Award Abstract #0549055

MARGINS: Cl Isotope Systematics of Neogene Izu Arc Volcanic Rocks

NSF Org:	EAR
Initial Amendment Date:	March 3, 2006
Latest Amendment Date:	March 3, 2006
Award Number:	0549055
Award Instrument:	Standard Grant
Program Manager:	William P. Leeman EAR Division of Earth Sciences GEO Directorate for Geosciences
Start Date:	March 1, 2006
Expires:	February 28, 2007 (Estimated)
Awarded Amount to Date:	$107569
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NSF Program(s):	PETROLOGY AND GEOCHEMISTRY
Field Application(s):	0000099 Other Applications NEC
Program Reference Code(s):	OTHR,0000
Program Element Code(s):	1573

ABSTRACT

The Earth remains a habitable planet through continual chemical exchanges between the deep interior (the mantle) and exterior reservoirs (atmosphere, oceans, continental and oceanic crust). Understanding the components of the dynamic Earth System is a central goal of modern research in the geosciences. The 'solid Earth cycle' begins with formation of oceanic crust by mantle melting beneath the globe-encircling mid-ocean ridges. The oceanic crust and the uppermost part

of the underlying mantle form a 'slab' of several 10 kilometer thickness that is 'subducted' back to the deep mantle at the deep-sea trenches. 'Subduction zones' are a vital part of the Earth system. On land they are recognizable from chains of volcanoes forming 'arcs' parallel to the deep-sea trenches (e.g. the Cascades, Aleutians, Indonesia). Subduction related hazards such as earthquakes, tsunamis and violent explosive eruptions can cause devastating destruction to human life and economics and are known to influence the global climate (e.g. 'year without summer' in 1816 following the 1815 eruption of Mt. Tambora in Indonesia). Such disasters are related directly to the processing of water in subduction zones. Water becomes enriched in the oceanic plate prior to subduction, and is subsequently lost from the slab (along with other volatile elements; e.g. Cl, CO2) during subduction. The processing of water in subduction zones may result in wide-spread 'serpentinization' of the upper mantle, which is the transformation of the dry and brittle peridotite into a hydrous, ductile serpentinite. Such serpentinite rocks may store large amounts of climatically active volatiles (e.g. H2O) that are injected or recycled to the atmosphere through explosive eruptions in arc volcanoes. The Subduction Factory portion of the MARGINS Program addresses the question of how serpentinite formation and destruction influences the volatile fluxes in subduction zones. However, direct geological evidence for serpentinite formation exists only to ~20-25 km depth, and investigation beyond these depths must rely on the chemistry of arc volcanoes. This is a challenging task because the chemistry of arcs reflects the influence of several source components, among which the signature of the serpentinite needs to be identified. Because serpentinite is a sink for the highly fluid-mobile Cl, its isotopes (35Cl, 37Cl) may have unique potential in tracing subduction serpentinization. This project aims to determine the potential of Cl isotopes as tracers of subduction serpentinite in Neogene (up to 20 million year old) volcanic rocks of the Izu Bonin arc (NW Pacific) via analysis of glassy volcanic ash fragments (<1 mm). Prior studies by co-PI Susanne Straub revealed high Cl abundances the Izu Bonin arc melts, with the Cl likely derived from the serpentinized mantle below the arc. Cl isotopic analysis in volcanic glass particles will utilize new SIMS (secondary ion mass spectrometry) technology. The study will test for the effects of melt differentiation (e.g. degassing) that might affect the intrinsic isotope ratios. As the first systematic study of Cl isotopes in an arc setting, this work will promote the understanding of Cl isotope fractionation as well as the fluxes of Cl, and likely H2O in the broader geochemical cycle. Broader Impacts: The issues to be addressed are at the core of current research activities on the role of water in subduction zones, and of one of the three fundamental science themes of the MARGINS Subduction Factory Initiative. The project will promote scientific partnership between three key science research institutions in the U.S. Support for women in the geosciences also will furthered. Susanne Straub, a female researcher with a disability, has already made substantial contributions to Izu Bonin magmatism that is a key focus of her research. An undergraduate student will also be involved to work on this project, as this provides an excellent introduction to research.