

## Y-791498 and A-881828: The least-altered CR chondrites in NIPR Antarctic meteorite collection.

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### 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;2]. CR chondrites range from almost wholly altered (CR2.0) to nearly anhydrous (CR2.8 or CR 3.0), while experiencing only minor degrees of thermal metamorphism [e.g., 3;4]. Because the previous studies of CR chondrites have been mainly performed on the fall/find samples or Antarctic meteorites from the US collection, the alteration variations of Japanese CR chondrites are poorly understood. We have investigated petrologic variations among the CR chondrites in the NIPR Antarctic meteorite collection, and found that two meteorites show little evidence for aqueous alteration, preserving the primitive nature of CR chondrites. Here we report the petrologic characteristics of Y-791498 and A-881828 as the least aqueously altered CR chondrites in the Japanese Antarctic meteorite collection.

### Methods:

Polished thin sections of nine CR chondrites including 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. 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 [5].

### Results and Discussion:

#### General Petrography

Y-791498 and A-881828 are both classified as CR2 and terrestrial weathering category B [6]. They contain abundant well-defined Type-I chondrules ranging from 300  $\mu\text{m}$  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. Aqueous alteration in CR chondrites is characterized by the oxidation of metal by magnetite, and replacement of chondrule mesostasis and silicate by phyllosilicates and carbonates [e.g., 7]. These alteration features are minor in the two samples, suggesting that both meteorites have mainly escaped from aqueous alteration.

#### Chondrules and their rims

Type I chondrules in the two meteorites are commonly multilayered, with cores dominated by forsteritic olivine and low-Ca pyroxene layers. It also contain Fe-Ni metal and feldspathic glass mesostasis; phyllosilicates replacing mesostasis are not identified. The clear boundaries between chondrules and fine-grained matrix are easily observed. One of the characteristics of primitive CR chondrites is the presence of smooth rims around chondrules [4, 8]. The smooth rims range up to 30  $\mu\text{m}$  in width and are observed around some chondrules (Figs. 1a,b). The rims appear to be two-toned, and SEM-EDS analyses show the composition of the BSE-dark region is Fe-poor compared to the brighter region, which is similar to the smooth rims in QUE 99177 and EET 92062 [4]. In addition, some rims are decorated with fine-grained magnetite grains ( $< 5\mu\text{m}$ ).

High-Ca pyroxene and silica rims are observed in the area adjacent to the smooth two-layered rims in some chondrules. "Honeycomb" structure, as also described in QUE 99177 [4], showing patches of silica residing within a high-Ca pyroxene rim, is also identified (Fig.1c). In chondrules where the silica rims occur, the rims form discontinuous layers in the outer part of type I chondrules [9;10] (Fig. 1b). These distinct rim occurrences are not observed in the other Antarctic CR samples described in [11].

#### Matrix petrology and Raman characteristics

Matrix is heterogeneously distributed in both meteorites. The distinct Fe-rich matrices, similar to those described by [12] in the pristine CR chondrite MET 00426, are observed in both samples (Figs. 1e,f). The Fe-rich matrix domains contain abundant fine-grained Fe-oxides, suggesting a higher degree of oxidation than other matrix regions.

Raman spectra were collected on randomly-selected matrix areas in thin sections. They all show low  $I_D/I_G$ , suggesting low thermal maturity, particularly in comparison with UOCs and CV chondrites [13].

Based on the observation of Y-791498 and A-881828 samples, it is suggested that the degree of aqueous alteration of these meteorite is lower than other samples. It should be noted that although the whole thin sections are not aqueously altered, the

presence of the Fe-rich matrix domains and the occurrence of framboidal magnetite (Fig. 1d) indicate the heterogeneous aqueous alteration and mixing of these materials. Nevertheless, Y-791498 and A-881828 share a petrographic similarity with the highly primitive CR chondrites QUE 99177, EET 92062, and MET00426, suggesting they have escaped from significant aqueous alteration and thermal metamorphism.

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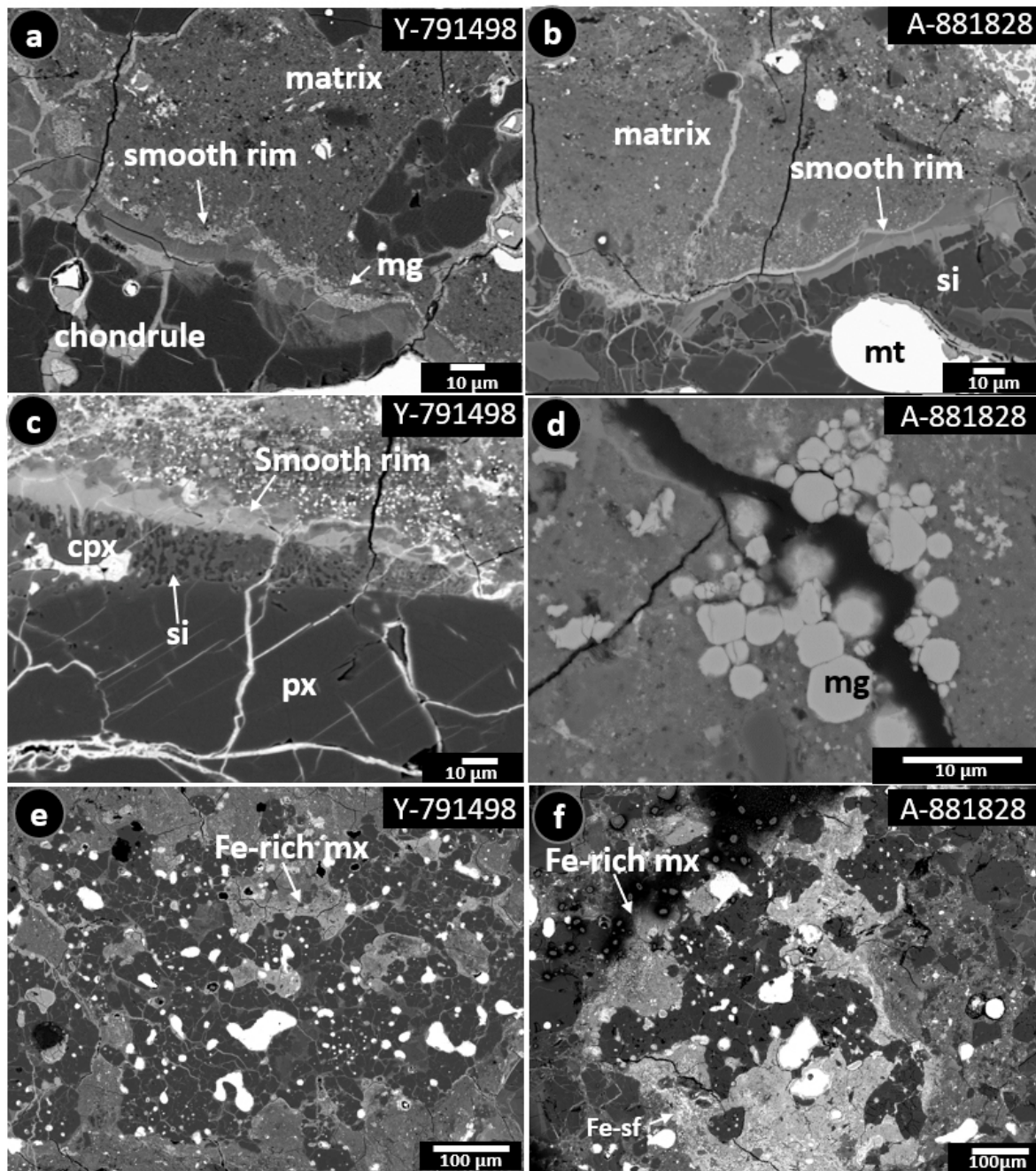


Fig.1. BSE images of characteristic regions of Y-791498 and A-881828. (a, b) Smooth rims around chondrules. Some rims are decorated with fine-grained magnetite grains. Si=silica, mt=Fe-Ni metal. (c) “Honeycomb” structure in high-Ca pyroxene (cpx) rim around chondrule in Y-791498. (d) Framboidal magnetite (mg) are rarely found in A-881828. (e, f) Fe-rich matrix (Fe-rich mx) is characterized by bright regions with Fe-oxides and Fe-sulfides (Fe-sf).