A CORUNDUM-RICH CAI IN THE MURCHISON (CM2) METEORITE.
S. S. Russell and A. T. Kearsley, Department of Mineralogy, The Natural History Museum, Cromwell Road, London SW7 5BD, UK.

Introduction: Corundum in meteorites is extremely rare. It is the first mineral proposed to condense from a gas of solar composition at pressures less than 10^{-2} atm [e.g. 1]. As a solar gas cools, corundum is predicted to react with gas to form hibonite. This reaction is thought to be the primary reason that corundum is much rarer than hibonite in meteoritic materials.

The Sample: Using automated large-area energy dispersive X-ray (EDX) montage mapping, a corundum-rich calcium aluminum-rich inclusion (CAI) was located in the CM2 meteorite Murchison (specimen BM 1988 M23, section P7250). The CAI is approximately 70 microns by 80 microns across and is dominated by a single rounded corundum grain, which appears red in ChromaCL cathodoluminescence (CL) images (Fig. 1). At 50 microns x 60 microns across, we believe this is the largest early solar system corundum grain reported in the literature. It is cross cut by hibonite laths (pale blue in CL) and is surrounded by spinel (green in CL image); Fig 2. The boundaries between all three phases are very distinct. Because of the bright red CL colour and corundum mineralogy we have named the CAI 'Murchison Ruby'.

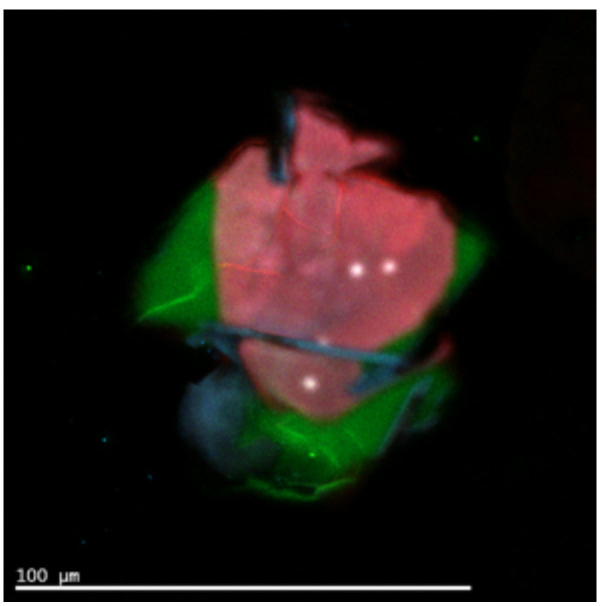

Figure 1. ChromaCL cathodoluminescence image of the corundum-rich CAI 'Murchison Ruby' . Corundum is red, hibonite blue, and spinel green. The white spots on this image are due to damage caused by prolonged EDX spot analysis. Imagery from Gatan ChromaCL on a Zeiss EVO 15LS SEM at the Natural History Museum, London.

Comparison with meteoritic corundum described in the literature

There have been several reports in the literature of corundum from meteorites. A few corundum-bearing CAIs have been located by examination of meteorite thin sections [e.g. 2]. Other studies have physically separated corundum-bearing CAIs [e.g. 3] or chemically separated corundum [e.g. 4] from the rest of the meteorite. Typically, corundum-bearing CAIs are fluffy aggregates of ~5 micron corundum, hibonite and accessory phases [2,3,5]. One reported hibonite-bearing CAI has a more compact texture, similar to that of Murchison Ruby [6].

A recent study of Al-Mg isotope systematics in corundum-bearing CAIs has shown that around half of corundum-bearing CAIs contained no live ^{26}Al when they formed, despite corundum being a very early stage condensate [7]. The authors concluded that ^{26}Al was injected into the disk as it was collapsing and was not spatially homogenized until after the formation of the first solids. Can some corundum therefore sample diverse isotopic reservoirs that predate establishment of the current bulk solar system composition?

Implications: The apparent cross-cutting relationship of the hibonite, and the sharply defined mantling of corundum by spinel in Murchison Ruby are difficult to explain simply as products of gaseous surface-reaction. The crystallization sequence appears to be hibonite → corundum → spinel; it is possible that corundum and hibonite formed at the same time. This is contrary to condensation theory in which corundum is expected to form first, and then react with gas to form corundum. Yet the very high temperatures and relatively high pressures required to melt corundum suggests that formation by condensation is more likely than from melt. If the CAI formed from a hot nebular gas, the high proportion of corundum compared to hibonite in Murchison Ruby suggests that it was removed from this environment before further reactions with the ambient gas could occur, and it was therefore isolated before any extensive isotopic re-equilibration could take place. This grain is therefore of considerable interest, and its relatively large size should allow multiple analytical measurements to be undertaken. Isotopic and trace element analyses on this CAI, including Al-Mg and O isotope systematics will be performed in the near future in order to better constrain conditions in the early solar system.

References: [1] Yoneda and Grossman, *Geochim. Cosmochim. Acta* **59** 3413-3444 (1995); [2] Krot et al., *MAPS* **36**

A105 (2001) [3] Simon et al., *MAPS* **37** 533-548 (2002) [4] Huss et al., [5] Fahey, PhD thesis, 1988 ; [6] Bar-Matthews *Geochim. Cosmochim. Acta* **46** 31-41. [7] Makide et al. *Astrophysical J.* **733** L31 (2011).

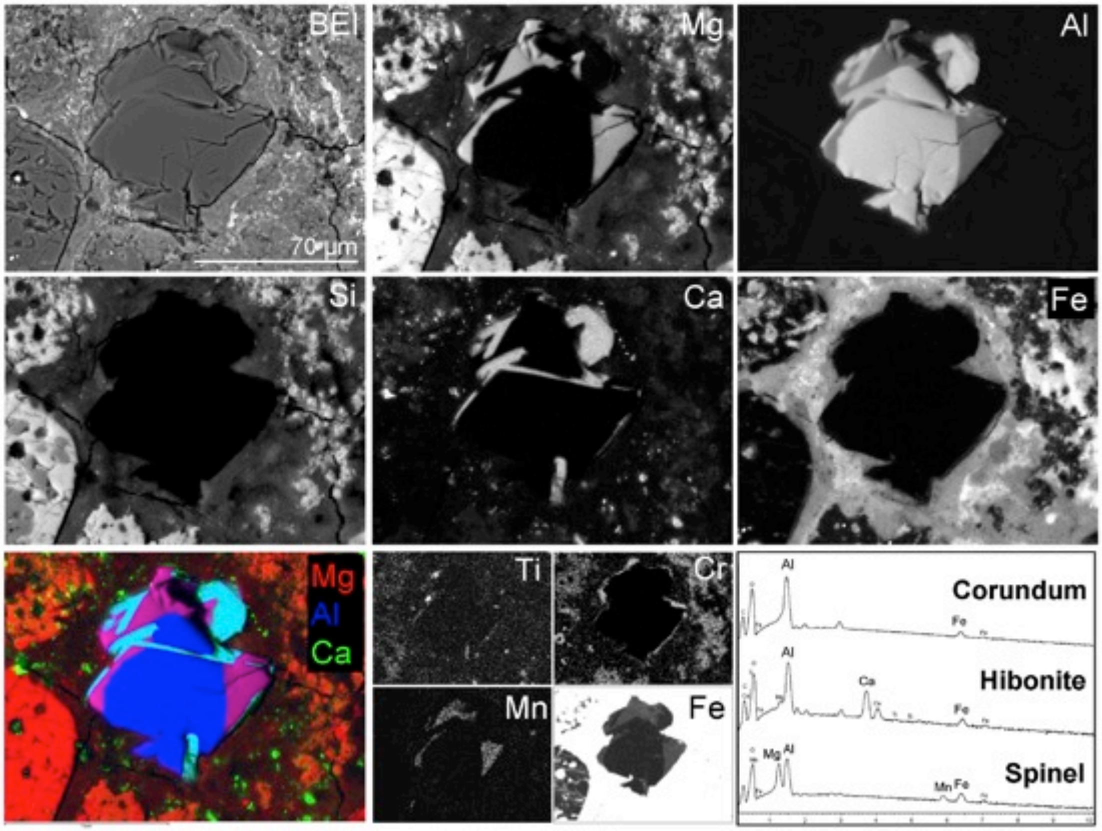

Figure 2. Backscattered electron image, and EDX element maps of Murchison Ruby. The inclusion is essentially free of Si, and is composed of corundum, hibonite and spinel. In the combined element map (bottom left), corundum is deep blue, hibonite is pale blue and spinel is pink/purple. EDX spectra show that corundum, hibonite and spinel contain trace amounts of Fe. Spinel contains minor Mn. Some parts of the hibonite contain Ti at levels detectable in the silicon drift detector EDX maps (> 0.2 %).