

## GENESIS OF SILICA MINERALS IN NORTH WEST AFRICA (NWA) 6594 AND CONSTRAINTS ON THE EARLY THERMAL HISTORY OF VESTAN CRUST

S. Liao<sup>1</sup> and W. Hsu<sup>2</sup>. <sup>1</sup>Purple Mountain Observatory, Nanjing, China. E-mail: [wbxu@pmo.ac.cn](mailto:wbxu@pmo.ac.cn), <sup>2</sup>Space Science Institute, Macau University of Science and Technology, Macau.

**Introduction:** The crystal structure of silica minerals is very sensitive to both pressure and temperature. Their petrologic occurrences and phase transformation in meteorites are useful for reconstructing the thermal history of the meteorite parent body. Silica minerals in HEDs are dominated by tridymite, quartz and some other minor phases. The genesis of tridymite and quartz are poorly understood. As for tridymite, some authors proposed a formation mechanism of post-crystallization during reheating and partial melting [1-2], whereas an igneous origin was also suggested [3]. As for quartz, there seems to be a consensus that it was transformed from tridymite during cooling [4-5]. NWA 6594, a type 5-6 unbrecciated basaltic eucrite, contains abundant tridymite and quartz (5–6 vol. %). This offers us opportunities to look into the genesis of tridymite and quartz in HEDs.

**Results:** Tridymite in NWA 6594 is dominated by monoclinic phase and usually occurs as irregular porous interstitial masses. Orthorhombic tridymite can only be found in large laths (0.3–1.5 mm), occurring as polysynthetic twin with monoclinic phase. Tridymite contains some minor elements (Al<sub>2</sub>O<sub>3</sub>: 0.2–0.4 wt%; FeO: 0.1–0.5 wt%; K<sub>2</sub>O: 0.1–0.2 wt%). Quartz is smooth and show embayed or irregular fractured structures, scattered throughout tridymite groundmass. It is poor in Al and K but has Fe comparable to that of tridymite. Both tridymite and quartz occur in mesostasis, coexisting with plagioclase and pyroxene grains with augite lamellae. A few quartz patches enclosing pyroxene with exsolution lamellae are found in mesostasis area.

**Discussion and Summary:** The occurrence of quartz in tridymite groundmass reflects either crystallization from tridymite during cooling, or remnant of partial melting associated with reheating. Arguments presented below support a remnant origin, rather than crystallization from tridymite of quartz: (1) If quartz formed by structural inversion of tridymite, hackle fractures or voids caused by molar volume contraction are expected [6-7], because tridymite is less dense than quartz. Quartz from NWA 6594 is smooth, without any regular fracture, against an origin from tridymite. (2) Crystallization or skeletal growth of quartz in tridymite would lead to euhedral to subdural crystals with regular edges [6-7]. This is at odds with the embayed or fractured structures of quartz, also in support of a remnant origin. (3) Amorphous silica are found around apatites within tridymite, but absent for those in contact with quartz. This kind of amorphous silica are best explained by depolymerization of the silicate melts due to participate of phosphate during melting [8], implying a partial melting origin of tridymite.

On the basis of observations above, coupled with the petrographic relationship between quartz and pyroxene, it follows that the quartz from NWA 6594 was crystallized during thermal metamorphic cooling. Both interstitial and large laths tridymite were products of post-crystallization during reheating and partial melting, whereas the latter crystallized from migrated silica-rich melts with higher temperature. This has an important implication to the thermal history of Vesta. NWA 6594 belongs to the group of unbrecciated eucrites, whose impact reheating ages clustered around ~4.48 Ga [9]. The ambient temperature of Vestan crust at ~4.48 Ga, at least in part, would have cooled down below 870 °C, the upper stability temperature of high quartz [10].

**References:** [1] Yamaguchi A. et al. 1996. *Icarus* 124: 97–112. [2] Yamaguchi A. et al. 2001. *GCA* 65: 3577–3599. [3] Hervig R. et al. 1986. *Meteoritics* 21: 395. [4] Delaney J. S. et al. 1984. *JGR* 89: C251–C288. [5] Yamaguchi A. et al. 2009. *GCA* 73: 7162–7182. [6] Jackson J. C. et al. 2011. *AM* 96: 81–88. [7] Seddio S. M. et al. 2015. *AM* 100: 1533–1543. [8] Dingwell D.B et al. 1993. *Eur. J. Mineral* 5: 133-140. [9] Bogard D. D. 2011. *Chemie der Erde - Geochemistry* 71: 207–226. [10] Fenner C. N. 1913. *Amer. J. Sci* 36: 331.

**Acknowledgments**—This work was supported by the National Natural Science Foundation of China (Grant No. 41573059, 41573060), the Natural Science Foundation of Jiangsu Province (BK20151609; BK20161098), the Minor Planet Foundation of China, and Macau FDCT (039/2013/A2).