University of Victoria | Graduate Studies

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

of

RAMESES JOSEPH D'SOUZA

MSc (University of Alberta, 2012)
BSc Honours (University of Alberta, 2008)

"Controls on the Sources and Distribution of Chalcophile and Lithophile Trace Elements in Arc Magmas"

School of Earth and Ocean Sciences

Wednesday, January 3, 2018
10:00 A.M.
Clearihue Building
Room B017

Supervisory Committee:
Dr. Dante Canil, School of Earth and Ocean Sciences, University of Victoria (Supervisor)
Dr. Laurence Coogan, School of Earth and Ocean Sciences, UVic (Member)
Dr. Stephen Johnston, School of Earth and Ocean Sciences, Uvic (Member)
Dr. Alexandre Brolo, Department of Chemistry, UVic (Outside Member)

External Examiner:
Dr. Pedro Jugo, Harquail School of Earth Sciences, Laurentian University

Chair of Oral Examination:
Dr. Helga Hallgrimsdottir, School of Public Administration, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

Volcanic arcs have been the locus of continental growth since at least the Proterozoic eon. In this dissertation, I seek to shine more light on arc processes by inferring the lower crustal mineralogy of an ancient arc by geochemical and structural modelling of its exposed levels. Arcs characteristically have high concentrations of incompatible elements, thus I also experimentally assess the ability of alkaline melts and fluids associated with sediment melting to carry lithophile and chalcophile elements in the subarc.

I measured the chemical composition of 18 plutonic samples from the Bonanza island arc, emplaced between 203 and 164 Ma on the Wrangellia terrane on Vancouver Island, British Columbia. Models using trace elements with Nd and Sr isotopes indicate < 10% assimilation of the Wrangellia basement by the Bonanza arc magmas. The Bonanza arc rare earth element geochemistry is best explained as two lineages, each with two fractionation stages implicating < 15% garnet crystallization. My inference of garnetbearing cumulates in the unexposed lower crust of the Bonanza arc, an unsuspected similarity with the coeval Talkeetna arc (Alaska), is consistent with estimates from geologic mapping and geobarometry indicating that the arc grew to > 23 km total thickness. The age distribution of the Bonanza arc plutons shows a single peak at 171 Ma whereas the volcanic rock age distribution shows two peaks at 171 and 198 Ma, likely due to sampling and/or preservation bias. Numerous mechanisms may produce the E-W separation of young and old volcanism and this does not constrain Jurassic subduction polarity beneath Wrangellia.

Although a small component of arc magmatism, alkaline arc rocks are associated with economic concentrations of chalcophile elements. The effect of varying alkalinity on S Concentration at Sulfide Saturation (SCSS) has not been previously tested. Thus, I conducted experiments on hydrous basaltic andesite melts with systematically varied alkalinity at 1270°C and 1 GPa using piston-cylinder apparatus. At oxygen fugacity two log units below the fayalite magnetite quartz buffer, I find SCSS is correlated with total alkali concentration, perhaps a result of the increased non-bridging oxygen associated

with increased alkalinity. A limit to the effect of alkalis on SCSS in hydrous melts is observed at ~7.5 wt.% total alkalis. Using my results and published data, I retrained earlier SCSS models and developed a new empirical model using the optical basicity compositional parameter, predicting SCSS with slightly better accuracy than previous models.

Sediment melts contribute to the trace element signature of arcs and the chalcophile elements, compatible in redox-sensitive sulfide, are of particular interest. I conducted experiments at 3 GPa, 950 – 1050°C on sediment melts, determined fluid concentrations by mass balance and report the first fluid-melt partition coefficients (Dfluid/melt) for sediment melting. Compared to oxidized, anhydrite-bearing melts, I observe high Dfluid/melt for chalcophile elements and low values for Ce in reduced, pyrrhotite-bearing melts. Vanadium and Sc are unaffected by redox. The contrasting fluid-melt behaviour of Ce and Mo that I report indicates that melt, not fluid, is responsible for elevated Mo in the well-studied Lesser Antilles arc.