PETROGENESIS AND HISTORY OF ORTHOPYROXENE-RICH LODRANITE Y 983119. M. Yasutake and A. Yamaguchi. Department of Polar Science, SOKENDAI, 10-3, Midori-cho, Tachikawa-shi, Tokyo, Japan. (yasutake.masahiro@nipr.ac.jp), National Institute of Polar Research, Midori-cho, Tachikawa-shi, Tokyo, Japan.

Introduction: Acapulcoites and lodranites are the second largest clan of primitive achondrites [1]. Lodranites are ultramafic rocks with coarser-grained textures, fractionated bulk chemical compositions, and mineral modal abundances depleted in plagioclase and/or troilite. It is generally accepted that lodranites are residues formed by partial melting <20% and removal of the melt (e.g. [2, 3]).

Yasutake and Yamaguchi [4] suggested that Y 983119 is an anomalous lodranite rich in orthopyroxene which formed by not only partial melting but suffered complex igneous processes. We found many melt inclusions in Y 983119, and some of them contain hornblende and biotite. The purpose of this study is better understanding of igneous history in the acapulcoite-lodranite parent body.

Sample and methods: We prepared two thick sections (.35 and .51) and one thin section (.51-2) of Y 983119. These sections were observed under an optical microscope and a FE-SEM (JEOL JSM-7100F) at NIPR. Phase identification was conducted by using of an EDS (Oxford Instruments AZTec Energy) attached on the FE-SEM. Mineral compositions were measured by using an EPMA (JEOL JXA-8200) at NIPR.

Results: Y 983119 is a coarse-grained rock that mainly consists of orthopyroxene (<4 mm), olivine and Fe,Ni-metal (Fig. 1). Most olivine grains contain embayments. Plagioclase and augite commonly occur as interstitial phases. Minor phases include troilite, Fe,Ni-phosphide, phosphates, spinel and carbon phases. Inclusions occur in many orthopyroxene and a few olivine grains. The modal abundances of orthopyroxene and olivine vary (44 vol. % orthopyroxene and 30 vol. % olivine in PTS .35 and 71-73 vol. % orthopyroxene and 4 vol. % olivine in PTS .51 and .51-2). The modes of plagioclase and augite are 9-14 vol. % and 2-6 vol. % respectively.

Compositions of orthopyroxene, augite and olivine are magnesian when compared to those of other lodranites (Wo0.8,2.5,En0.3,96, Wo8,48,En57,51, and Fo47). Olivine grains have chemical zoning along rims and cracks from Fo to 97 to 95. The compositions of plagioclase vary among and in the grains (Ab67,73). The compositions of spinel have a range (molar Mg/(Mg+Fe) = 41-65, molar Cr/(Cr+Al) = 83-99). The Mg/Mn ratios of orthopyroxene (~180) and olivine (~300) are higher than other lodranites.

We found 40 melt inclusions in orthopyroxene and olivine grains. Most inclusions consist of augites, plagioclases, alkali-feldspars and silica-rich phases. Alkali-feldspars in many cases occur as thin lamellae in plagioclase (Fig. 2). Several feldspars contain tiny pores. Few inclusions contain orthopyroxene and olivine grains. We found minute carbon phases (<10 μm). We found 10 hornblende-bearing (edenite to pargasite) inclusions in 40 inclusions (Fig.2). Several hornblende occur as isolated crystals in orthopyroxene. We found biotites in two inclusions. Biotites have euhedral lath shapes with clear cleavages. There are inclusions that contain Zr-bearing phases.

The compositions of constituent minerals in the inclusions are heterogeneous (Fig. 3). The compositions of plagioclase are more albite (Or2.5,4.8Ab8.96) than those of coarse-grained plagioclase. The compositions of alka-lifeldspar are Or71,66Ab10,27,5. Porous feldspars contain a significant amount of Cl (<2.7 wt. %). The compositions of augite are Wo45,43En34,52. Silica-rich phases have compositional range of SiO2 from 75 to 99 wt. %. Hornblends contain F (1.9-2.8 wt. %), Ti (2.7-4.3 wt. %) and Cr (1.6-2.5 wt. %). The formula of average composition for hornblende is (Na0.51K0.23)Σ2.02(As0.74(Ca1.69Na0.31)Σ2.02)Σ1.98(Ti0.35V0.01)Σ1.98Zr0.01Σ1.98Mg4.18Fe0.99Mn0.01Ca0.10Σ1.98Si6.57Σ1.98Al1.41Σ1.98K0.04Cl0.03OH0.99). Hydroxyl concentration was estimated from atom per formula unit on 23 O by the following equation; OH=2-F-Cl. Estimated H2O contents of hornblende are 0.79-1.22 wt. %. Since no replacement of OH by O2+ was assumed, the estimated H2O contents provide the upper limit. Biotites contain F (1.7-2.1 wt. %), and contain minor Ti (4.7-6.5 wt. %) and Cr (1.0-1.3 wt. %). The formula of average composition for biotite is (K1.09Na0.90)Σ2.07(Ti0.38Cr0.12Fe0.27Ni0.03Mg4.90)Σ5.63(Si5.67Al2.00Ti0.33)Σ8(F1.88Cl0.03OH2.09). Hydroxyl concentration was estimated by the same manner to that of hornblende. Estimated upper limits of H2O contents of biotites are 2.0-2.4 wt. %.

Discussion and Conclusions: Y 983119 is anomalously rich in orthopyroxene and poor in olivine compared to other lodranites. The mineral compositions of host phases are similar to magnesium-rich lodranite like Gibson and Y-8002. In particular, Y-8002 has high Mg/Mn ratios of mafic minerals and compositions of plagioclase similar to those of Y 983119. We previously suggested that Y 983119 is not a residue after extraction of partial melt, and experienced more complex igneous processing.
The occurrences and compositions of the melt inclusions provide us with further constraints on the petrogenesis of Y 983119. The occurrences and constituent minerals indicate that the melt inclusions were trapped during crystallization of the host minerals. The constituent minerals of inclusions indicate that parent melts of inclusions were felsic. In addition, the melt was rich in incompatible elements such as K, Ti, and Zr.

The occurrences and textures indicate that most hornblende and biotites directly crystallized from trapped melts. The inclusions that contain amphibole and biotite are not common in asteroidal meteorites. Few meteorites contain amphibole. Martian meteorites commonly contain amphiboles (kaersutite) in magmatic inclusions (e.g. [5, 6]). Few asteroidal meteorites, for example, the HaH 193 winonaite [7] and LAP 04840 R-chondrite [8] contain amphibole. Amphiboles in these meteorites are thought to have formed by replacement of pyroxene and olivine during secondary alteration. The occurrences of hornblende in Y 983119 are similar to those of Martian meteorites, rather than those of LAP 04840 and HaH 193. These affinities to Martian meteorites imply large-scale igneous processes. In addition the parent melts probably contain significant amounts of F and OH.

The mineralogical and petrological lines of evidence indicate that Y 983119 is a cumulate rock. The compositions of melt inclusions imply that parent melts were rich in incompatible elements, F and OH. We suggest that acapulcoite-lodranite parent body had suffered large degree igneous processes, at least locally.