MINERALOGICAL AND CRYSTALLOGRAPHIC STUDIES OF LODRANITE AND PRIMITIVE ACHONDRITE GROUPS BEARING ON THEIR GENETIC LINK. H. Mori1, Hiroshi Takeda2, M. Prinz2 and G. E. Harlow2.1Mineralogical Inst., Faculty of Science, Univ. of Tokyo, Hongo, Tokyo 113, Japan and 2Amer. Mus. Nat. Hist., N.Y., N.Y.10024.

Lodran is a one-of-a-kind meteorite and its origin has been related to ureilites (1) or igneous cumulates (2). Three new Antarctic meteorites similar to Lodran have been recovered by Yanai and Kojima (3,4) and Matsumoto et al. (5) and called lodranites. Some resemble primitive achondrites, which have also been called winonaites and silicate inclusions in IAB irons (6). In order to gain a better understanding of their origin, thermal histories and genetic relationship, we have studied Lodran and Yamato 75274 (5), by combined X-ray diffraction, analytical transmission electron microscopy (ATEM) and electron microprobe techniques.

About ten mineral grains were picked from Lodran (AMNH 314). Several grains of olivine and a polished thin section of Y75274 were supplied by the Natnl. Inst. of Polar Res. Euhedral crystals of olivine and clear pale yellow fragments of orthopyroxene (Opx) and two green grains were examined by precession camera. After X-ray study, these crystals were mounted in epoxy resin and the surfaces were polished for electron microprobe study. Ion-thinned samples were examined with a Hitachi H-600 ATEM.

The TEM examination of the Lodran olivine crystals revealed that they contain only small numbers of straight [001] dislocations with no evidence of recovery, which have been observed in some ureilites. The dislocation substructure may be interpreted as having been induced by a late-stage collisional event. The Y75274 olivine is uniform (Fa3.9 with 6.8% Mean Dev., range Fa3.5 to Fa4.5). The crystals do not show reverse chemical zoning as was reported for the Lodran olivine, indicating either no reduction or more likely, complete reduction.

Opx crystals in Lodran show small variations in Ca content. One high Ca crystal (Ca3.4Mg83.5Fe13.1) shows fine exsolution of augite with (100) in common, similar to the texture of the Ibbemhrlen diogenite Opx. However, another crystal with lower Ca content (Ca2.6Mg84.3Fe13.4) shows almost no exsolution in its X-ray photos. One green crystal in Lodran has been confirmed to be a chromain diopside compatible with C2/c symmetry and no exsolution by the X-ray method. The Y75274 Opx (Ca2.2Mg83.5Fe13.4) also show the Ca variation (Fig. 1), but the Ca contents are not high enough to produce exsolved Aug. Ca-content variation of Opx suggests that the homogenization is not complete. The amount of Aug in Lodran (1%) is less than that in Y75274 (Ca1.5Mg52.7Fe13.2), which is 3%. The small Ca variations in Lodran and Y75274 appear to be large enough to justify that they are not the result of analytical error and really represent some relict differences which have not been homogenized in these highly equilibrated samples. The extent of this phenomenon has not yet been fully explored in these samples, as well as in other lodranites.

Temperatures of last equilibration were estimated from the chemical compositions of the coexisting Opx and Aug by the two-pyroxene geothermometer of Ishii et al. (7), calibrated for natural systems and are 1035-1050°C for Lodran and 1070°C for Y75274. These temperatures are significantly higher than those of type 6 ordinary chondrites and equal to that of a shock recrystallized LL chondrite (Y74160, LL7) (7). The higher Na2O and Cr2O3 contents of Ca-rich clinopyroxenes (diopside-augite) compared with values in type 6 ordinary chondrites have been known for partly molten and recrystallized meteorites (Fig. 2) such as Y74160, Y74130, and ALH77081. Lodran and
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Y75274 may also have had a similar thermal history. The high temperatures of equilibration estimated for these meteorites are in agreement with this interpretation.

The presence of Opx with variable Ca contents indicates that the cooling rates at the highest temperatures were fast enough to preserve inhomogeneity (stage 1). Subsequent cooling rates at temperatures where the exsolution was developed may have been slow, judging from the well developed exsolution texture in the high Ca Opx in Lodran (stage 2). The last stage (stage 3) cooling rates estimated from the metal data (2), are extremely slow in comparison with those of the higher temperatures.

The presence of discrete grains of chromian diopside in Lodran as confirmed by the X-ray method, and of augite and the reduced silicates in Y75274, and the presence of plagioclase in Y791493 reported by Yanai and Kojima (3), are in agreement with the working hypothesis that lodranites are closely related to the primitive achondrites. Oxygen isotopic and mineralogical data are discussed by Prinz et al.(6). The primitive nature of these meteorites suggested by the presence of planetary-type noble gases and the trace element distribution (1), is in line with the incomplete homogenization of the silicates. The data presented give further support of a genetic link with primitive achondrites, and further work is needed to continue to clarify this relationship and its significance.

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Fig. 1. Pyroxene quadrilateral of Lodran and primitive achondrites. Other data after Prinz et al. (6).

Fig. 2. Na₂O vs. Cr₂O₃ plots of L: Lodran, Y3: Y74130, Y5: Y75274, Y6: Y74160, AL: ALH77081, and Ch: type 6 chondrites.