Petrography and mineralogy of the Yamato nakhlites and the MIL 03346 nakhlite

Naoya Imae[1]; Yukio Ikeda[2]

[1] AMRC, NIPR; [2] Dept. of Sci., Ibaraki Univ

Introduction: The first Antarctic nakhlite (Yamato 000593, Yamato 000749 and Yamato 000803; the three are paired, and we call them Yamato nakhlites) was found in 2000. More recently, the second Antarctic nakhlite MIL 03346 was found in 2003. The two Antarctic nakhlites are comparatively studied based mainly on petrography and mineralogy in this paper.

Petrography of Yamato nakhlites: The modal abundances of constituent phases are augite phenocrysts 77% (1 mmx0.5 mm in size with homogeneous cores of En36-20Fs25-40Wo39-40), olivine phenocrysts 12% (less than 0.8 mmx0.8 mm in size with a compositional range of Fa60-70), mesostasis 10%, and titanomagnetite microphenocrysts 1%. Augite phenocrysts consist of core (61 %) and rim (16%). The rim is 80 mm or less in width, and is divided into inner and outer rims. Inner rim has constantly high Wo content and becomes enriched in Al2O3 content toward the outer rim. The high Wo and Al2O3 contents rapidly decrease in the outer rim, due to the growth of plagioclase in the mesostasis.

Lamellae and symplectite that consist of magnetite and augite occur in olivine phenocrysts. Magmatic inclusions also occur in olivine phenocrysts. Secondary hydrous minerals are observed along fractures in olivine phenocrysts. Mesostasis consists of plagioclase, orthoclase, tridymite, ferroan olivine (Fa80), augite, pigeonite, titanomagnetite, apatite, hydrous minerals, and pyrrhotite.

Petrography of MIL03346: Modal abundances of constituent phases are augite phenocrysts 68%, olivine phenocrysts 1% and mesostasis 31%. The mesostasis is very fine-grained. Dendritic Fe-rich olivines (Fa92~95) and skeletal titanomagnetites are the most abundant, but plagioclase is not found in mesostasis. A small Ca- and P-bearing phase (probably apatite) and a silica mineral often occur in mesostasis. Tiny titanomagnetite grains with ilmenite lamellae and pyrrhotite grains with minor chalcopyrite are also found in mesostasis.

The grain size of augite phenocrysts in MIL03346 is ~1x0.5 mm or less, and seems to be slightly smaller than that of Yamato nakhlites. Augite phenocrysts consist of core (57%) and rim (11%). The augite cores have a homogeneous composition of En36~38Fs24~22Wo40 and accompany Fe-rich rims with the thickness of ~20 mm in average, which are much thinner than those of Yamato nakhlites.

Al2O3 content of the Fe-rich rims increases up to 10 wt%, and TiO2 content also increases up to 1.5 wt%, being very similar to the inner rims of Yamato nakhlites augite phenocrysts. The high contents of Al2O3 and TiO2 in the Fe-rich rims may be caused by metastable crystallization of the mesostasis melts which were brought deeply into plagioclase liquidus field by suppression of plagioclase crystallization under rapid cooling conditions.

Olivine grains in MIL03346 are minor in amounts and the grain size is 0.5x0.5 mm or less. The core composition of olivine is more magnesian (Fa55-57) and the rim is more ferroan (up to Fa85) than those in Yamato nakhlites. Augite-magnetite symplectite and lamellae are not observed in olivine grains of MIL 03346, although they are common in olivine of Yamato nakhlites.

Discussions: Nakhlites seem to have experienced rapid to slow cooling rates in lava flows that were caused by eruption of magmas consisting of mixtures of a magma and a cumulate with intercumulus melts. The bulk compositions of nakhlites and the modal abundances of augite cores are very similar among all nakhlites. On the other hand, modal amounts and chemical zoning of olivine phenocrysts, rims of augite phenocrysts, and mineral assemblages in mesostasis are different among nakhlites. These differences may correspond to cooling rate differences of nakhlites. MIL 03346 cooled the most rapidly among all nakhlites, although Yamato nakhlites cooled moderately. Nakhla, Govenador Valadares, and Lafayette may have cooled more slowly.