New Caledonia Ophiolite, Marginal Rifting to Fore-arc Evolution

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Citation: Cluzel et al., 2020. New Caledonia Ophiolite, Marginal Rifting to Fore-arc Evolution. Acta Geologica Sinica (English Edition), 94 (supp. 1): 9–10. DOI: 10.1111/1755-6724.14431

Abstract: The New Caledonia Ophiolite (Peridotite Nappe), represents about one third of the island's surface (i.e. 5 500 km^2). The ophiolite is composed of harzburgites, dunites, lherzolites, minor mafic-ultramafic cumulates, and various dykes and sills. The mantle section underwent a polyphase evolution, which involved prominent depletion and re-fertilization.

The oldest events are probably recorded by abyssal-type lherzolites of the northern massifs, which bear traces of moderate partial melting. Plagioclase lherzolites were formed by shallow entrapment of highly depleted MORB melt in residual spinel lherzolites. Nd isotope compositions are consistent with derivation from an asthenospheric mantle source that experienced a recent MORB-producing depletion. This evolution was most likely accomplished during the late Cretaceous breakup of the eastern Australian margin.

The harzburgite-dunite association, which forms the bulk of Peridotite Nappe was probably formed through a multistage magma-producing process. Harzburgites composition may have be obtained by a first phase of ~15% dry fractional melting, followed by 15%–18% hydrous melting in a supra-subduction zone setting. Variable ε_{Nd} negatively correlate with $^{87}Sr/^{86}Sr$, while Pb isotopes cover a wide range, trending from depleted mantle towards enriched, sediment-like, compositions. Such signatures likely reflect the evolution of a highly depleted fore-arc mantle wedge variably modified by different fluid and melt inputs during Eocene subduction.

The harzburgite-dunite set is overlain by a dunite transition zone ~300m thick, in turn discontinuously covered by cumulate lenses consisting of layered pyroxenites, dunites, and wherlites at the base and gabbronorites/websterites on top. The mafic cumulates crystallized from primitive, ultra-depleted melts in the nascent lower fore-arc crust. In particular, FME enrichments and Nd-Pb isotopes support an origin from a refractory mantle source modified by slab fluids for the gabbronorite-forming melts.

The Peridotite Nappe has been extensively serpentinized (40% to 100%) with extremely scarce occurrences of unserpentinized rocks. Lizardite, brucite, magnetite and minor chrysotile developed from joints and intra-granular cooling cracks in a near-static environment. Serpentine-coated joints and peridotite foliation have been thereafter reopened and injected by various felsic, mafic and ultramafic supra-subduction melts emplaced within a narrow time interval (55–50 Ma), immediately after subduction inception at 56 Ma, i.e. the age of granulite-facies metamorphic sole. The youngest magmatic event is represented by island-arc tholeiite dykes dated at 50 Ma.

A widespread set of antigorite and tremolite-bearing veins crosscut all previous structures in a progressively cooling fore-arc environment. The former are synkinematic crack seals, which display highly radiogenic, sediment-like $^{87}Sr/^{86}Sr$ ratios suggesting direct derivation of fluids from the subduction zone, while the latter bear mantle-like isotopic signatures and probably originated from the interaction of wall rocks with Ca-rich fluids released by Eocene dykes or fluids that leached them.

Finally, continental subduction and obduction occurred during the 44–34 Ma interval and were accompanied by the development of the HP-LT metamorphic belt of northern New Caledonia, which constrains the polarity of subduction.

Key words: ophiolite, supra-subduction, slab fluids, metasomatism

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