University of Victoria | Graduate Studies

Notice of the Final Oral Examination
for the Degree of Doctor of Philosophy

of

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"The Evolution of the Oceanic Lithospheric Mantle: Experimental and Observational Constraints"

School of Earth and Ocean Sciences

Friday, August 7, 2015
1:30 P.M.
Bob Wright Centre
Room A319

Supervisory Committee:
Dr. Laurence Coogan, School of Earth and Ocean Sciences, University of Victoria (Supervisor)
Dr. Kathryn Gillis, School of Earth and Ocean Sciences, UVic (Member)
Dr. Dante Canil, School of Earth and Ocean Sciences, UVic (Member)
Dr. Tom Fyles, Department of Chemistry, UVic (Outside Member)

External Examiner:
Dr. Eric Hellebrand, School of Ocean and Earth Science and Technology, University of Hawaii

Chair of Oral Examination:
Dr. Karena Shaw, Department of Environmental Studies, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

The oceanic lithosphere forms as a residue of partial melting of the mantle beneath the mid-ocean ridge axis. Subduction of this residual layer has a profound impact on the Earth's thermal and geochemical cycles as the recycling of this layer facilitates heat loss from the Earth's interior and induces geochemical heterogeneities in the mantle. The goal of this study is to understand the thermal and geochemical evolution of the oceanic lithospheric mantle from a petrological perspective. An empirical geobarometer is calibrated for ocean island xenoliths in order to understand the thermal structure of the oceanic lithospheric mantle. The results of 0.1 MPa experiments from this study and high-pressure experiments from previous studies are used in the calibration. The uncertainties on pressures derived using the above geobarometer are high and hence could not be tested against thermal models for the oceanic lithosphere. The geochemical evolution of the oceanic lithospheric mantle involves post-melting geochemical modifications such as metasomatism. The geochemical evolution of the uppermost oceanic lithospheric mantle is studied using harzburgites from Hess Deep ODP Site 895, which are depleted in moderately incompatible elements relative to the global suite of abyssal peridotites. A comparison between Yb-abundances in Hess Deep harzburgites and those of a model depleted MORB mantle (DMM) residue reveals that the harzburgites have undergone 15-27% melting, assuming 0.5% melt porosity. Higher light and middle rare earth elements in the Hess Deep harzburgites than the model DMM melting residue are interpreted as the result of plagioclase precipitation due to interaction of the harzburgites with the melts being extracted by diffuse porous flow through the upper mantle. The effect of plagioclase precipitation does not affect the chemistry of residual mineral phases as evidenced from the depleted light rare earth element abundances in clinopyroxene relative to the bulk rock. Ocean island xenoliths are studied to understand when and where metasomatism occurs in the deeper portion of the oceanic lithosphere. The median values of measured and reconstructed bulk concentration of Al2O3 in ocean island xenoliths is lower than in abyssal peridotites, which generally would be interpreted as indicating a higher extent of melting in the former. However, a comparison between Yb-abundances in ocean island xenoliths and abyssal peridotites with a model DMM melting residue suggests that the extents of melting in the suites of rocks are broadly similar. The higher Al2O3 concentration in abyssal peridotites than ocean island xenoliths is thus due to plagioclase precipitation in the uppermost oceanic lithospheric mantle. Metasomatism is observed in both, ocean island xenoliths and abyssal peridotites in the form of higher bulk rock Ce and Nd concentration than the model DMM melting residue but the extent of metasomatism is higher in ocean island xenoliths. There is no correlation between the concentrations of bulk rock Ce, Nd, Sm and Eu of ocean island xenoliths and age of the oceanic lithosphere from which the xenoliths originate. It is interpreted that metasomatism in the lower oceanic lithospheric mantle occurs near the ridge axis above the wings of the melting column.