The Pecora Escarpment (PCA) 91020 EL3 Chondrite and the EL3 Parent Asteroid

INTRODUCTION

Enstatite (E) chondrites have important implications for the evolution of the inner Solar System and asteroid belt having stable isotopic compositions that link them to the Earth-Moon system and possibly the other terrestrial planets [1-3]. Also, they represent extremes in the conditions that resulted in formation of chondrites in that they have unusual, reduced and/or sulfidized assemblages, and compositions unlike any other primitive meteorite groups [4, 5]. The origin of E chondrites has been very controversial, and the role of impact is a major question.

In this present we present a petrologic study of the Pecora Escarpment (PCA) 91020 EL3 chondrite recovered from Antarctica. PCA 91020 was selected because of its consideration as being the most highly shocked enstatite chondrite (shock stage 5S). It is also characterized as having foliation, elongated chondrules and elongated opaque assemblages with a preferred orientation [6, 7]. It was previously concluded that impact was responsible for deformation and foliation [6].

We studied of two thin sections of PCA 91020 to characterize the size, shape, texture, and mineral compositions of its chondrules and opaque nodules. Our primary objective in this study is to better understand the deformation history of this meteorite to better understand the collisional history of the enstatite chondrite parent asteroid.

METHODS

The following tools were used to study and characterize the two PCA 91020 thin sections:

1. Petrographic Microscope and Scanning Electron Microscope (JEOL JSM-6390LV at Kingsborough)
2. Electron probe (Camcra SX 100 and SX5 at the AMNH).

The Petrographic and scanning electron microscope were used to document chondrule sizes, shapes and textures, while the electron probe was used to construct element maps of the thin sections and analyze the mineral compositions. Maximum and minimum dimensions were measured for 19 chondrules and 38 metal-rich nodules (Table 3 and 2).

RESULTS

PCA 91020 contains ellipsoidal chondrules and elongated opaque nodules in both sections studied (Fig. 1). Length, width and aspect ratios (length/width) for chondrules and metal-rich nodules are reported in Tables 1 and 2. The chondrules show radiating, porphyritic, cryocrystalline and barred textures. They are dominantly enstatite-rich with few olivine-bearing chondrules. Silicates in many chondrules show a cloudy (possibly shock darkened) appearance in plane polarized light. Olivine in chondrules and fragments has a range of compositions similar to other E3 chondrites indicating that PCA 91020 is an unequilibrated E chondrite (Fig. 2).

The chondrules have apparent shapes that range from near-spherical to ellipsoidal (Fig. 3a) and the opaque (metal-sulfide) nodules are clearly elongated (Fig. 3b) in comparison to the nodule described in other EL3 chondrites, suggesting deformation. Long axes of chondrules and nodules are generally aligned (Fig. 1). Chondrules were measured. Their sizes range in length from 435 to 2882μm with an average length of ~1233μm and width ranges from 350 to 1704μm with an average of ~924μm. The aspect ratio ranges from 1.01 to 1.89 with an average of 1.31.

DISCUSSION

PCA 91020 shows evidence of deformation throughout the meteorite in both the chondrules and the opaque (metal-sulfide) nodules, as previously described [6] and shows a general alignment along the longest dimensions of the elongated chondrules and metal-rich nodules. The presence of deformation throughout the meteorite suggests the chondrules were deformed in situ. Such deformation is present in chondrites from many O and C chondrite groups [e.g., 8, 9, 10], as well as on other EL3 chondrites to different degrees [6, 7]. The origin of this feature in this meteorite has been attributed to (1) accretionary sedimentation [8], (2) static deformation due to overburden compaction during progressive accretion [9] and (3) impact-induced deformation [e.g., 6, 10]. PCA 91020 is classified as shock stage 5S, the most heavily shocked among the EL3 chondrites [6]. Shock features identified by [6] include the presence of enstatite laths intergrown with metal, rapidly solidified metal-troilite textures and the possible presence of maskelynite. However, enstatite laths intergrown with metal is a characteristic feature of opaque (metal-sulfide) nodules in all EL3 chondrites regardless of shock stage. We observed shock darkening and textures interpreted to be impact melt (e.g., Fig. 3c). A study of silica polymorphs in E chondrites by [11] found silica glass and tridymite in PCA 91020, and no evidence of high pressure polymorphs. Additionally, if chondrule deformation is a result of impact, the absence of such textures in many highly shocked chondrites needs to be better understood.

CONCLUSION

Thus, PCA 91020 is an EL3 chondrite with deformed chondrules and inclusions. Impact was likely an important process in the evolution of all chondrate parent bodies including the EL3 asteroid. Chondrule and metal-rich nodule deformation in PCA 91020 may have been produced by impacts. However, there are inconsistencies in reconciling an impact hypothesis with all of the observations and further work is needed to better test this and other hypotheses for deformation of chondrules in PCA 91020 and other EL3 chondrites.

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REFERENCES