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Fe isotope ratios of magnetite as a tool for tracking mush-to-magma processes

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How silicic plutonic and volcanic systems (P-V) are connected remains an open question in geosciences. Interpretations of their relationship range from a cogenetic evolution to a completely unrelated origin.

An example of this ongoing P-V debate is the granodioitic Rio Hondo Pluton and the rhyolitic Amalia Tuff in the Latir volcanic field, NM. These have been interpreted as being related by crystal-melt separation (i.e. Amalia Tuff being a melt-rich cap of the pluton) [1] or by emplacement of two different magmas [2]. To gain insight into how these two systems are connected, we analyzed Fe isotope ratios of magnetite and whole rock (WR). Magnetite is the main phase controlling the Fe budget of these rocks and therefore, offers the best insight into their δ^{56}Fe systematics. As shown by [3], crystallization of magnetite removes heavy δ^{56}Fe. Hence, magnetite should be heavier than the coexisting liquid from which it grew (assumed as WR). While this is true for magnetite from the Rio Hondo Pluton, magnetite from the Amalia Tuff are isotopically lighter than WR (Fig. 1). An explanation by crystal-melt separation or by emplacement of two different magmas becomes challenging, as both require magnetite to be heavier than WR. Therefore, we turn towards a model proposed by [4], whereby differentiation is aided by ascending low temperature silicate liquid (LTSL). This water-rich liquid would have interacted with magnetite in the mush - with magnetite removing heavy δ^{56}Fe, LTSL would become progressively lighter as it ascended. Thus magnetite in the lower parts of the mush, e.g. now exposed as the Rio Hondo Pluton, would have heavier δ^{56}Fe, whereas magnetite in the upper parts of the mush, e.g. the erupted Amalia Tuff, would be isotopically light. The observation that all magnetites have a very low TiO_2 content is consistent with the premise that LTSL plays a major role in forming the magnetite and setting its δ^{56}Fe.

[1] Lipman (1988) *Earth Environ. Sci. Trans. R. Soc. Edinb.* **9**, 265-288. [2] Tappa *et al.* (2011) *Geochem. Geophys*. **12**. [3] Heimann *et al.* (2008) *Geochim. Cosmochim. Acta* **72**, 4379-4396. [4] Lundstrom *et al.* (2022) *GSA Special Papers.*

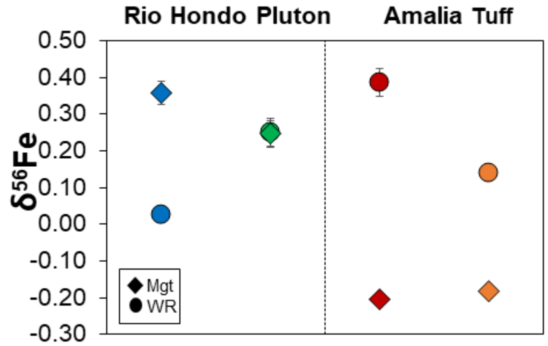

Fig. 1: *δ^{56}Fe of magnetite and of whole rock for the Rio Hondo Pluton and the Amalia Tuff.*