INTERSTITIAL CA-RICH SILICATE MATERIALS IN THE YAMATO UREILITES WITH REFERENCE TO THEIR ORIGIN. Hiromi Ogata, Hiroshi Takeda, Mineralogical Inst., Faculty of Science, Univ. of Tokyo, Hongo, Tokyo 113 and T. Ishii, Ocean Res. Inst., Univ. of Tokyo, Minamidai, Nakano-ku, Tokyo 164, Japan.

Ca-, Al-containing materials have been found in Yamato 790981 (1,2) and fine-grained, interstitial, Mg-rich silicates have been found in 11 ureilites (3). Pigeonitic rim materials have also been found in Yamato 74123 (2). These materials are interpreted to represent primary trapped interstitial liquid (3) and the principle carrier of light REE in ureilites. Spitz and Boynton (4) suggested that it is difficult to account for the light REE enrichment as being a primary feature of the liquid from which the ureilites formed, based on REE modeling studies. We have studied interstitial materials in the three Yamato ureilites which have not been characterized previously by mineralogical techniques. We have found that interstitial augite-like materials in Y74123 and interpret its origin on the basis of a model of ureilite formation by crystal coarsening of mafic silicates in the C-rich chondritic precussor during removal of interstitial melts (2).

Y74123 is the most olivine-rich ureilite (2). One polished thin section (PTS) from NIPR consists entirely of olivine (Fa_{19}) with pigeonitic rims and carbonaceous matrix, but another PTS contained two graines of pigeonite with $Ca_5Mg_{77}Fe_{18}$. Over all abundance of pigeonite may be 3 vol. %. The bulk chemical composition (analysis by H. Haramura) is in agreement with olivine-rich mineralogy. Thin pigeonitic rims of olivine crystal are common but the thickness varies from 3 to 20 microns. The shape is mostly thin film-like covering the olivine crystal. The thickest portion is found at the olivine side of the olivine-pigeonite boundary, where the rim is extended into the olivine crystal, forming an island, and the thickness reaches up to 100 microns. At the triple point juncture of three olivine crystals, the rim materials are concentrated up to 20 microns thickness.

The enrichment of Ca and Al in Y74123 is seen within the pigeonitic rim, but the variations are not corelated. The Ca-poor portion is enstatite with $Ca_{1.1}Mg_{94.6}Fe_{4.3}$, and the Ca-rich portion is from Ca-rich pigeonite $Ca_{12.8}Mg_{79.6}Fe_{7.6}$ to augite $Ca_{34.3}Mg_{57.9}Fe_{7.8}$. The most Al-rich portion is Ca-poor $Ca_{2.8}Mg_{95.5}Fe_{1.7}$ with Al_2O_3 up to 7.6 wt. %. The Al content is low in the interstices between the olivines. At a grain boundary between olivine and pigeonite, an augite-rich rim (95 x 70 microns), which includes silica-rich island extends into the olivine crystal. Some portions of the augite is Al-rich (6.6 wt. % Al_2O_3). At the opposite side in the pigeonite, there is a rim of Mg-rich pyroxene and glass with variable concentration of Ca and Fe, and the Al contents are less than 0.53 wt. %. Common rim materials are low- and high-Ca pyroxene, silica-rich glass, and Fe metal without or with Ni (3.9 wt. %). Al-rich portions are present at both pyroxenes and glasses. The carbonaceous materials at the gain boundaries often include Fe and sometimes chlorine (0.30 to 3.2 wt. %).

ALH78019 is another olivine-rich less shocked ureilite, but the pigeonitic rim materials are very thin (less than 5 microns). The thickest one reaches up to 20 microns. Y82100 is a very small ureilite (wt. 12.4g) with mineral compositions intermediate between Dingo Pup Donga and Y790981 (5). The Fa content of olivine is 19 to 16 and the pigeonite composition is $Ca_9Mg_{76}Fe_{15}$. The modal abundance of olivine and pigeonite is 80:20. The interstitial material is present but the thickness is less than 20 microns. The compositions are Ca-rich and rim materials are present at pyroxene-pyro-

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xene boundaries. The compositions vary from $Ca_{25}Mg_{64}Fe_{11}$ to $Ca_{37}Mg_{57}Fe_{6}$. Y790981 contains also interstitial materials, however the presence of Ca- and Al-rich inclusions that were definitly formed by the shock partial melting were confirmed by the analytical TEM by H. Mori (1). A new Y79 ureilite similar to Y74659 (5) contains pigeonites more Ca-rich than Y74659 and a large number of low-Ca pyroxene the same as Y74659 which is poorer in Ca than the pigeonite. The Ca-rich rims are also found.

Goodrich (3) suggested that the interstitial material represents trapped primary interstitial liquid during the cumulate process from a magma by progressive reduction model. As was pointed out by others (2,4), they are compatible with other models. The chemical variation of the interstitial pyroxenes is within the field of the inclusions found in the shock partial melted Y790981 pigeonite and does not show differentiation trend of the trapped liquid. Inhomogeneous distribution of Al is not agreement with the trapped liquid model. In this paper we interpret our results on the basis of other models (2). One of these models has been proposed on the basis of weak negative correlation of MnO/FeO and the crystallization trend of pyroxene. This model assumes that ureilites were formed by crystallization or coarsening of olivine and pyroxene crystals of C-rich chondritic materials by the Ostwald ripening process with presence of a very little interstitial partial melt produced by shock heating event of a planetesimal scale collision. The oriented mafic crystals by shock compaction can grow large in expence of small crystals and matrices. Carbonaceous and partly melted matrix materials are acumulated into the grain boundaries during the growth. The Fe-Ni-S eutectic melt and Ca-, Al-rich partial melt will be drained away from the grain boundaries by surface tension between solid and liquid. Some residual materials may form interstitial rim materials.

By this process it is easy to explain the island-like augite-rich rim materials enclosed in olivine. They can be trapped in olivine during the coarsening process. If the liquid uniform in composition was trapped during the cumulate process (3), they can be integrated into the pyroxene by diffusion during the high temperature episode, and form homogeneous pyroxene. The inhomogeneous distribution of Ca and Al is not compatible with the interstitial trapped liquid model. By our model the augite can be formed by Ca-rich partial melt. If the amount of such melt is large which was accumulated through grain boundaries from other interstitial portions, the augite will be formed in expence of pigeonite. The presence of pigeonite entirely enclosed in augite in Y74130 (2) can be explained by this process. The presence of pigeonite more Mg-rich than coexisting three pyroxene phases in Y74130 suggests that the temperature will be raised towards the Mg-rich side by a progressive reduction magma model. Then the magma will never be cooled, since we do not see any differentiated product in the ureilite parent body. It is important to understand what kind of heating process will take place during the collision of two large planetesimals.

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