CHROMIUM ISOTOPIC COMPOSITION OF ALMAHATA SITTA. L. Qin[1], D. Rumble[2], C. M. O'D. Alexander[1], R. W. Carlson[1], P. Jenniskens[3], and M. H. Shaddad[4]. [1]Department of Terrestrial Magnetism, and [2]Geophysical Laboratory, Carnegie Institution of Washington, Washington, DC 20015, USA. [3]Carl Sagan Center, SETI Institute, 515 North Whisman Road, Mountain View, CA 94043, USA [4]Department of Physics, University of Khartoum, P. O. Box 321, Khartoum 11115, Sudan. (E-mail: lqin@ciw.edu)

Introduction: Ureilites are a unique group of achondrites. They are composed mostly of olivine and pigeonite with igneous textures. However they also have some features that make them appear "primitive"[1]. In a 3-oxygen-isotope plot (δ^{17}O vs. δ^{18}O), ureilites plot on the upper 1/3 of the CCAM (carbonaceous chondrite anhydrous minerals) mixing line [2]. Thus, a carbonaceous chondrite precursor material has been suggested for these meteorites [3]. However, ureilites exhibit considerable variation along the CCAM line (making it difficult to pair them with any particular carbonaceous chondrite). Studies have suggested that Cr isotopic compositions can be used as a fingerprint for meteorite classification (e.g. [4-7]). This is because different types of chondrites and achondrites show distinct ^{54}Cr/^{52}Cr ratios. In particular, carbonaceous chondrites show positive ^{54}Cr anomalies of up to 2ε (relative deviation of the isotope ratio from a terrestrial standard times 10000), and ordinary chondrites show uniform negative anomalies of ~ -0.4ε. Thus Cr isotope composition is a promising tool to test the genetic link between ureilites and chondrites.

The recent ureilite fall Almahata Sitta is comprised of hundreds of stones that were recovered from the Nubian Desert coincident with the projected Earth-impacting orbit of the Asteroid 2008 TC_3 [8]. Oxygen isotope data for this sample cover the entire range previously observed for ureilites of both monomict and polymict classes (Rumble et al. this volume). The heterogeneity in O isotope compositions of this meteorite makes it ideal for studying the correlation between Δ^{17}O and ε^{54}Cr displayed by carbonaceous chondrites [6]. Another advantage of studying Cr isotopic composition is that ^{53}Cr is the decay product of ^{53}Mn, an extinct nuclide with a half time of 3.7 Ma. It can thus potentially provide age constraints on this meteorite if it formed before ^{53}Mn decay ceased.

Methods: Eight samples of Almahata Sitta were studied for Cr isotopic composition. Only the non-magnetic fractions of the samples were studied, except for one sample in which both the magnetic and non-magnetic portions were analyzed. About 5 mg of fine chips pre-treated with diluted HCl was dissolved with a concentrated HNO_3/HF mixture. All materials went into solution except for some dark residue. Raman spectra revealed that these residues are mostly graphite.

Chemical separation of the Cr followed the method described in [7], and Cr isotopic compositions were measured on a Triton thermal ionization mass spectrometer at DTM. Each sample and the terrestrial laboratory standard were analyzed at least 6 times. Each run consisted of 420 ratios, with each ratio integrating ion intensity for 8 seconds. Only the average of the Cr isotope ratios from all the runs are reported here.

Results and Discussions: The Cr isotopic compositions of the non-magnetic fractions of the samples are shown in Fig. 1. All samples essentially have the same ε^{54}Cr within error, averaging at -0.75. This value is distinctive from the positive anomalies observed in carbonaceous chondrites (Fig. 1.). However, it is equal to the values measured for eucrites and diogenites [5]. This indicates that Almahata Sitta was derived from a parent body that has a similar Cr isotopic composition to the HED parent body. It is noted that so far all the achondrites analyzed show negative ε^{54}Cr anomalies. The magnetic portion of one sample shows a ε^{54}Cr value of -1.86±0.20, which is significantly lower than the values for the non-magnetic fractions. It has an ε^{53}Cr value of 0.35±0.14, similar to the non-magnetic portion of the sample. Thus the lower ε^{54}Cr value of the magnetic fraction is not likely to be caused by mass fractionation, as this would have been reflected in a lower value of ε^{53}Cr. Little is known about the difference in the mineralogy between the non-magnetic and magnetic fractions of the sample except that the latter contains most of the metal. The more negative ε^{54}Cr value in the magnetic fraction might reflect the Cr isotope signature in the impactor that disrupted the ureilite parent body. But no previously analyzed meteorite type has ε^{54}Cr this low. Further constraints on the cause of the Cr isotope heterogeneity in Almahata Sitta require the analyses on the magnetic fractions of more Almahata Sitta samples, along with a thorough study on the mineralogy in the magnetic-fraction.

The ε^{53}Cr values in the non-magnetic fractions range from 0.15±0.03 to 0.34±0.04. The total variation of 0.2ε is resolvable with our analytical precision, indicating live ^{53}Mn at the last Cr isotope equilibrium in

Almahata Sitta meteorite. Mn/Cr ratios will be determined to constrain the age of this event.

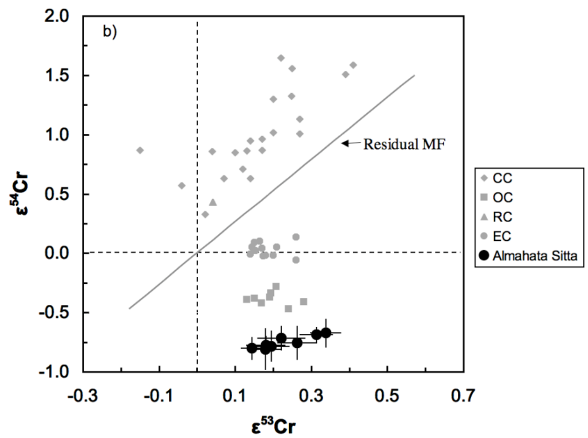

Fig. 1. Cr isotopic composition of Almahata Sitta and chondrites. The chondrite data are from [7].

A positive correlation of ε^{54}Cr with Δ^{17}O has been suggested for carbonaceous chondrites (e.g. [5, 9]). Because the variations in Δ^{17}O are thought to result from photodissociation, and variations in ε^{54}Cr are conventionally believed to be nucleosynthetic in origin, the apparent correlation between the two was used to question the photodissociation explanation for the O isotope variations in carbonaceous chondrites. Fig. 2 shows that ε^{54}Cr does not correlate with Δ^{17}O in Almahata Sitta. This implies that the process that governed the distribution of the ^{54}Cr carrier may not be responsible for the O isotope heterogeneity in the Solar System. This is consistent with the lack of correlation in the inner Solar System materials [7].

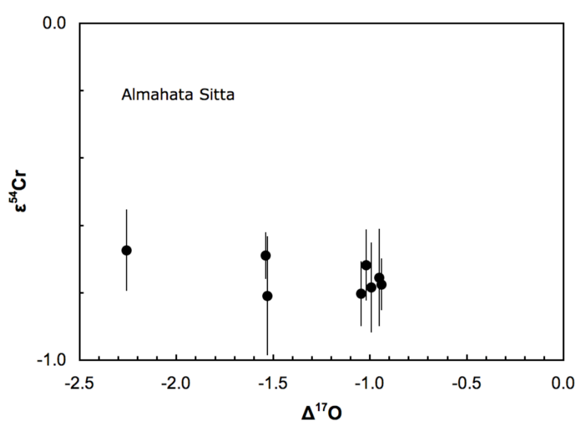

Fig. 2. ε^{54}Cr vs. Δ^{17}O for Almahata Sitta.

Conclusions: The Cr isotope compositions of Almahata Sitta samples suggest that this meteorite is derived from a parent body that is different from that of known carbonaceous chondrites, contradicting what has been suggested based on O isotopic compositions. Almahata Sitta has a similar ε^{54}Cr value to that of the HED parent body. We note that so far all the achondrites that have been analyzed all display negative ε^{54}Cr anomalies. The lack of a correlation between ε^{54}Cr and Δ^{17}O suggests that the process that has governed the O isotope heterogeneity may not be responsible for the heterogeneity of Cr isotopic composition. Variations of ε^{53}Cr likely reflect live ^{53}Mn at the time of the last isotopic equilibration.

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