Fe$ that varies from 0.11 to 0.26. This ratio correlates positively with opx mode (from 7 to 26 wt%) as well as bulk rock $Al_2O_3$ content.

Oxygen fugacities ($fO_2$) were calculated at 1 GPa using the spinel-based oxybarometer of Wood [4] and the temperatures of equilibration of the peridotites. For the least melt-depleted (or most opx- and $Al_2O_3$-rich) peridotites, $\Delta \log fO_2$ values are FMQ to FMQ+0.8 (Avacha) and FMQ+0.3 to FMQ+1.7 (Ritter), where FMQ refers to the fayalite-magnetite-quartz reference redox buffer. These values are substantially higher than those reported for abyssal peridotites [5]. Therefore, our new Mössbauer data and the recent models for the petrogenesis of the sub-arc lithospheric mantle [4] substantiate the results of earlier studies suggesting that the mantle sources of subduction zone magmas are more oxidised than those of mid-ocean ridges. The positive correlations between spinel $Fe^{3+}/\sum Fe$ and opx or whole rock $Al_2O_3$ contents in Ritter peridotites are in line with experiments demonstrating a more incompatible behaviour of $Fe^{3+}$ than for $Fe^{2+}$ during mantle melting [6]. We present partial melting models that simulate the potential processes controlling the observed trends and use them to further discuss controls on and evolution of mantle wedge redox state.

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