Cathodoluminescence images of forsterite in the Yamato 81020 (CO3) chondrite

naoji sugiura[1], Hajime Hiyagon[2], Iffat Jabeen[3]

[1] Earth and Planetary Sci., Univ.of Tokyo, [2] Dept. Earth & Planet. Sci., Univ. Tokyo, [3] Earth and Planetary Sci., Univ. of Tokyo

N.Sugiura, H.Hiyagon and I.Jabeen

Cathodoluminescence (CL) of rock samples gives valuable information on physicochemical conditions experienced by the constituent minerals. In order to obtain information on the early solar system, CL images of various meteorites were taken. The instrument was a panchromatic system attached to a SEM. In the case of achondrites, the main minerals that give CL are feldspar, quartz and phosphates, because CL is generally not emitted from Fe-rich minerals. Similarly, in the case of metamorphosed chondrites, CL is mainly emitted by feldspar and phosphate. In the case of primitive chondrites, many more minerals that contain little Fe, emit CL. Among these, forsterite is the most interesting one because it often shows internal structure. There are three or four groups of forsterite in primitive chondrites that can be distinguished by CL and trace element chemistry. Below we describe forsterite observed in the Yamato 81020 (CO3) chondrite.

AOA (amoeboid olivine aggregate): AOA gives bright CL. They contain only small amounts of Ca and Fe. The internal structure is not clear because of the limited size.

Forsterite in type I chondrules: This is characterized by a high Cr concentration, presence of mesostasis and/or metal and CL of moderate intensity. The CL image often shows zoning which reflects igneous fractionation of trace elements during the growth of the forsterite.

Isolated olivine: Here, isolated olivine is defined by a Ca-rich, Cr/Mn-poor composition and absence of textural evidence of melting (glassy mesostasis). It shows homogeneous CL and usually devoid of metal grains. It was suggested that such olivine grains are condensates from the hot solar nebula gas (Steele, 1986).

There are many olivine grains with a Ca-rich, Cr/Mn-poor composition and similar to that described above, but seems to have experienced brief heating of chondrule formation events. In many cases, such olivine grains are either enclosed in type II chondrules, or associated with glassy materials. Often, CL in such olivine grains shows zoning. Some of the zoning pattern can be explained by over-growth of olivine around a relict isolated olivine or diffusion of Cr/Fe into a relict isolated olivine. However, there are a few olivine grains that show quite complicated zoning that cannot be explained by the processes explained above. It is likely that a very quick heating event occurred to these forsterite but the exact process that produced such zoning is not known at this time.

It was reported (Jabeen and Hiyagon, 2003) that the oxygen isotopic compositions of various groups of olivine in Murchison are distinct from each other. Thus, oxygen isotopic compositions of the forsterite described here may also be distinct. In particular, it is of interest if oxygen isotopic compositions are different within forsterite that show complicated zoning pattern. Trace elements as well as oxygen isotope studies on the forsterite grains are planned.

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I.M.Steele, Geochim.Cosmochim.Acta, 50,1986,1379-1395.