Oxygen isotope evidence for diverse origins of post Pan-African A-type granites in Southern Israel (Arabian Nubian Shield)

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A multi-mineral oxygen isotope study sheds light on the origin and emplacement of late Neoproterozoic A-type granites in the Arabian Nubian Shield of Southern Israel. The oxygen isotope ratio of zircon of Timna monzodiorite (TM), quartz syenite (TQS) and alkaline granite (TAG) are within the range of mantle zircon [δ^{18}O(Zrn)=5.3±0.6‰, 2σ], supporting a co-genetic mantle-derived origin previously suggested from geochemical data, εNd(T) values and U-Pb ages (610 Ma) [1]. Likewise, olivine norite xenoliths within TM [δ^{18}O(Ol)=5.41‰] may have formed as a cumulate in a parental mantle-derived magma. Within the Timna igneous complex the youngest and most evolved rock unit, the TAG, has the lowest isotopic ratio [δ^{18}O(Zrn)=5.50±0.02‰] whereas its inferred parental magma, the TM, has slightly higher and more variable δ^{18}O(Zrn) values (5.60 to 5.93‰). The small isotopic variation may be accounted for either by differences in the temperature of zircon crystallization or by minor contamination of the TM magma followed by rapid shallow emplacement and intrusion by the TAG. The TAG evolved, however, from a non-contaminated batch of mantle-derived magma. The formation of the Yehoshafat alkali-granite (YG; 605Ma), [δ^{18}O(Zrn)=6.63±0.1‰], exposed ~30km south of Timna and mineralogically comparable to the TAG, involved significant contribution from supracrustal rocks.

Fast grain boundary diffusion modeling and measured quartz-zircon fractionations demonstrate that the TAG and YG cooled very rapidly below 600°C in accordance with being epizonal. One to three orders of magnitude slower cooling is calculated for the 30m.y older calc alkaline granites of the host batholiths, indicating a transition from thick orogenic to extended crust. The A-type granites of Southern Israel thus evolved by variable amounts of crustal assimilation, followed by extension-assisted shallow emplacement of plutons of variable degree of crustal contamination.

[1] Beyth *et al.* (1994) *Lithos* **31**, 103-124.

Concerted TOF-SIMS and TEM analysis of cometary matter captured by Stardust

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In 2006, the Stardust mission returned cometary dust grains to Earth [1]. These grains were captured using low-density silica aerogel during flyby at comet 81P/Wild 2 in 2004. Recent analyses revealed a wide variety of minerals in these samples [2], while the overall elemental composition is close to average solar system composition [3].

However, Wild 2 matter seems not to represent the most primitive building blocks of the solar system as predicted. A relatively low abundance of presolar grains [4], the unexpected presence of minerals processed at high temperatures [2], and the apparent absence of hydrous minerals indicate grain formation close to the sun, with subsequent particle transport to outer regions of the solar system, and final comet formation beyond the snow line.

A major challenge, however, is to decipher primary cometary properties from the material captured by Stardust at 6.1 km/s in aerogel, since most of the cometary grains fragmented and even melted upon deceleration into this fragile medium.

In this study, particle fragments from various locations along the aerogel tracks were investigated by time-of-flight secondary ion mass spectrometry (TOF-SIMS) and transmission electron microscopy (TEM). The major goal of such studies is to better understand the fragmentation process and to determine the chemical and mineralogical properties of the original Wild 2 matter.

The observations suggest that some compact single mineral grains tend to survive the impact into aerogel as terminal particles while the more fragile, fine-grained material is often decelerated faster, is more likely to melt and then mix with melted aerogel along the tracks. Some of the cometary matter, at least from its physical and chemical properties, seems to resemble anhydrous porous interplanetary dust particles.

[1] Brownlee D. *et al.* (2006) *Science* **314,** 1711–1716. [2] Zolensky M. E. *et al.* (2006) *Science* **314,** 1735–1739. [3] Stephan T. (2007) *Space Sci. Rev.,* DOI 10.1007/s11214-007-9291-2. [4] Stadermann F. J. & Floss C. (2008) *Lunar Planet. Sci.* **39,** #1889.