Crystal-scale records of the mid-ocean ridge magma plumbing system

Supervisors

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Project description

Minerals carried up from depth by volcanic rocks record a wealth of information about the magma plumbing system beneath. They enable a reconstruction of magma compositions and temperature, residence times of crystals in magma chambers and reactions between between crystals and melt (e.g., Cashman and Blundy, 2013). In addition, they provide insights into the dynamics of the magma plumbing system, recording replenishment and mixing events and the associated movement of crystal cargo. This information is complementary to that which can be obtained from plutonic rocks (e.g., Lissenberg et al. 2013).

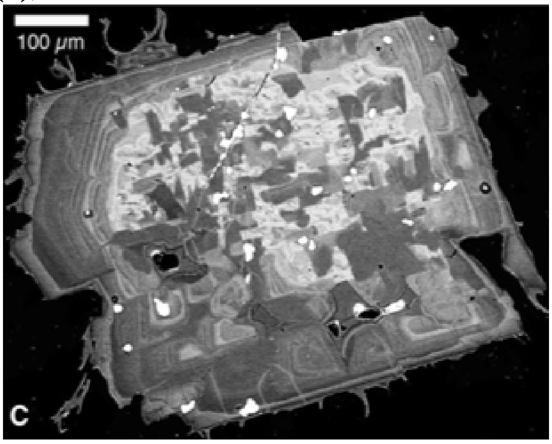
In this project, the student will study phenocrysts to enhance our understanding of magmatic processes at mid-ocean ridges. A comprehensive study will be made of olivine and plagioclase phenocrysts from a number of mid-ocean ridges covering the full spectrum of spreading rates. Analytically, the project has been designed to capitalise on the capabilities of Cardiff's recently installed state-of-the-art Analytical FEG-SEM. This system, the first of its kind in the world, is designed to enable rapid mapping of mineral compositions at high spatial resolution over large areas. Hence, the student will be able to acquire a statistically significant database of the compositional variations of phenocryst assemblages in each of the samples. In addition, the FEG-SEM's trace element mapping capabilities allow rigorous studies of the distribution of low-concentration elements that record both initial growth as well as subsequent cooling to be made. Finally, the phenocryst major- and trace element data will be complemented by Sr isotopic measurements using Cardiff's new laser ablation multicollector ICP-MS.

Combined, the integrated dataset will enable the student to address the following questions: What is the compositional evolution of mid-ocean ridge magma chambers over time? Do individual samples record multiple populations of phenocrysts, attesting to replenishment and crystal slurry remobilisation? What are the residence times of phenocrysts in mid-ocean ridge magma chambers? Do phenocrysts preserve records of mantle source heterogeneity, implying that melt extraction in the mantle and processing in the crust is insufficient to smooth out source signals? Do any of these variables correlate with spreading rate?

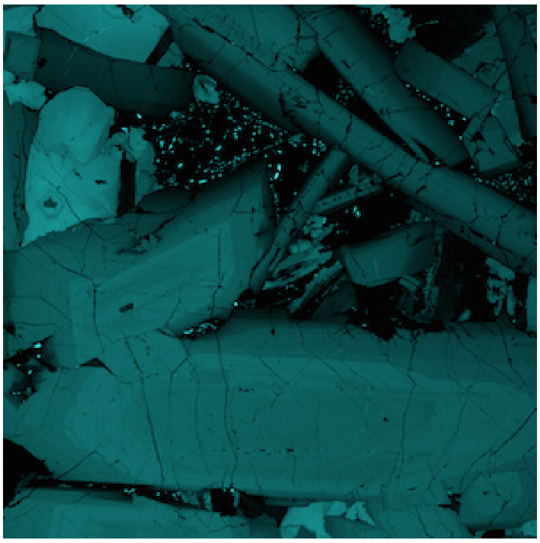
When viewed as a whole, these results will enable the student to reconstruct how the magma reservoirs that underlie mid-ocean ridges function, and how this relates to the different magma budgets as controlled by spreading rate. This represents a major step forward in our understanding of one of Earth most fundamental processes; the generation of new crust in the oceans.

Cashman, K., and J. Blundy (2013), Petrological cannibalism: the chemical and textural consequences of incremental magma body growth, Contributions to Mineralogy and Petrology, 166(3), 703-729.

Lissenberg, C. J., C. J. MacLeod, K. A. Howard, and M. Godard (2013), Pervasive reactive melt migration through fast-spreading lower oceanic crust (Hess Deep, equatorial Pacific Ocean), Earth and Planetary Science Letters, 361(0), 436-447.



Complexly zoned plagioclase pnenocrysts preserving multiple stages of growth. From Cashman & Blundy (2013)



Calcium element map of dolerite from the Pacific ocean, revealing the presence of two distinct plagioclase populations; a high-anorthite population of large crystals (bottom left) and a lower-anorthite population of higly elongate crystals (top right)