Geochemistry of Balls Pyramid and Lord Howe Island

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The aim of this funding request was to obtain comprehensive geochemical data for a small sample suite from across the Lord Howe Island (LHI) Group, specifically Balls Pyramid and Lord Howe Island, to establish a basic understanding of the

- intra- and inter-suite relationships between Balls Pyramid and Lord Howe Island;
- character and evolution of the mantle source and volcanic reservoirs;
- interaction between the mantle source and overlying crust.

This was a fundamental first step in our broader project, the focus of which is the complete characterisation of the LHI Group in order to understand mantle evolution, magma generation, and eruptive processes of monogenetic intraplate volcanoes. The LHI Group was chosen because of its unique setting:

- Its latitude (~31°S) places it near the region of the South Pacific Ocean where the mantle reservoirs are postulated to change from EM1/EM2 (north of ~33°S) to HIMU (south of ~33°S), making it ideal to investigate this hypothesis;
- Its tectonic setting is presumed to be consistent with Oceanic Island Basalts. The Group is, however, located on the margin of the submerged Zealandia continent where the crust is thinner.

Our GeoQuest Round 1 2021 funding enabled us to obtain the following data:

- Major and trace element measurements (including the REE) for the 10 Australian Museum samples. This suite includes material from Balls Pyramid as well as from locations on Lord Howe Island not covered in the UOW suite.
- Further REE data for the UOW samples to complete and enhance that already obtained via XRF and INAA.
- FeO measurements for all samples. These data are important for classification and determining source evolution but also for accurate modelling and the correction of loss on ignition data (Lechler & Desilets 1987). The latter is particularly important for our samples because petrographic examination, as well as previous research (Game 1970), shows that many contain abundant opaque minerals.

This study extends significantly the data available for the LHI Group, including the first reported data for Balls Pyramid and the first trace element data for Lord Howe Island, and provides an initial picture

of the mantle source characteristics for this small intraplate volcanic field. Our conclusions can be summarized as follows:

- Classification and discrimination diagrams, based on immobile element concentrations and ratios in order to avoid misinterpretation due to alteration or weathering, show the Lord Howe Island Group has a Continental Rift Basalt to Continental Intraplate Basalt evolutionary sequence rather than an Oceanic Island Basalt setting as has been previously suggested.
- The investigated sample suite shows characteristics typical of a monogenetic volcanic field, including minimal (if any) interaction with Zealandia continental crust, and is thus a valuable addition to the global database of such fields.
- The nature of the mantle source, or sources, appears to be an enriched garnet peridotite that has undergone varying degrees of partial melting and carbonatitic metasomatism. Data for Balls Pyramid suggest that its source has been more strongly influenced by metasomatism than the Lord Howe Island source, consistent with lateral heterogeneity and therefore derivation from discrete asthenosphere sources rather than a plume origin.

We have submitted our findings to the *New Zealand Journal of Geology and Geophysics* (Williams & Jones 2022) due to the connection to Zealandia and because of the contribution it makes to the understanding of mantle dynamics in that region of the Southwest Pacific. The paper has been reviewed and we are currently addressing the suggested revisions.

This initial study thus gave important new fundamental insights into the eruptive history and mantle source characteristics of the LHI Group, consistent with our aims. Further investigations are required, however, to better determine the nature and sequence of the eruptive history of the islands, and the details of source enrichment, heterogeneity, and origins. To this end field work and sample collection is being planned for July 2022.

References

Game PM 1970. Petrology of Lord Howe Island, Part I: the younger volcanics. Bulletin of the British Museum (Natural History) Mineralogy 2(5): 221-284.

Lechler P, Desilets M 1987. A review of the use of loss on ignition as a measurement of total volatiles in whole-rock analysis. Chemical Geology 63(3-4): 341-344. https://doi.org/10.1016/0009-2541(87)90171-9.

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