# Separation of natural and synthetic gemstones using LA-ICP-MS: Amethyst, citrine, and malachite

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Differences in chemical composition between natural and synthetic gemstones have long been used to separate them. However, the recent increase in availability of LA-ICP-MS analysis for gemstone identification has opened many new possibilities for the use of trace elements to make these separations. For some gemstones, like quartz (amethyst and citrine varieties) and malachite, where gemological observation is not always capable of distinguishing natural from synthetic, trace elements detectable by LA-ICP-MS have proven to be quite valuable.

LA-ICP-MS analysis of over 100 samples of natural and synthetic amethyst and citrine quartz indicated that Ga was a very reliable trace element for separation.
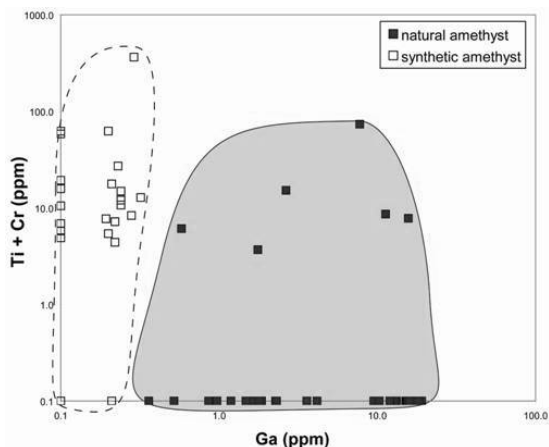
Figure 1: Ga was enriched in natural samples relative to the synthetics. Additionally, synthetic colored quartz samples showed slightly elevated concentrations of Ti and Cr.

Trace element analysis of natural and synthetic malachite samples, similarly to [1], also showed noticeable trace element differences that are useful for separation. Natural malachite had distinctly higher concentrations of Be, Al, P, Sc, V, Co, Ga, Ba, U, and REEs, whereas synthetic samples showed elevated B, Na, Mg, Ti, Mn, Fe, Zn, Pb, and As.

LA-ICP-MS analysis of malachite and colored quartz has allowed for identification of natural and laboratory grown gemstones that was not possible by gemological observation or spectroscopy. These types of applications emphasize the current and future value of the technique in gemology.

[1] Chernenko & Melnikov (2003) *Gemol. Bull.* **8**, 11–27.

Biotic-abiotic interactions in deep-sea hydrothermal plumes

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A growing body of evidence suggests that, in addition to abiotic processes, biotic - and particularly microbial - processes can be important within hydrothermal plumes [1]. The most recent studies indicate that organic C binds a significant fraction of the dissolved and particulate metals in hydrothermal plumes by complexation, and aggregation – processes which can have competing influences on chemical dispersal and may act to preserve some fraction of hydrothermal plume chemical constituents in their reduced forms [2, 3]. Water-column microbial populations may be significantly influenced by energy derived from the oxidation of reduced hydrothermal plume chemical species [4].

To elucidate the mechanistic links between biotic and abiotic hydrothermal plume processes, we recently collected a synoptic suite of rising plume geochemical and microbial samples from vent fields along the Eastern Lau Spreading Center (ELSC) and Valu Fa Ridge (VFR). Rising hydrothermal plumes were sampled systematically, from the vent orifice up into the water-column – where time permitted as high as 200 m above the vents – using a novel ROV deployed sampling system. These samples are being used to investigate the initial particle formation process. Initial measurements of particulate S, Fe, Mn, Al, P, V, Cr, and As are being used to characterize the rising plume chemical environments along the ELSC and place initial constraints on the energy available for chemosynthetic microbial activity.
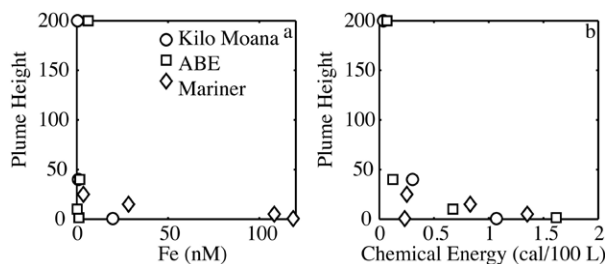
Figure 1: Particulate Fe (a) and a baseline estimate of plume particulate chemical energy (b) as functions of plume height.

[1] Cowen *et al.* (1986) *Nature* **322**, 169–171. [2] Bennett *et al.* (2009) *GCA* **73**, 5619–5634. [3] Toner *et al.* (2009) *Nature Geoscience* **2**, 197–201. [4] McCollom, T.M. 2000. *DSR* 47(1), 85–101.