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Dendritic magnetite spherules produced by fine particle heating / quenching experiments

ISOBE, Hiroshi[1*], GONDO, Takaaki[1]

[1]Grad. Sch. Sci. Tech., Kumamoto Univ.

Magnetite is a common accessory mineral in various rocks. Crystal shapes and habits of magnetite show diversity depending on crystallization conditions, especially cooling rate. Characteristic dendritic or skeletal magnetite crystals occur in quench rims of effusive rocks (e.g. Szramek et. al., 2010). The dendritic magnetite also occur in micrometeorites undergone quick heating and quenching at atmospheric entry (e.g. Genge, 2008, 2006, Toppani and Libourel, 2003).

In this study, we constructed a fine particle free fall apparatus in a high temperature furnace and carried out crystallization experiments with quick heating and quenching. In the experiments with volcanic ash particles, we found quite characteristic dendritic magnetite spherules. From the powdered meteorite, we got melted artificial micrometeorites (Gondo and Isobe, 2012).

Experiments were carried out in a vertical tube furnace with CO_2, H_2 and Ar mass flow controllers to control oxygen partial pressure and total gas flow rate. At the top of the furnace, a silica glass tube with an orifice with approximately 0.5mm in diameter was set to keep falling rate of particles. Particles were retrieved in an alumina crucible at the bottom of the furnace tube.

Terminal velocity of silicate particles with 100 micron meters in diameter in Ar gas at 1200 degree C is 18 cm/sec. Gas ascent rate at 1200 degree C is 11 cm/sec in the furnace tube when gas flow rate is approximately 1 l/min at standard condition. The falling speed of the particles with 100 micron meters in diameter, therefore, is reduced to approximately 7 cm/sec. When the highest temperature of the furnace set to 1520 degree C, the falling particles reach 1400 degree C within 2 seconds, keep above 1400 degree C more than 1 second, and are quenched within 1 second. For the fine particles with 100 micron meters in diameter, time scale of thermal equilibrium by radiation is within 1 second.

With this experimental apparatus, we carried out quick heating / quenching experiments of volcanic ash particles from Sakurajima volcano. The volcanic ash particles are sieved to 60 to 160 micron meters in diameter, and contain plagioclase, pyroxene, magnetite and groundmass glass in various proportions. Some particles contain quite high volume fraction of magnetite. After the experiments, more than half of the volcanic ash particles were well melted to show spherical shape. Groundmass glass and plagioclase particles formed clear glass spherules.

From particles with high volume fraction of magnetite, we can see quite characteristic texture in which dendritic magnetite cover almost whole surface of the spherule. Magnetite dendrite crystals with particular crystallographic direction to the spherule surface also occur. We discuss on dendritic magnetite texture with heating / quenching rate of fine particles.

Keywords: magnetite, dendritic crystal, quench texture, fine particles