A First Look at the Petrography of the Buzzard Coulee (H4) Chondrite: A Recently Observed Fall From Saskatchewan

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INTRODUCTION:

On November 20, 2008 a bright fireball was observed across three Canadian Prairie provinces. Between November 27 and December 6, 2008 more than one hundred individual pieces of this fall were recovered in Saskatchewan, Canada [1]. Here we describe some notable features observed in this meteorite.

CHONDRITE CLASS AND PETROGRAPHIC TYPE:

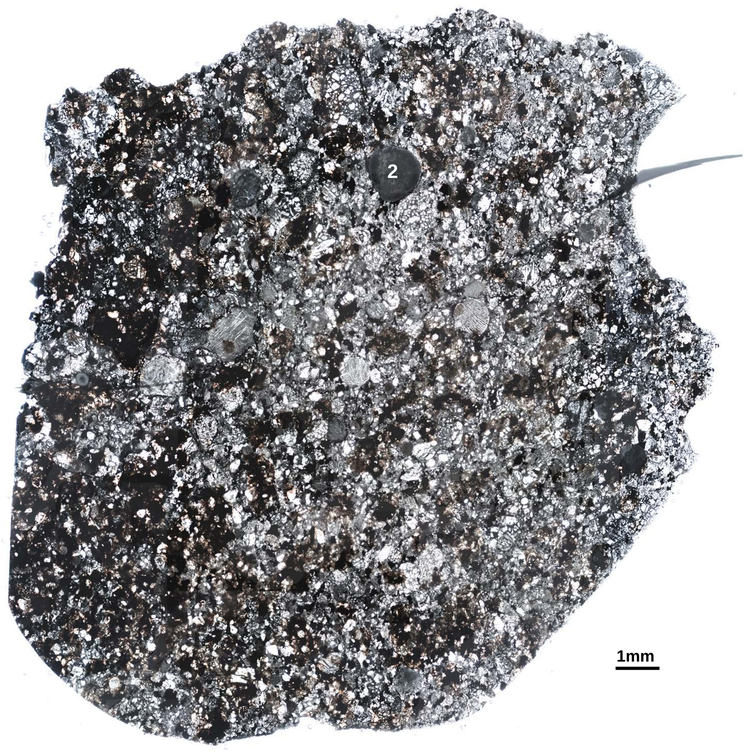


Fig. 1. Photomosaic in transmitted light of one (BC1) of two thin sections examined of the Buzzard Coulee chondrite. The largest cryptocrystalline chondrule in the section is marked as “2”.Relatively well-defined chondrules are easily seen in the upper half of the thin section, whereas the lower half appears finer-grained.

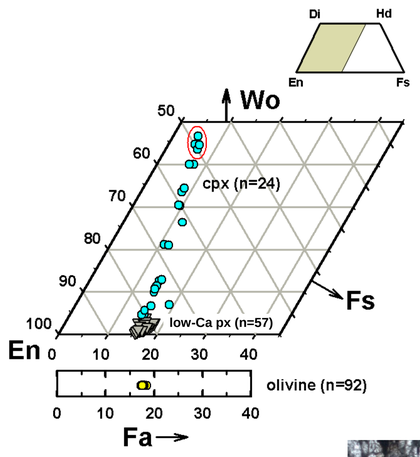
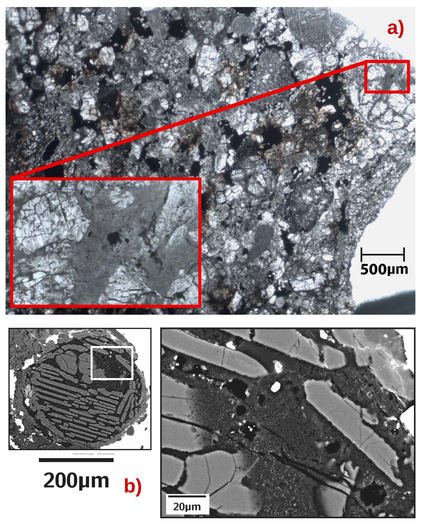


Fig. 2 shows olivine and pyroxene compositions in Buzzard Coulee. Low-calcium pyroxene ($Fs_{16.1\pm0.8}$, $Wo_{1.6\pm1.0}$, n=59) and olivine ($Fa_{17.8\pm0.3}$, n=92) compositions indicate that Buzzard Coulee is an H-group chondrite [2]. Olivine and low-Ca pyroxene grains are equilibrated. The spread in high-Ca pyroxene compositions most likely represents a mixing line between diopside (circled in red) and low-Ca pyroxene.



Figs. 3a-b. Fig. 3a is a transmitted light photomicrograph, while Fig. 3b is a BSE image. Turbid glass is widely present in chondrule mesostases (Fig. 3a), and also in small objects between chondrules. However, some small patches of clear glass appear to be present in the mesostases of a few chondrules (Fig. 3b). This, combined with the presence of low-Ca pyroxenes with lamellar structures, suggests that Buzzard Coulee is a type 4 chondrite (e.g., [2]), and possibly transitional from a type 4 to a type 3 chondrite.

References:
[1] Hildebrand A.R., Milley E.P., Brown P.G., McCausland P.J.A., Edwards W., Beech M., Ling A., Sarty G., Paulson M.D., Maillet L.A., Jones S.F. and Staugger M.R. (2009) Characteristics of a bright fireball and meteorite fall at Buzzard Coulee, Saskatchewan, Canada, November 20, 2008. *40th Lun. Plan. Sci. Conf.* Abstr. 2505.
[2] Sears D.W.G. and Dodd R.T. (1998) Overview and classification of meteorites. In Kerridge J.F. and Matthews M.S. (eds.) *Meteorites and the Early Solar System*, 3-31.
[3] Lauretta D.S., Nagahara H. and Alexander C.M.O'D. (2006) Petrology and origin of ferromagnesian silicate chondrules. In Lauretta D.S. and McSween H.Y. Jr. (eds.) *Meteorites and the Early Solar System II*, 431-459.

CRYPTOCRYSTALLINE CHONDRULES:

Buzzard Coulee contains numerous cryptocrystalline and partly cryptocrystalline chondrules and fragmental material, ranging in size from ≤ 50µm to > 1mm in diameter. Microprobe traverses and estimated bulk compositions were obtained for ten fine-grained chondrules in section BC1 (Fig. 1).

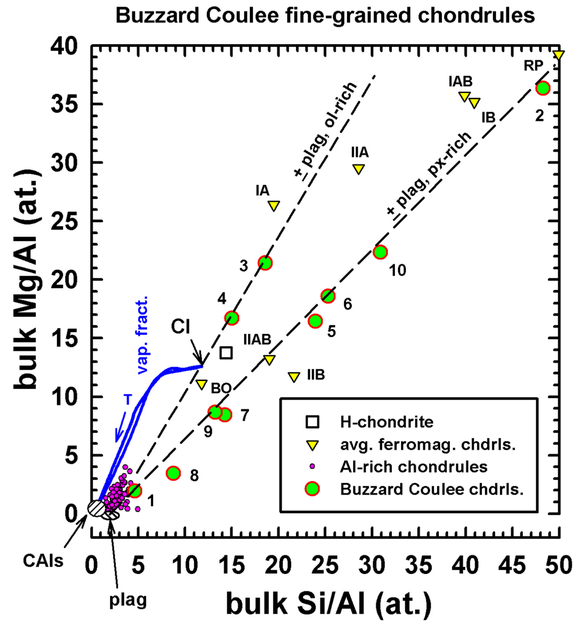
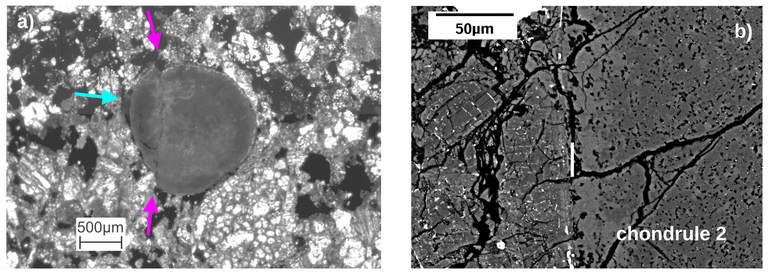


Fig. 4 plots bulk Mg/Al vs. Si/Al for the ten chondrules that were analyzed. Chondrules fall on two trends. Two of the chondrules are olivine-rich with varying amounts of a normative plag component, and are similar to BO and IA chondrules (chondrule classifications taken from [3]). The remaining chondrules fall along a mixing line between plagioclase and pyroxene which goes through the composition for IIAB chondrules.



Figs. 5a-b. Fig. 5a shows a transmitted light photomicrograph of chondrule 2, which is the largest cryptocrystalline chondrule in the section (labeled “2” in Fig. 1), and which is also the most pyroxene rich of the chondrules analyzed (near RP in Fig. 4). This chondrule is cut by a microfault indicated by the pink arrows. Fig. 5b shows a BSE image of the contact (indicated with a white line) between the chondrule and an arc-shaped region which adheres to one side of the chondrule (indicated with a blue arrow in Fig. 5a).

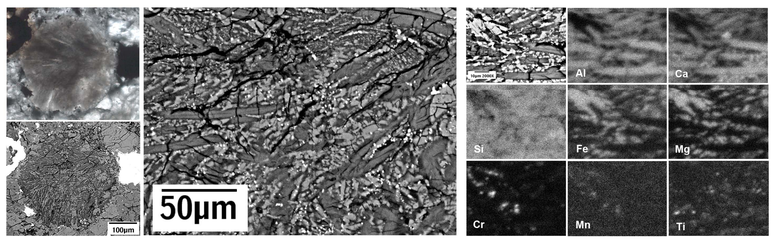
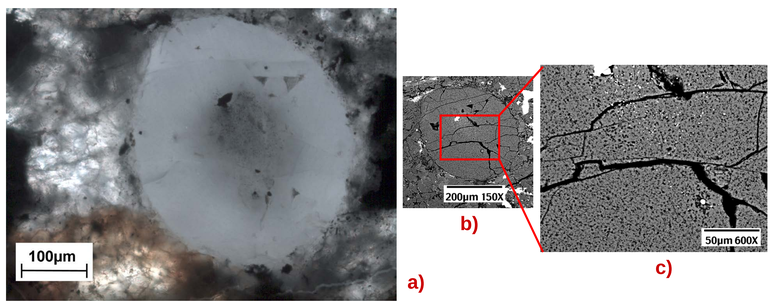
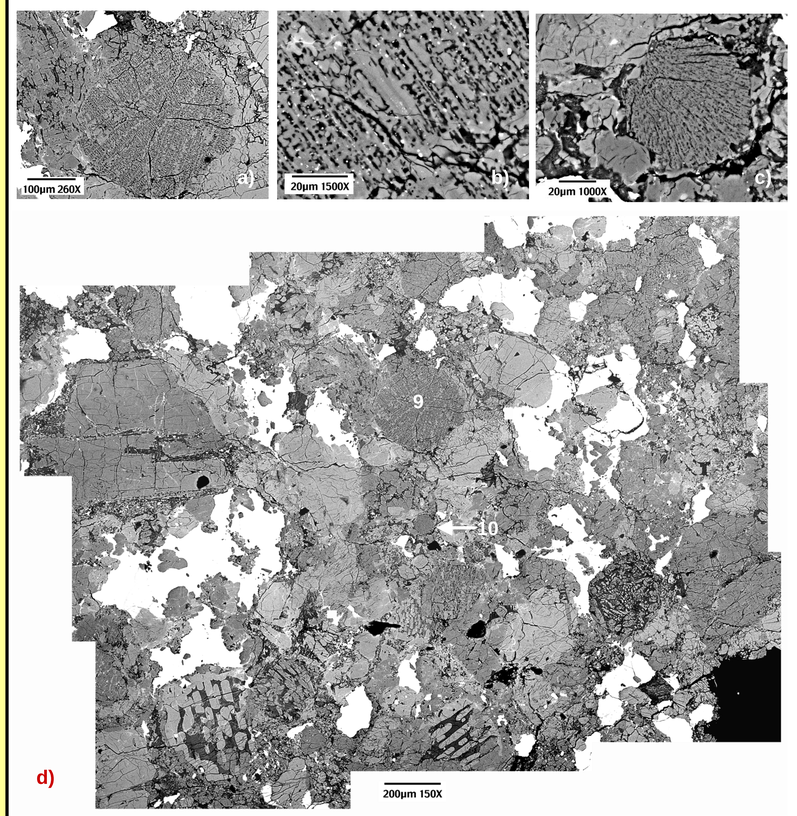


Fig 6. The leftmost image shows a transmitted light photomicrograph and the corresponding BSE image of chondrule 1, which is the most feldspathic chondrule analyzed. It falls in among Al-rich chondrules in Fig. 4. Next to the overview images is a BSE enlargement, which better shows the texture of this chondrule. X-ray maps, shown on the right, indicate that the chondrule is dominated by a plagioclase and a pyroxene component, although phases rich in Cr and Ti show up as well. The Cr is probably in chromite. The phase containing Ti has not yet been determined.



Figs 7a-c show chondrule 3, in a transmitted light photomicrograph (Fig. 7a) and in BSE (Figs 7b and 7c). This chondrule is the most olivine-rich of the cryptocrystalline chondrules studied. Although it appeared zoned under the optical microscope, BSE images show that the darkening of the central region is due to opaque inclusions.

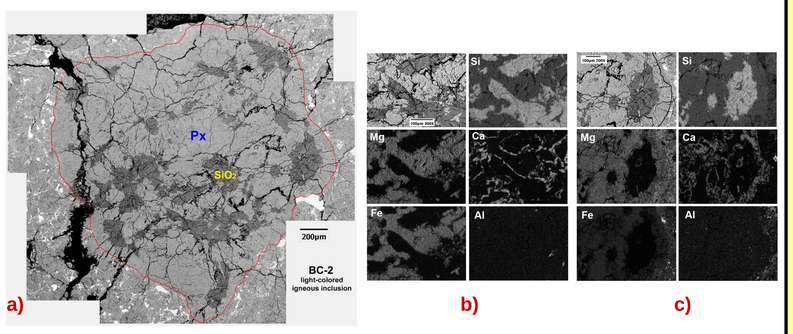
CHONDRULES 9 AND 10 IN A FRAGMENTAL SETTING:



Figs 8a-f. As shown in Fig. 1, the lower half of section BC1 has a dark, finer-grained appearance in thin section, with few obvious complete chondrules. Cryptocrystalline chondrules 9 and 10 are located near the bottom of Fig. 1 just to the left of center. BSE images of chondrule 9 are given in Figs. 8a and 8b, and a BSE image of chondrule 10 is given in Fig. 8c. A transmitted light photomicrograph showing both chondrules is given in Fig. 8f. Chondrule 10 is not the smallest cryptocrystalline chondrule examined in this section, but is still difficult to pick out of a low-magnification transmitted light photomicrograph (Fig. 8e). As is apparent in Fig 8e, and even more so in Fig 8d (a BSE mosaic of the same region), this region of Buzzard Coulee consists of fragmental material, including partial BO chondrules. Silicates are surrounded by opaques that must have been at least partly fluid at the time of emplacement, as they fill in around grain and fragment edges.

LIGHT-COLORED INCLUSION:

Light-colored inclusions up to ~0.5cm across were observed on the broken surfaces of a few of the hand specimens of the Buzzard Coulee chondrite. One of the inclusions is present in section BC2.



Figs 9a-c. Fig 9a is a BSE mosaic of the inclusion in BC2. The edge of the inclusion is outlined in red. The inclusion has an igneous texture. X-ray maps from the lower center of the inclusion (Fig. 9b) and the right edge of the inclusion (Fig. 9c) demonstrate that the inclusion consists of only three phases: a silica polymorph, low-Ca pyroxene, and a complex webwork of high-Ca pyroxene that separates the previous two phases from each other. The inclusion lacks opaques. It also lacks any feldspathic component. The few bright Al spots inside the inclusion are remnants of Al polishing powder in pits or holes. EMP data confirm the silica-rich phase is stoichiometric SiO_2. Observations in cross-polarized light confirm that the SiO_2 phase is crystalline and not a silica glass.