PETROLOGY OF CHONDRULE RIMS IN YAMATO-791498 AND ASUKA-881828, THE LEAST-ALTERED CR CHONDRITES IN THE JAPANESE NIPR COLLECTION. M. Komatsu[1] , T. J. Fagan[2], A. Yamaguchi[3], M. Kimura[3], M. Yasutake[4], T. Mikouchi[5] and M. E. Zolensky[6], [1]The Graduate University for Advanced Studies, SOKENDAI, Hayama, Kanagawa, Japan (komatsu_mutsumi@soken.ac.jp), [2]Dep. of Earth Sciences, Waseda University, Japan, [3]National Institute of Polar Research, Japan, [4]Ritsumeikan University, Shiga, Japan, [5]The University Museum, University of Tokyo, Japan, [6]ARES, NASA Johnson Space Center, Houston, USA.

Introduction: CR chondrites are a group of carbonaceous chondrites with well-preserved records of formation of their components in the solar nebula [e.g., 1-3]. The CR chondrites have undergone a wide range of aqueous alteration from nearly anhydrous (CR2.8 or CR3.0) to extensive recrystallization of primary minerals, including replacement of coarse-grained silicates in chondrules (CR2.0) [e.g., 4,5]. At the same time, CRs have experienced only minor thermal metamorphism except for rare CR6 samples. Identifying minimally altered CR chondrites is a priority because they preserve (1) relatively pristine records of the solar nebula and (2) minerals and textures at the beginning stages of aqueous alteration. Here we report the petrologic characteristics of Y-791498 and A-881828 as the least aqueously altered CR chondrites in the Japanese NIPR meteorite collection. Previous studies have shown that fine-grained rims on chondrules are indicators of incipient alteration of primitive CR chondrites [5-7], therefore we focus on rims around chondrules in the two meteorites.

Methods: Polished thin sections of Y-791498 and A-881828 were studied using a JEOL JSM-7100F FE-SEM and a JEOL JXA-8200 EPMA at NIPR. The extent of aqueous alteration was estimated from the preservation of glass in chondrule mesostasis, textural replacement of chondrule phenocrysts, alteration of primary anorthite and metal. Aqueous alteration in CR chondrites is characterized by the oxidation of metal by magnetite, and replacement of chondrule mesostasis and silicates by phyllosilicates and carbonates [e.g., 8]. In CRs classified as 2.8 by [5], some chondrules have smooth-appearing, phyllosilicate-rich rims; some of the rims have distinct BSE-dark and BSE-bright ("two-toned rims" of [5]); similar rims on chondrules were not observed by [5] in CRs with subtype ≤2.7.

The degree of thermal metamorphism of the meteorites was evaluated using Raman spectra of matrix grains collected with a JASCO NRS-1000 Raman Spectrometer at NIPR. The Raman constraint on metamorphic temperature is based on the G- and D-bands (associated with graphite and defects, respectively) in the carbonaceous matter. With increasing metamorphic temperature, the full-width at half-maximum (FWHM) of the D-band decreases, and the intensity ratio I_D/I_G increases [9].

Results: *General Petrography*

Y-791498 and A-881828 are both classified as CR2 and terrestrial weathering category B [10]. They contain abundant well-defined Type-I chondrules ranging from 300 µm to 3 mm across in thin sections. Refractory inclusions are rarely found - only AOA and a few CAIs are observed in each thin section of both Y-791498 and A-881828. Framboidal magnetite occurs in A-881828 but is rare, and other alteration features are minor in the two samples, suggesting that both meteorites have mainly escaped from aqueous alteration.

Matrix petrology and Raman characteristics

Matrix is heterogeneously distributed in both meteorites. Distinct Fe-rich fine-grained matrix domains, similar to those described by [11] in the pristine CR chondrite MET 00426, are observed in both samples (Fig. 1). The Fe-rich matrix domains are extremely fine-grained, and contain abundant fine-grained sulfides. Raman spectra were collected on randomly-selected matrix areas in thin sections. Although D and G-bands from the fine-grained matrix are unclear compared to the normal matrix areas, all data show low I_D/I_G, suggesting low thermal maturity, particularly in comparison with UOCs and CV chondrites [12].

Chondrules and their rims

Type I chondrules in the two meteorites are commonly multilayered, with cores dominated by forsteritic olivine and low-Ca pyroxene, and mantles with abundant Fe-Ni metal grains. Feldspathic glass mesostasis was identified in some chondrules in both meteorites; phyllosilicates replacing mesostasis were not identified. Chondrules have clear boundaries with fine-grained matrix. Rims similar to those identified by [5] in CR2.8 chondrites occur around some chondrules in Y-791498 and A-881828. The rims are ≤30 µm in width with smooth appearance in BSE, often are two-toned in BSE, and in some cases have honeycomb textures with silica surrounded by high-Ca-pyroxene (Figs. 2a,b). Some rims are decorated with fine-grained magnetite grains (<5 µm) (Fig. 2c). BSE-dark parts of the two-toned rims SEM-EDS are Fe-poor compared to the brighter regions, and their compositions are within the range of fine-grained rims in QUE 99177 and MET 00426 (Fig. 3).

Discussion: Based on the occurrence of fine-grained rims on some chondrules combined with the preservation of glass in chondrule mesostasis, Y-791498 and A-881828 have experienced minor aqueous alteration compared to other CR samples in the NIPR collection. Aqueous alteration of Y-791498 and A-881828 was similar in extent to primitive CR chondrites QUE 99177, EET 92062, and MET00426, suggesting classification of CR 2.8.

References: [1] Weisberg M. K. et al. (1993) *GCA*, 57, 1567-1586. [2] Krot A.N. et al. (2002) *MaPS.*, 37, 1451-1490. [3] Komatsu M. et al., (2018) PNAS 115, 7497-7502. [4] Alexander C.M.O'D. et al., (2013) *GCA*, 123, 244-260. [5] Harju E.R. et al. (2014) *GCA*, 139, 267-292. [6] Abreu N. M. (2016) *GCA*, 194, 91-122. [7] Martinez M. and Brearley A. J. (2019) Met. Soc. Meeting 82, Abst # 6097. [8] Jilly-Rehak C.E. et al. (2017) *GCA*, 201, 224-244. [9] Quirico E. et al. (2003) *MaPS* 38, 795-881.[10] Kojima H. and Yamaguchi A (2005) *Meteorite Newsletter*, Vol.13, No.1. [11]Abreu N.M. and Brearley A.J. (2010) *GCA* 74, 1146-1171. [12] Bonal L. et al. (2006) *GCA*, 70, 1849-1863. [13] Lodders K. (2003) *Astrophysical Jour.* 591, 1220-1247.

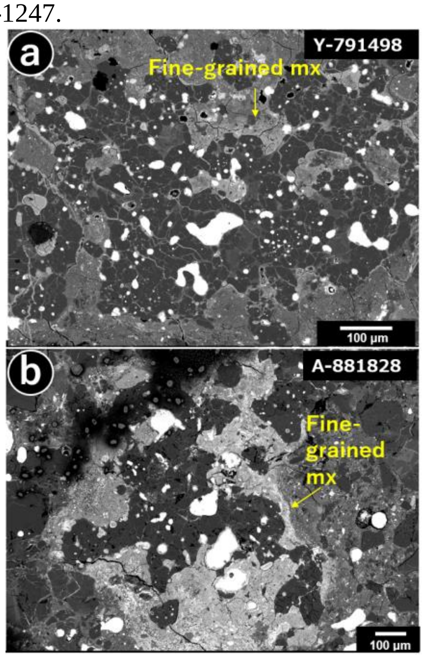

Fig. 1. BSE images of fine-grained rims in Y-791498 and A-881828. The fine-grained matrix contains abundant fine-grained sulfides.

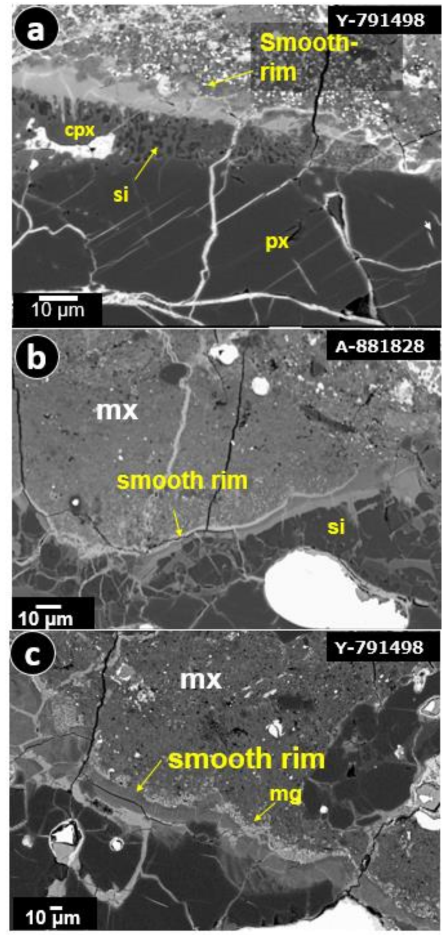

Fig. 2. BSE images of two-tone rims in Y-791498 and A-881828. The "honeycomb" structure of silica (si) in high-Ca pyroxene (cpx) in Y-791498 (a), and coexistence with silica rim around chondrule in A-881828 (b) are also observed. Some rims are decorated with fine-grained magnetite grains (c).

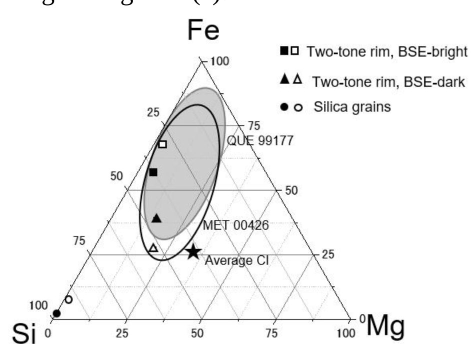

Fig. 3. Ternary diagram of compositions of the two-tone rim and silica grains in Y-793495 (open symbols) and A-881828 (solid symbols) determined by SEM-EDS analyses. The compositions of fine-grained rims in QUE 99177 and MET 00426 (data from [11]), and average CI composition ([13]) are shown for comparison. The compositions of silica rims are also plotted.