Thermal histories from crystal records

KARI M. COOPER[1]* AND ADAM J.R. KENT[2]

[1]Department of Geology, University of California Davis, Davis, CA 95616, USA
(*correspondence: kmcooper@ucdavis.edu)
[2]College of Earth, Ocean and Atmospheric Sciences, Oregon State University, Corvallis, OR 97330, USA

Many volcanic eruptions, including some of the largest ever, involve crystals stored in magma reservoirs within the crust for significant periods (10's to 100's ka) prior to eruption. Knowledge of the conditions of magma storage are critical for efforts to understand the processes that lead to initiation of eruptions and eruption dynamics, but these remain surprisingly poorly known [e.g., 1,2]. Eruption of homogeneous crystal-rich magma is often argued to reflect the mobilization of magma stored at near solidus conditions, but in other cases these are considered to reflect storage of magma at significantly higher temperatures for extended periods prior to eruption [3,4]. What has been heretofore lacking in this debate is clear observational evidence linking the thermal (and therefore physical) conditions within a magma reservoir to time scales of storage - i.e., thermal histories. We present a novel method for constraining pre-eruptive thermal histories of magmas by combining estimates of crystal residence time based on U-series systematics, textural information, and trace-element zoning in crystals.

At Mt Hood, Oregon, andesitic magmas are formed by mixing of silicic and mafic endmembers, with CSDs showing two populations of plagioclase [5]. The large (silicic-derived) population has cores >21 ka with rims that crystallized near eruption, yet preserve disequilibrium concentrations of Sr. By combining the ^{238}U-^{230}Th-^{226}Ra crystal age data with diffusion calculations and with crystal growth times based on CSDs, we show that only a small fraction of the total storage duration (<<5%) has been spent at temperatures above the critical crystal fraction of 40-50%, where the magma body is easily mobilized. Partial data sets for other volcanoes suggest that similar conditions of magma storage are widespread, which predicts that largely-liquid bodies that could be imaged geophysically will be ephemeral features.

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Analytical chemistry, natural organic matter and climate change: Linking chemical signatures and microbial communities that affect carbon cycling in northern peatlands

W. T. COOPER[1], M.M. TFAILY[1], J.P. CHANTON[1], J.E. KOSTKA[2], X. LIN[2] P. CHANTON[2], J.M. STEINWEG[3] AND C.W. SCHADT[3].

[1] Florida State University, Tallahassee, FL, USA
[2]Georgia Institute of Technology, Atlanta, GA, USA
[3]Oak Ridge National Laboratory, Oak Ridge, TN, USA

Global peatlands sequester half as much carbon as that contained in the atmosphere. However, the response of these large carbon reservoirs to global warming remains uncertain. In this presentation the results of experiments designed to identify the reactive and refractory dissolved organic matter (DOM) pools from peatlands in the Marcell Experimental Forest, northern Minnesota, will be described, along with accompanying differences in microbial communities. These experiments included advanced analytical techniques[1] (ultrahigh resolution (UHR) mass spectrometry, PARAFAC-modeled 3-D excitation-emission matrix [EEM] fluorescence spectroscopy) and a combination of next generation sequencing and metagenomics.[2] Surface peat (0-10 cm) was characterized by high DOC concentrations and relatively low aromaticity. In more decomposed layers at 30-50 cm depth, UHR mass spectra identified distictly different reactive and refractory DOM pools, as well as the appearance of lipid-like compounds of apparent microbial origin. PARAFAC-modeled EEM revealed fluorescent components (products and reactants) that were consistent with microbial processing. Below 75 cm, results indicate slower degradation of organic matter under anaerobic conditions and stable enzymatic activity. Microbial community structure corresponded strongly to the vertical stratification of dissolved organic matter (DOM) quantity and composition. Atmospheric pressure photoionization was used to selectivly observe mass spectra of dissolved organic nitrogen (DON), and changes in DON were correlated to nitrogen-specific enzymatic activity in the solid phase peat. These results have important implications for predicting the fate of carbon storage in peatlands, since warming may lead to an increase in deposition of more labile DOM and enhanced phenol oxidase activity, the net effect being a release of a significant store of soil carbon to the atmosphere.

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