LITHOPHILE ELEMENT CHARACTERISTICS OF ACAPULCOITE-LODRANITE AND WINONAITES: IMPLICATIONS FOR THE CHEMICAL COMPOSITION OF THEIR PRECURSOR MATERIALS. Y. Hidaka[1], A. Yamaguchi[2, 3], N. Shirai[1], S. Sekimoto[4] and M. Ebihara[1], [1]Department of chemistry, Tokyo Metropolitan University, 1-1 Minami-Osawa, Hachioji-shi, Tokyo, Japan 192-0397, e-mail: [2]National Institute of Polar Research, Tachikawa, Tokyo, Japan , [3]Department of Polar Science, School of Multidisciplinary Science, Graduate University for Advanced Sciences, Tachikawa, Tokyo, Japan, [4]Kyoto University Research Reactor Institute, Kumatori, Osaka, Japan.

Introduction: Primitive achondrites are one of the most important meteorite groups to understand the early differentiation on asteroid bodies. There are two major groups, acapulcoite-lodranite clan and winonaites. With extensive petrological and mineralogical studies on these primitive achondrites, it was revealed that parent bodies of acapulcoite-lodranite clan and winonaites have undergone different evolutional processes [1, 2, 3]. Compared with mineralogical and petrological descriptions, chemical composition data of these primitive achondrites are still poor. Therefore, we have conducted chemical analyses of 13 acapulcoite-lodranite clan meteorites and winonaites to characterize their chemical properties and understand alteration processes during early differentiation on their parent bodies.

Samples and Method: We have studied 13 primitive achondrites; 7 acapulcoites (Dhofar 125, Dhofar 290, MET 01195/01198/01244 pairs, Y-74063 and Y-981505), 4 lodranites (three portions of GRA 95209, NWA 2235, Y-791491 and Y-981505) and 2 winonaites (NWA 725 and Y-8005)). Among these samples, NWA 725 was classified as an acapulcoite, but the O-isotopic composition is similar to those of winonaites [4]. Therefore, here we list NWA 725 as a winonaite. Several chips weighing 200-300 mg of each meteorite were ground into powder for instrumental neutron activation analysis. Magnetic separation was carried out for samples to discuss the lithophile elements and siderophile elements, separately. Nonmagnetic portions were analyzed except for Dhofar 290 and Y-74063, for which bulk powder samples were analyzed.

Results: Most acapulcoites analyzed in this study show nearly chondritic compositions, being less depleted abundances of light-rare earth elements (LREEs) and plagiophile elements such as Na, Al and K. Among our samples, Y-74063 is the most similar to chondrites in lithophile element compositions. On the other hand, Y-981505 is severely depleted in LREEs and K, showing anomalous chemical characteristics among acapulcoites.

Lodranites show various lithophile element abundances. Three portions of GRA 95209 have similar elemental compositions to each other, being depleted in K, but less depleted in LREEs, Na and Al. NWA 2235 is severely depleted in Al, Eu and Na as well as Sc and Ca, but not depleted in LREEs. NWA 2235 is less depleted in K compared with the depletion of other plagiophile elements. Y-791491 is severely depleted in plagiophile elements but not REEs. Y-981725 is less depleted in LREEs and K.

Two winonaites show chondritic lithophile element compositions, being similar to those of the Y-74063 acapulcoite sample of this study.

Discussion: Because primitive achondrites have suffered various degrees of metamorphism and partial melting, a large range of elemental compositions will be expected even among the same meteorite groups. We firstly consider the effects of such metamorphism to individual samples. In Fig. 1, three plagiophile elements (Na, Al and K) are compared with a chalcophile element (Se). Elemental abundances of these elements are normalized to CI chondrite abundances and their Mg contents. This figure is modified from [5]. In Fig. 2, La/Yb ratio is compared with Na/Sc ratio. These element abundances are also normalized to CI chondrite abundances. In Fig. 1, samples having high plagiophiles and Se abundances are considered as more primitive while samples with low plagiophiles and Se abundances are considered to be more evolved. Acapulcoite-lodranite clan meteorites may be classified into 5 subgroups [6]; “primitive acapulcoites” with high-Se, “typical acapulcoites” with middle-Se, “transitional acapulcoites” with low-Se , “enriched acapulcoites” with high-K and “lodranites” with low-Se, low-K.

An acapulcoite Y-981505 is plotted near the “transitional acapulcoites” (Fig. 1). However, this meteorite shows a severe depletion of LREEs (Fig. 2) not observed in other “transitional acapulcoites”. On the other hand, a lodranite Y-791491 is severely depleted in plagiophile and chalcophile elements, but not depleted in LREEs (Figs. 1, 2). in Y-981505 and Y-791491, behavior of REEs is puzzling. The chemical composition of Y-981505 implies that LREEs were removed from parent rocks during the first step of partial melting. On the other hand, the chemical composition of Y-791491 implies that REEs remained in parent rocks during silicate partial melting. A possibility of introducing REEs by melt intrusion can be ruled out for Y-791491, because the REE abundances of Y-791491 are not frac-

tionated from those of CI chondrite (Fig. 2). The conflicting evidence of REE abundances in acapulcoite-lodranite meteorites indicates the complex evolutionary history of the acapulcoite-lodranite parent body(ies).

An acapulcoite Y-74063 and winonaites NWA 725 and Y-8005 show the most primitive characteristics of chemical compositions among the samples analyzed in this study (Fig. 1), with respect to plagiophile elements and Se. For NWA 725 and Y-74063, the presence of relict chondrules was reported [6, 7], strongly supporting the primitive characteristic of these two meteorites. Y-74063, NWA 725 and possibly Y-8005 may provide us the information about the precursor chondritic materials of these primitive achondrites. In Fig. 3, CI- and Mg-normalized lithophile element abundances of these three samples are compared with those of some chondrites. It was reported that a winonaites Y-74025 is more depleted in V, Cr, Mn and Zn compared with an acapulcoite Y-74063 [8]. For Y-74063, NWA 725 and Y-8005, no such a difference is observed between acapulcoite and winonaite except for Zn abundance (Fig. 3).

We suggest that primitive acapulcoites and winonaites are similar to each other for lithophile element compositions and that their compositions are chondritic with a slight depletion of V and Cr as shown in Fig. 3. Among known chondrites, EL chondrites show similar depletion for V and Cr, but not for other lithophile elements to those of acapulcoites and winonaites. H chondrites were suggested to be the most similar to primitive achondrites in elemental composition [10]. Lithophile element compositions of H chondrites and primitive achondrites are similar to each other, but are evidently different in V, Cr and Se (Fig. 3). There are some possible explanations for such difference: (1) sample heterogeneity coming from low chromite abundance, (2) removing and addition of silicate and/or Fe-FeS partial melts, (3) terrestrial weathering, and (4) the characteristics of precursor chondritic materials of acapulcoite-lodranite and winonaites.

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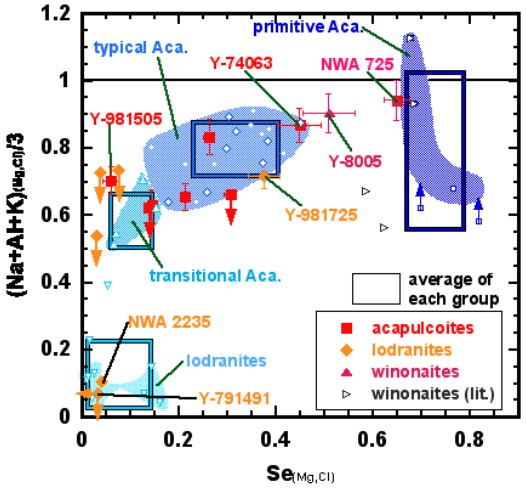

Fig. 1. Mg, CI-normalized (Na+Al+K)/3 vs. Se. Shaded areas boxes show the range of literature values and of their average with standard deviation (1 σ). CI values are from [11].

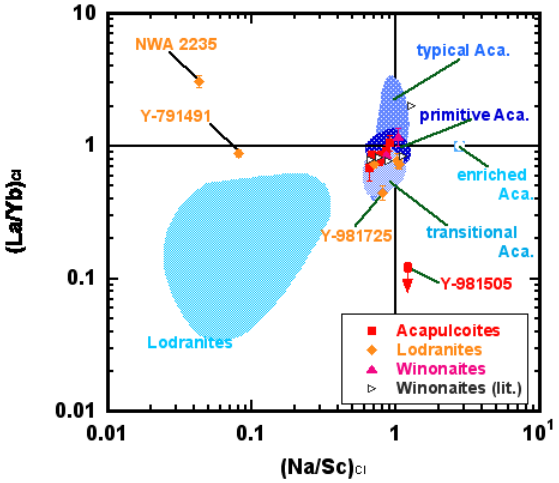

Fig. 2. CI-normalized La/Yb vs. Na/Sc ratio.

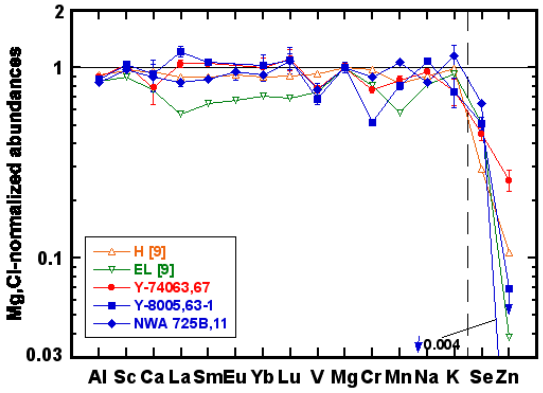

Fig. 3. Mg, CI-normalized lithophile and chalcophile element abundances.