Phosphorus in olivine from Italian potassium-rich lavas

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Phosphorus in igneous olivine is promising as a petrogenetic proxy and as a sensitive indicator of crystal growth histories [1,2]. To explore its applicability in solving outstanding issues concerning Italian K-rich magmatism, we analyzed a collection of well characterized forsterite-rich olivines, along with their Mg-rich melt inclusions (MI) for P contents. The wide compositional range of the basaltic samples (from high to low-K) and the regional coverage of volcanic centres (between the Roman Province and Vulture) enabled us to detect variations in magmagenetic conditions that control the behaviour of phosphorus.

Phosphorus concentrations in the olivines were determined by EPMA (15kV, 100nA, extended counting times) and by LA-ICPMS, along with standard major and trace element analyses that included homogenized MI. Intra-crystal variations were explored in rim-to-rim traverses by EPMA, following a procedure optimized for P. Detection limits were 40±20 ppm for both techniques, based on the analyses of a series of reference materials. The measured olivines cover an overall range in P between 40 and 230 ppm, despite their consistent forsterite-rich nature (Fo>87). The olivines from the medium to low-K series (M-LKS) contain less P (<70 ppm, except for Campi Flegrei where <230ppm was found) than those from the high-K series (HKS) which reach a maximum of 130 ppm. Corresponding MI from M-LKS and HKS samples contain up to 0.7 and 1.9 wt.% P_2O_5, respectively.

The P contents in olivine tend to increase with K_2O and P_2O_5 contents in the melt, and show regional systematics, suggesting that they signal variations in mantle source composition and/or mode of melt extraction. On the other hand, some M-LKS melts with similar P contents crystallized olivines with significantly different contents, indicating that P in the melt may not be the only control of uptake by olivines. Additional factors to be considered include growth rate [1] and coupled substitutions (e.g., with Al, Cr, Ti). Also, profiles in selected olivines show P depleted zones around MI, which questions the supposed immobility of P in olivine.

[1] Brunet & Chazot (2001) *Chem. Geol.* **176**, 51-72. [2] Milman-Barris *et al.* (2008) *CMP,* **155**, 739-765

High-precision age for the Haifanggou Formation and its implications for the coevolution of plants and atmospheric CO_2

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Atmospheric CO_2 levels have fluctuated greatly during the Phanerozoic [1]. Although many organic and inorganic factors affected atmospheric CO_2 levels, plants have played an important role in CO_2 fluctuations. Recently, most paleobotanists accept an Early Cretaceous origin for angiosperms and support that angiosperms underwent a rapid ecological radiation in middle-late Cretaceous [2]. Because high concentrations of Cretaceous atmospheric CO_2 underwent a long-term decline, several hypotheses suggested that the origin and radiation of angiosperms and atmospheric CO_2 levels are closely related [3].

The recent discovery of *Schmeissneria* from the middle part of the Jurassic Haifanggou Formation provided evidence that the origin of angiosperms could predate the Early Cretaceous [4]. Because previously reported ages for the Haifanggou Formation are scattered and the uncertainties of these ages were fairly large, our on-going work aims to establish high-precision $^{40}Ar/^{39}Ar$ ages for volcanic ashes from the Haifanggou Formation.

Our preliminary results indicate that *Schmeissneria* is older than 160 Ma. The age results will provide a robust geochronological calibration for the oldest angiosperm and will improve our knowledge of the link between atmospheric CO_2 and the rise and the radiation of angiosperms.

[1] Berner *et al.* (2001) *American Journal of Science* **301**, 182-204. [2] Friis *et al.* (2005) *Current Opinion in Plant Biology* **8**, 5-12. [3] Beerling (1994) *Philosophical Transactions of the Royal Society, London* ***B*346**, 421-432. [4] Wang *et al.* (2006) *Progess in Natural Science* **16**, 222-230.