Heat producing element enrichment in granitic rocks & zircon Hf isotopic constraints on crustal evolution in NE Queensland, Australia

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The primary processes causing enrichment of incompatible Heat Producing Elements (HPE; U, Th & K) in granitic rocks are still poorly understood and are topical in light of increasing interest in engineered geothermal systems. Differentiation of the continental crust, through successive events of granitic magmatism, is expected to lead to a HPE-enriched upper crust and a depleted lower crust. In such a closed system crust model, younger granitic rocks should be more isotopically evolved. Instead, our study of granitic rocks, emplaced within a relatively restricted area (~200x100km), reveals a paradox: isotopic systems become more primitive over time, but HPE concentrations are more elevated. The study area has had ~360 Myr history of granitic magmatism with mainly I- to minor A-type granitic rocks of Carboniferous, Permian, Triassic, Cretaceous & Tertiary age.

Long-term compositional trends are recognised: modal mineralogy and bulk-rock composition record enrichment of K-feldspar and the increase of HPE concentration from the Permo-Carboniferous to the Cretaceous. In contrast, new MC-ICP-MS zircon Hf isotope data indicate secular changes to bulk crustal source compositions. Triassic (εHf: +4.9 to +8.5) and Cretaceous (εHf: +8.3 to +10.8) zircons are generally more isotopically primitive compared to Permo-Carboniferous (εHf: -7.3 to +1.2 & +3.6 to +9.8) and Tertiary (εHf: +0.5 to +5.1) zircons. The restriction of more isotopically primitive zircons in Triassic and Cretaceous rocks does not favor the model of a simple differentiated crust but rather an open crust system and progressive basification of the lower crust. Paradoxically, the isotopically primitive Mesozoic intrusions are also the most compositionally evolved, and have the highest HPE enrichments. To explain this, we interpret that fluid fluxing associated with a subduction-related contractional event in the Late Permian-Triassic was important for fertilising the lower crust and enriching it in HPE. This overcame the effects of basification by underplating during earlier back-arc extensional events. Cretaceous-Tertiary intraplate igneous events then provided important catalysts for more typical crustal differentiation.

Hydraulic and geochemical survey of the lithium-resources in the Salar de Uyuni (Bolivia)

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The Salar de Uyuni, located in the southern Altiplano of the Bolivian Andes, is the largest salt flat in the world (10,000 km^2, 3,653 m a.s.l.). Its alternating sequence of salt, mainly composed of halite, and lacustrine sediments contain a brine which is highly enriched in lithium (up to 4.7 g/L) among other elements [1]. Moreover, it is considered to be the largest lithium-brine deposit in the world.

Between 2009 and 2012 exploration drillings which completely penetrate the upper salt layer (with a maximum thickness of 11 m) as well as brine sampling were conducted at various sites on the salt flat. Porosity measurement of salt cores was realized gravimetrically on dried (70°C, until $\Delta_{weight\ loss} < 1\%$) core samples. Additionally, X-ray tomography on selected core samples was used to verify porosity results. Geochemical analyses on brine samples were conducted using ICP-MS.

Porosity data showed large horizontal differences of the salt crust. While the uppermost two meters of the salt are characterized by total porosities between 25 and 40%, deeper parts of the salt crust showed significantly lower porosities between 5 and 18%. Chemical analyses revealed an inhomogeneous distribution pattern for different elements. Among others, highest lithium concentrations were found close to the main tributary in the south as well as in a small fringe in the north of the salt flat.

Using stratigraphic information from drill cores, porosity data as well as the distribution pattern of lithium concentrations in the brine, a conceptual model was developed in order to estimate the total volume of brine occurring in the salt flat as well as the lithium-resource. The total amount of lithium in the Salar de Uyuni is estimated to around 6.6 million tons. This is in contradiction to previous publications [1, 2] which assume the lithium-resources to be about 35% higher.

[1] F. Risacher, B. Fritz (1991) *Chemical Geology* **90**: 211-231 [2] USGS (2012) *Mineral Commodity Summaries 2012*, p. 94-95

DOI:10.1180/minmag.2013.077.5.19