In situ observation of radial pyroxene chondrule formation from levitated melts

K. NAGASHIMA[1], Y. MORIUCHI[1], K. K. TANAKA[2] AND K. TSUKAMOTO[1]

[1]Graduate School of Sci., Tohoku Univ., Japan (nagasima@ganko.tohoku.ac.jp)
[2]Institute of Low Temperature Sci., Hokkaido Univ., Japan

Chondrules were crystallized from levitated melts to study the rate of crystallization during cooling. Levitation is known to reduce the heterogeneous nucleation rate considerably and thus highly supersaturated melt become stable for a long time.

The levitation experiments were done by using a gas-jet levitator (Nagashima *et al*., 2006). $MgSiO_3$ glass spherule (diameter < 3 mm) was set at the top of nozzle of the gas jet levitator and the melt temperature was kept at a given temperature by adjusting the power of CO_2 laser power. To investigate the seeding effect, enstatite ($MgSiO_3$) particles, ~ 5 μm in diameter, in the gas flow were forced to be impinged to the surface of the supercooled melt droplet, the nucleation process of which was observed by a high speed CCD camera.

Although we had expected easy heterogeneous nucleation from the melt droplets by this seeding, this seeing experiments failed over a wide range of supercooling. Crystallization was found to be possible only at a very large supercooling temperature regime (ΔT ~ 260-860K). When the ΔT is less than 260K, neither homogeneous nucleation nor heterogeneous nucleation could be detected. If ΔT is more than 860K, crystallization was impossible because of glass formation.

Typical radial textures from levitated melts (fig. 1) was obtained at ΔT ~ 800K, in which a single nucleation center at surface of the melt was observed. The fact that natural radial textures in chondrule starts from the surface might suggest the impingement of a few cosmic dust particles during the cooling.

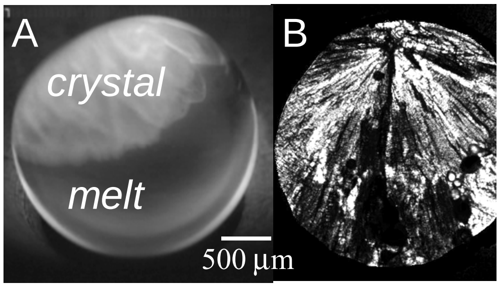

Figure 1: (A) In-situ observation of the levitated melt during crystallization. Radial texture was formed at ΔT ~ 800 K. (B) Polarized image of (A).

Reference

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Crystal chemistry of pumpellyite: Chromium distribution between the octahedral sites

MARIKO NAGASHIMA[1], MASAHIDE AKASAKA[2], ATSUSHI KYONO[3], KUNIAKI MAKINO[4] AND KO IKEDA[5]

[1]Institut für Geowissenschaften, Christian Albrechts Universität zu Kiel, Germany (mn@min.uni-kiel.de)
[2]Department of Geoscience, Shimane University, Japan (akasaka@riko.shimane-u.ac.jp)
[3]Division of Earth Evolution Sciences, University of Tsukuba, Japan
[4]Department of Geology, Shinshu University, Japan
[5]Department of Advanced Materials Science and Engineering, Yamaguchi University, Japan

The crystal structure of a chromian pumpellyite of general formula $^{VII}W_8{}^{VI}X_4{}^{VI}Y_8{}^{IV}Z_{12}O_{56-n}(OH)_n$ from Sarani, Urals, Russia, was refined using X-ray single-crystal data to investigate the crystal-chemical behavior of Cr in pumpellyite. The chemical composition of the crystal is CaO 21.9, MgO 3.6, total Fe_2O_3 0.2, V_2O_3 0.2, Cr_2O_3 14.6, Al_2O_3 16.3, and SiO_2 35.4 wt.%. Optical spectroscopic analysis showed the oxidation state of Cr to be trivalent. The crystal structure [a=8.807(6), b=5.943(4), c=19.18(1) Å, β=97.44(2)°] was refined using 1297 unique reflections that converged to a R factor of 2.8%. The site populations at the X and Y sites were determined by using the observed site-scattering values. Since Mg is only located at the X site, as confirmed by TOF neutron powder diffraction analysis (Nagashima and Akasaka, in press), it was assigned to the X site. The crystal chemical formula $Ca_8(Mg_{1.81}Cr_{1.45}Al_{0.74})_{\Sigma 4.00}(Al_{5.58}Cr_{2.42})_{\Sigma 8.00}Si_{12}O_{42.19}(OH)_{13.81}$ results. The Cr amount, derived from the site-scattering values (3.87 apfu), is consistent with that obtained by EPMA analysis (3.85 apfu). Although Cr^{3+} is located at both the X and Y sites, the distribution coefficient $((Cr/Al)^X/(Cr/Al)^Y=4.46)$ indicates a stronger preference of Cr for the X site than the Y site, contrary to the proposal of Ivanov *et al*. (1981) that Cr^{3+} prefers the Y site. The volume of the YO_6 octahedra and the mean Y–O distance increase with increasing Cr^{3+} substitution for Al at the Y site, which also causes an increase in the a, b, and c unit-cell dimensions. However, the volume of the XO_6 octahedra and the mean X–O distance are not correlated with the site populations of cations at the X site. Distortion parameters for the Y site tend to decrease with an increasing mean Y–O distance and volume of the YO_6 octahedra. This indicates that the YO_6 octahedra become less distorted with the expansion of the octahedra through substitution of cations larger than Al.

References

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