CHROMIUM ISOTOPES IN ORDOVICIAN FOSSIL METEORITES AND THE QUEST FOR THE IMPACTOR THAT BROKE UP THE L-CHONDRITE PARENT BODY

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Introduction: For more than twenty years we have recovered meteorites that fell on the sea floor during the Ordovician period [1]. This is pursued in collaboration with the workers in a quarry in southern Sweden, where marine limestone is sliced into thin slabs for commercial use. About 100 fossil ordinary chondrites have been found, with sizes in the range 1-21 cm. Analyses of elemental and oxygen isotopic composition of relict spinels from the meteorites have shown that almost all are L chondrites. In 2011 one meteorite, called the "mysterious object" (MO), was found to contain very different spinels from those in ordinary chondrites [2]. The PGE analyses of the bulk sample, along with chemical and preliminary oxygen isotopic analyses of the spinels showed that this fossil meteorite did not match any documented recently fallen meteorite. The only material with similar features is a cm-sized winonaite-like, dark clast in the Villalbeto de la Peña (L6) meteorite [3]. The spinels of the MO have cosmic-ray exposure ages similar to fossil L chondrites at the same level in the Ordovician strata, indicating that the MO may be a fragment of the body that hit and broke up the L-chondrite parent body 470 Ma ago. Here we present Cr-isotopic analyses of Ordovician fossil meteorites, including the MO.

Methods: Chromium isotopic analyses (i.e., ε^{54}Cr) were performed on ~50 mg aliquots of bulk, homogenized powders of the fossil meteorites Österplana 029 and 032 (or Gol 001 and Bot 003, respectively) and two subsamples of the MO. Gol 001 and Bot 003 were shown to be L chondrites based on oxygen isotopic and/or chemical analyses of relict spinels. Separate chrome spinel grains from the Lundsgard (L6) meteorite and the winonaite NWA725 were also analysed.

Results and Implications: The spinel grains from Lundsgard and NWA725 yield ε^{54}Cr values the same as previously analyzed L6 chondrites [4] and winonaites, respectively. Samples of Gol 001 and Bot 003 yield ε^{54}Cr results in agreement with an ordinary chondrite. This indicates that bulk-sample analyses of fossil meteorites provide reliable Cr-isotopic results. In contrast to the chemical and oxygen isotope data for MO spinels, that indicate a potential winonaite affinity, the MO has ε^{54}Cr values of -0.26 to -0.23, which are within the uncertainties of previously measured ordinary chondrites [4]. The ε^{54}Cr results for the MO thus rule out a winonaite-like origin as suggested in [2]. The new results underline that the MO does not resemble any known meteorite type. Further analyses, primarily high-precision oxygen isotopic analyses of the spinels are required to further assess its origin. Cr-isotopes of the dark clast in Villabeto de la Peña may also add to this. If the MO is a piece of the impactor that created one of the largest asteroid families 470 Ma ago, a better characterization of its origin is warranted.

References: [1] Schmitz B. 2013. *Chemie der Erde* 73:117-145. [2] Schmitz B. et al. 2014. *Earth and Planetary Science Letters* 400:145-152. [3] Bischoff A. et al. 2013. *Meteoritics & Planetary Science* 48:628-640. [4] Jenniskens P. et al. 2014. *Meteoritics and Planetary Science* 49:1388-1425.