Magma differentiation in a T gradient: Thermal migration and Soret effects are not dead!

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Most magma differentiation probably occurs within a body having significant temperature gradients. Compositional zoning tied to temperature differences in silicic ignimbrites were attributed to thermogravitational diffusion [1], catalyzing temperature gradient experiments by Walker and co-workers [2]. Experiments showed, however, that compositional zoning in silicic rocks was opposite to Soret effects in a silicate melt [3]. Our experiments/models suggest reassessment of temperature gradient effects.

We report on thermal migration experiments using wet andesite (AGV-1) or wet rhyolite (RGM-1). AGV-1 was run in 2 cm capsule with top at 950°C and bottom at 350°C in a piston cylinder apparatus for 66 days at 0.5 GPa. Bulk major-trace element compositions vary with position reflecting changing mineralogy with temperature and form a linear "calc-alkaline trend" on an AFM diagram. Surprisingly, static diffusion-reaction in a temperature gradient produces a granitic bulk composition at the cold end of the experiment. Notably, the all-melt upper third of the experiment that lies in a T gradient does not show the Soret effect of higher SiO_2 at higher temperature. Instead SiO_2 in the melt slightly decreases down temperature. Using the model Iridium [4] which now includes Soret diffusion, we find that this lack of SiO_2 enrichment at higher T reflects the tendency of chemical diffusion driven by the coexisting mineral mush at lower T to overwhelm Soret effects. However, this does not mean that Soret diffusion is not occurring—the melt rich portion of the AGV-1 experiment shows large correlated changes in $\delta^{56}Fe_{IRMM}$ and $\delta^{26}Mg_{DSM}$ with total offsets of 2.8‰ and 9.9‰. In both systems, the hot end is enriched in the lighter isotope, as expected for Soret diffusion. Using Iridium and changing the Soret or chemical diffusion coefficients by 1% to simulate mass dependent diffusion, the isotopic shift observed in the melt having little concentration gradient can be reproduced. Thus, these isotope systems can be used to identify Soret diffusion effects that are not apparent based on concentration. Measurement of these systems on zoned silicic samples could provide evidence for temperature gradient driven differentiation processes occurring in magmas.

We will also report compositional, isotopic and modelling results for a currently running cold seal experiment using RGM-1 in order to better compare to zoned silicic ignimbrite compositions and conditions.

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Geochemical study of sandstone-type uranium deposits in the Ordos basin

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Introduction

The Ordos basin is the second largest sedimentary basin in China. With the deep-going ore exploration, in-situ leachable sandstone-type uranium deposits have been discovered in several localities in different parts of the basin (Liu, 2005). The Mesozoic strata of the Ordos basin are underlain by a typical sequence of North China Block Palaeozoic passive margin and cratonic sedimentary rocks. Trace elements, REE, carbon and oxygen isotopes were analyzed to study genesis of these uranium deposits.

Results

The total C content of the carbonate-bearing sandstone matrix ranges from 0.5 to 16.1 wt%. The positive relationship between carbon contents and U contents are seen. Higher Th/U ratios reflect a minor contribution from pre-existing detrital U-minerals in the sandstone. Carbon and oxygen Isotopic analysis of carbonate cement from the uraniferous sandstone reveals relatively large variations in $\delta^{13}C_{PDB}$ and $\delta^{18}O_{SMOW}$, from -4.20 to -23.62 ‰, and from 10.32 to 19.52 ‰, respectively. The lower $\delta^{13}C_{PDB}$ values (-10.00 ‰ to -23.62‰) can be explained by the addition of bitumen during low-grade hydrothermal alteration of the sandstones.

This study indicates that the main U-bearing strata of Zhiluo group (J_2) have suffered from oxidizing by thermal fluids. These fluids were probably derived from the circulation of surface waters and ground water that was heated by Cretaceous magmatic activity (Yang *et al*., 2006).

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