High-temperature metasomatic alteration of CV chondrites

A. N. KROT, K. NAGASHIMA

HIGP, University of Hawai'i at Mānoa, 1680 East-West Rd, Honolulu, HI 96822, USA. E-mail: sasha@higp.hawaii.edu

Most ordinary, (H, L, LL), carbonaceous (CI, CM, CR, CO, CV, CK) and R chondrite parent bodies accreted water ices together with anhydrous minerals, were internally heated by decay of a short-lived radionuclide ^{26}Al ($t_{1/2}$ ~ 0.7 Myr), and experienced various degrees of metasomatic alteration and thermal metamorphism in the presence of aqueous solutions [1,2]. Alteration of CVs occurred at relatively high, but poorly constrained temperature (>300–600K) and low water/rock mass ratio (<0.2) [3]. It affected all primary components (CAIs, chondrules, matrix), and resulted in localized mobilization of Ca, Si, Na, Cl, S, Fe, Mg, Al, Ti, W, Be, and formation of a diverse suite of secondary minerals, both hydrous (phyllosilicates) and anhydrous (magnetite, Fe,Ni-sulfides, fayalite, kirschsteinite, andradite, salite-hedenbergite pyroxenes, anorthite, dmisteinbergite, Al-diopside, grossular, monticellite, forsterite, wollastonite, nepheline, sodalite, wadalite, Na-melilite). ^{53}Mn-^{53}Cr dating of secondary fayalite [4] and kirschsteinite [5] suggests that alteration occurred ~3–4 Myr after CV CAIs, the oldest Solar System solids dated [6]. The inferred initial ^{26}Al/^{27}Al ratios in Kaba (CV3.1) chondrules, (3–6)×10^{-6} [7] show that they formed ~2–3 Myr after CAIs with the canonical $(^{26}\text{Al}/^{27}\text{Al})_0$ of ~5.2×10^{-5} [8]. These observations and thermal modeling of a CV-like asteroid [4] imply that alteration occurred shortly after accretion of the CV asteroid and that ^{26}Al was its main heating source. On a three-isotope oxygen diagram (δ^{17}O *vs*. δ^{18}O), compositions of the secondary minerals, that either precipiated from a fluid or formed by replacement of O-free minerals, plot along mass-dependent fractionation line with Δ^{17}O (=δ^{17}O–0.52×δ^{18}O) value of ~–1.5‰, which reflects the composition of the fluid. Interaction with this fluid resulted in O-isotope exchange in some primary minerals of CAIs and chondrules. By using apropriate standards [9], the range in δ^{18}O values of secondary minerals can be used to constrain alteration temperature.

[1] Brearley and Krot (2012) In *Metasomatism and the Chemical Transformation of Rock – Lecture Notes in Earth System Sciences*, 659. [2] Krot et al. (2015) In *Asteroids IV*:635. [3] Zolotov et al. (2006) *MAPS* 41:1775. [4] Doyle et al. (2016) *Nat. Comm.* 6:7444. [5] MacPherson et al. (2016) *LPSC* 46:2760. [6] Connelly et al. (2012) *Science* 338:651. [7] Nagashima et al. (2015) *MAPS* 50:5167. [8] Jacobsen et al. (2008) *EPSL* 272:353. [9] Thomen et al. (2016) this issue.