Mineralogical and petrological study of Aguas Zarcas CM2 chondrite

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Introduction

Aguas Zarcas is a carbonaceous chondrite fell in Costa Rica on April 23, 2019. According to initial studies reported in the Meteoritical Bulletin, Aguas Zarcas is a brecciated CM2 chondrite. Another previous research showed that the meteorite was composed of several different lithologies, including unique metal-rich lithologies which are uncommon in CM chondrites, and they suggested that the Aguas Zarcas parent body was formed by impact with the CR chondrite parent body (Kerraouch et al., 2021). Kerraouch et al. (2021) describes such a metal-rich lithology called "Met-1" in detail, however, does not describe other lithologies, such as C1 lithology, in detail. Therefore, in this study, we performed detailed observation and analysis of the various lithologies in Aguas Zarcas and discussed further lithologic diversity of this meteorite.

Sample and analytical techniques

We prepared a dry-polished thick section (7 mm x 11 mm) from the Aguas Zarcas sample (10.32 g). It was first observed by optical microscopy in order to measure chondrule sizes. The average particle size, which is the average of the major and minor axes, was used as the size of the chondrule. The area and the length of the chondrules were measured on the image taken with optical microscopy using the ImageJ software. After using optical microscopy, observation by FE-SEM (JEOL JSM-7001F, Kyoto Univ.) and chemical composition analysis of the minerals by EDS attached to it were performed.

Results and discussion

The sample used in this study was found to contain four different lithologies, Clast-1 to -4, including lithologies that are not described either in the initial analysis or in Kerraouch et al. (2021) (Figure. 1). (1) Clast-1 lithology is a CM lithology, similar to the "Primary Accretionary Rocks" described by Metzler et al. (1992), which seemed to be a lithology that has not experienced brecciation (Figure. 1c). The petrologic subtype of this lithology was estimated to be 2.2 using the classification suggested by Lentfort et al. (2021) (Figure. 2). (2) Clast-2 lithology is a brecciated CM clast (Figure. 1c). (3) Clast-3 lithology is a metal-rich clast with a subtype of 2.2-2.8 and is considered to be a CM clast experienced relatively low degree of aqueous alteration (Figure. 1b). (4) Clast-4 lithology is also a metal-rich clast, but it is distinguished from Clast-3 by the almost complete absence of tochilinite-cronstedtite intergrowths (TCIs) (Figure. 1d). This may be similar to the most primitive CM lithology, which has experienced only a limited degree of aqueous alteration, as well as Asuka (A)12085, A12169, and A12236 described by Kimura et al. (2020).

Conclusion

Clast-1 is not described in Kerraouch et al. (2021), and this study shows that Aguas Zarcas contains a lithology that is previously unknown. Moreover, the CR chondrite-derived metal-rich lithologies described in the previous study and the Clast-3 and Clast-4 in this study have similar petrological and mineralogical characteristics. However, this study indicates that Clast-3 and Clast-4 may have experienced only a limited degree of aqueous alteration on the CM chondrite parent body, which has not been considered in previous studies. These results suggest that the Aguas Zarcas parent body contains a greater variety of lithologies showing different degrees of aqueous alteration than previously thought.

References

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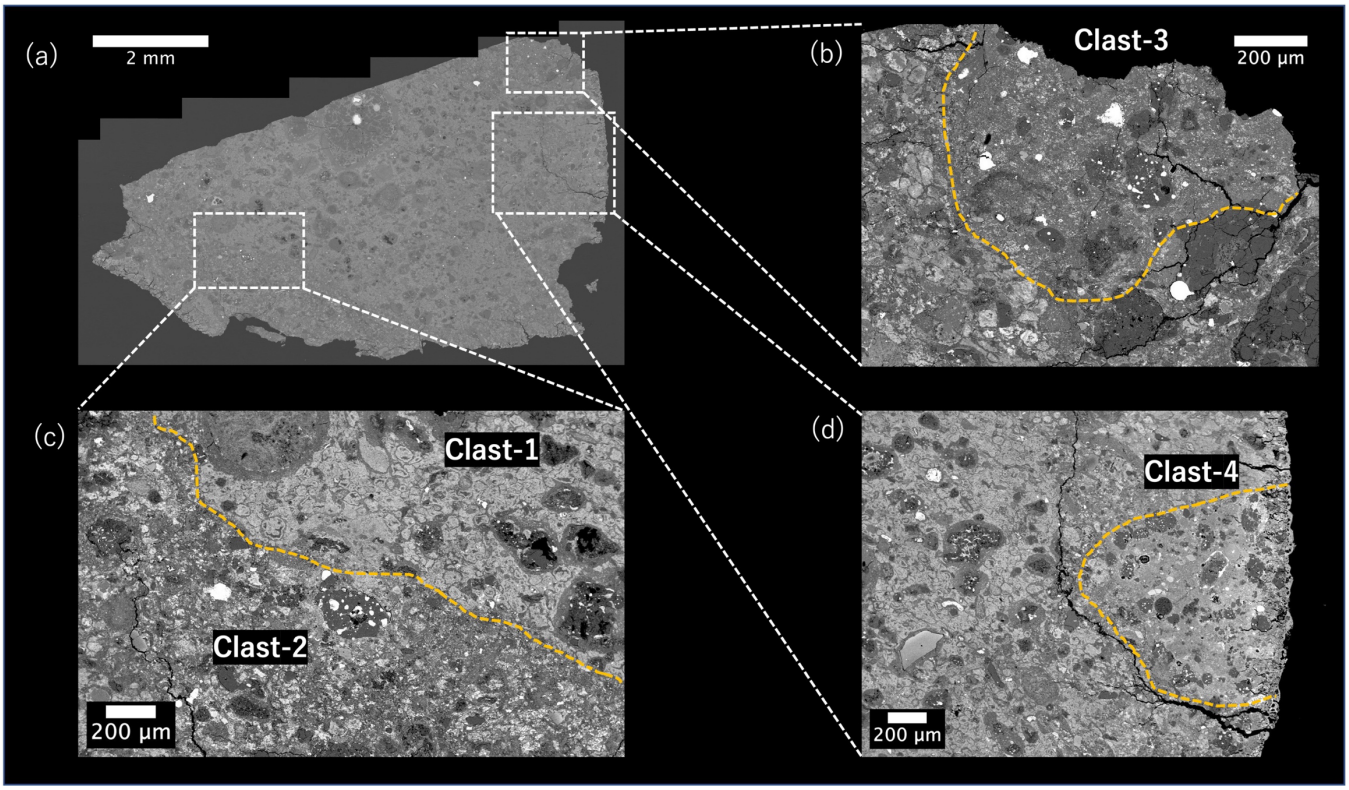

Figure. 1 Back-scattered electron (BSE) images of the Aguas Zarcas polished section studied, showing the presence of multiple lithologies. (a) Overall BSE image of the Aguas Zarcas sample. (b) Higher magnification BSE image, with the area surrounded by the dotted line indicating Clast-3 lithology. (c) Higher magnification BSE image, with the dotted line indicating the boundary between Clast-1 and Clast-2 lithologies. (d) Higher magnification BSE image, with the area surrounded by the dotted line indicating Clast-4 lithology.

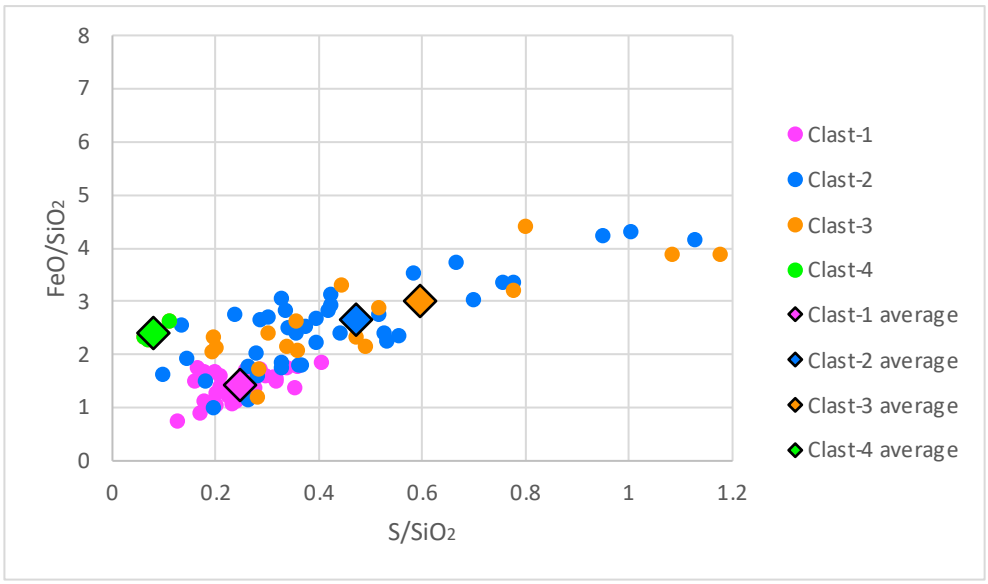

Figure 2. "FeO"/SiO_2 versus S/SiO_2 ratio for TCIs in each different lithology of the Aguas Zarcas sample analyzed in this study. Using the classification suggested by Lentfort et al. (2021), petrologic subtypes were determined from the ratios of "FeO"/SiO_2 for each lithology.