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Mantle Composition and Processes during the Earliest Magmatic Stage of Subduction Initiation: Evidence from Forearc Peridotites of the IBM and Tonga Regions

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Subduction initiation is the key to create subduction zone and maintain plate tectonics [1]. However, its mechanisms remain a topic of debate as the dynamics of subduction initiation differ across individual subduction zones and the geological record is often obscured by subsequent processes.

Magmatic activity is influenced by both the stage of subduction initiation and its nature [1]. The earliest stage of subduction initiation of the IBM and Tonga regions generated basalts and residual mantle peridotites, and their compositions are therefore believed to reflect the nature of subduction initiation [1&2]. However, our understanding of mantle processes during the earliest magmatism is limited because most reported forearc peridotites are depleted, having formed through hydrous melting associated with boninite formation at the later stage. Although some forearc peridotites record basaltic magma infiltrations [2], no residual forearc peridotites that underwent partial melting and melt extraction without melt-rock reaction processes have been identified.

We re-examined the major and trace element compositions of minerals in harzburgite and lherzolite samples previously reported from the IBM and Tonga regions [2&3] to find out primary records reflecting the earliest stage of subduction initiation. Key petrological features distinguishing these peridotites from typical forearc peridotites include the presence of amphibole (<0.1 vol.%), low Cr/(Cr + Al) ratio in spinel, and clinopyroxenes showing high HREE concentrations with low LREE/HREE ratios. The petrological features and our open-system melting model results suggest that these peridotites formed through partial melting under 'moist' conditions and are residues after basaltic magma extraction. Therefore, we identified residual peridotites that capture mantle processes during the earliest magmatic activity of subduction initiation. These findings highlight differences in mantle source composition and melting processes, shedding light on to elucidate subduction initiation styles in the IBM and Tonga forearc regions.

[1] Arculus et al. (2019), Oceanography 32(1):160–174

[2] Birner et al. (2017), Journal of Petrology 58(9) 1755–1780

[3] Ishii et al. (1992), Proceedings of the Ocean Drilling Program 125 445–485