A REMARKABLE AND WELL-ROUNDED Zn-CAI IN THE CO3 CHONDRITE DAR AL GANI 083

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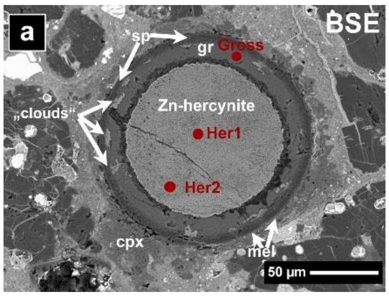
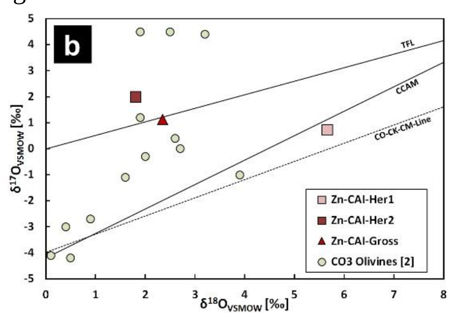
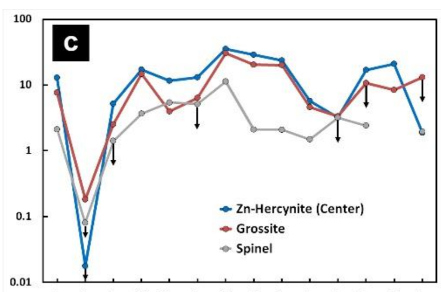
Introduction: Ca,Al-rich inclusions (CAIs) are regarded as the first material which condensed from a hot solar nebula (e.g., [1]). They mainly consist of refractory Ca, Al, Mg, and Ti-rich oxides and silicates. The presence of moderately volatile or volatile elements indicates low temperature alteration on their distinct parent bodies or in the solar nebula. Therefore, CAIs record the timing and conditions of different events in the early solar system. In this work the conditions and history of a Zn-rich CAI will be investigated based on major, minor, and trace element (REE) concentrations and O-isotope data.

Results: The well-rounded CAI from the CO3 chondrite Dar al Gani 083 (Fig. a) has a diameter of 155 µm without the Ca-pyroxene layer. Grossite (14-15 µm) encloses the inner part and Mg-spinel (4-7 µm) is the outer layer of the round CAI. Small Fe-bearing "alteration clouds" are visible between the grossite and spinel layer. These "clouds" are often connected with small cracks through the Mg-spinel layer but are not present in the Mg-spinel layer itself. The well rounded part of the CAI is surrounded by a wrinkled layer of Ca-pyroxene with some minor occurence of melilite. Main elements were measured by an electron microprobe. The Zn-hercynite is dominated by Al_2O_3 (53.5 wt%), FeO (26.4 wt%), and ZnO (7.4 wt%). CaO (1.57 wt%) and TiO_2 (1.70 wt%) are also abundant. The O-isotopes of two spots in the center and one spot in the grossite were measured with the Cameca IMS 1280-HR at the University of Heidelberg. The results are plotted in Fig. b. The center of the Zn-hercynite (Zn-CAI-Her1) plots close to the CCAM-line ($\delta^{17}O$ = 0.73 and $\delta^{18}O$ = 5.66 ‰). In contrast, the second measurement from the outer parts of Zn-hercynite (Zn-CAI-Her2) plots above the TFL-line ($\delta^{17}O$ = 2.00 and $\delta^{18}O$ = 1.81 ‰). The grossite plots on the TFL-line ($\delta^{17}O$ = 1.12 and $\delta^{18}O$ = 2.35 ‰) close to Zn-CAI-Her2. The REEs from the center, the grossite, and the spinel layer were measured with an LA-HR-ICP-MS at the University of Münster. The CI-normalized values are plotted in Fig. c. The arrows mark values below the detection limit. The Zn-hercynite can be enriched up to 35x CI and the grossite up to 30 x CI. The Zn-hercynite and the grossite yield a similar pattern whereas the spinel differs in some elements. The spinel layer is very thin and the measurement was possibly affected by the surrounding Ca-pyroxene layer. All three pattern show a strong negative anomaly for Ce. The Zn-hercynite and the grossite also have negative anomalies in Sm and Eu and in Ho and Er.







Discussion and Conclusion: The Zn-CAI is not only a remarkable sample because of its texture and appearence, but also due to the fact that the volatile and moderately volatile elements like Zn (the T_{50} condensation temperature is 726 K [3]) are situated in the center of the object and are surrounded by refractory minerals like grossite and Mg-spinel (with a condensation temperature for grossite of 1500-1600 K [4]). The data are not ambiguous at the moment and more work will be necessary. However, some assumptions can be made. The precursor of the Zn-hercynite was most likely a refractory mineral. This is indicated by the high enrichment in the REEs and the negative anomalies of Sm and Eu, which is well known from CAIs and Na-Al-rich chondrules [5]. The refractory inclusion altered in a low temperature region of the nebula (incorporating Fe and Zn) leading to the formation of Zn-hercynite and equilibrated with the local O-isotopic reservoir (CCAM line). It is possible that the object was subsequently transported to a hot, ^{17}O-enriched region of the solar nebula, where the refractory layers of grossite and Mg-spinel were formed. A olivine grain from the CO3 chondrite Allan Hills A77307 reported by [2] probably formed in a isotopically similar reservoir. The condensation of grossite and Mg-spinel was rapid enough to avoid evaporation of Zn and Fe from the interior. Furthermore, the heating and cooling events happened quickly leading to different O-isotopic ratios within the Zn-CAI.

References: [1] Connelly J.N. et al. (2012) *Science* 338:651-655 [2] Jones R.H. et al. (2000) *Meteoritics & Planetary Science* 35:849-857 [3] Lodders K. et al. (2009) In *Landolt-Börrnstein, New Series, Vol. VI/4B, Chap. 4.4*:560-630 [4] Ebel D.S. (2006) In *Meteorites and the Early Solar System II*:253-277. [5] Ebert S. and Bischoff A. (2016) *Geochimica et Cosmochimica Acta* 177:182-204.