(Na-)Al-RICH CHONDRULES AND Ca,Al-RICH INCLUSIONS FROM UNEQUILIBRATED ORDINARY CHONDRITES

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Introduction: Meteorites carry the cosmological information and history of the first particles formed, evolved, and accreted into planetesimals. Ca,Al-rich inclusions (CAIs) are considered to be the oldest solids formed in the solar system [1] and are embedded together with chondrules, metals, and sulfides within matrix material of chondrites. Variations in mineralogy, petrology, and isotopic compositions of CAIs in different chondrite groups suggest that there are multiple generations of refractory inclusions. A connection between the generations of CAIs and chondrules has been insufficiantly clarified until today. Ebert and Bischoff [2] showed that Na-Al-rich chondrules, a variety of Al-rich chondrules [3,4], in ordinary and CO chondrites have volatility fractionated bulk rare earth element (REE) patterns similar to CAIs [5], and suggested that refractory materials, like CAIs, were a main part of the precursor material for these chondrules. However, Na-Al-rich chondrules in ordinary chondrites (OCs) have no enrichment in ^{50}Ti, which is in contrast to CAIs from carbonaceous chondrites (CCs) and Na-Al-rich chondrules in CO chondrites [6]. They concluded that refractory precursors – similar in mineralogy and chemistry to CAIs in CCs, but different in their ^{50}Ti – was part of the precursors of the Na-Al-rich chondrules in OCs. If this is the case, differences in isotopic compositions of CAIs in OCs and CCs may be expected. To gain more information about the origin of the Na-Al-rich chondrules and their precursors, additional (Na-)Al-rich chondrules and CAIs from ordinary chondrites were studied by SEM and EDX. Oxygen and Al-Mg studies of the (Na-)Al-rich chondrules and the refractory inclusions are in progress.

Results: 50 Al-rich chondrules (20 are Na-rich), 14 CAIs, and 2 AOAs from the unequilibrated ordinary chondrites NWA 3358 (H3.1), Adrar 003 (L/LL 3.1), Krymka (LL3.2), and Vicência (LL3.2) were identified. The Na-Al-rich chondrules are enriched in sodium (Na_2O >5 wt%) and aluminum (Al_2O_3 >10 wt%) and typically composed of magnesian olivine ($Fa_{0–7}$) and high-Ca pyroxene ($Fs_{0–9}Wo_{20–50}$) embedded in a glassy mesostasis (Figs. 1 and 2). The CAIs consist mainly of melilite, spinel, perovskite, and Al±Ti-diopside; secondary alteration minerals are minor (for example Fig. 3).

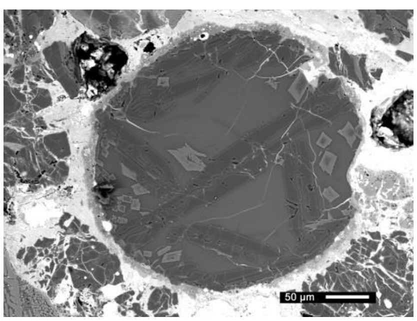

Figure 1: Na-Al-rich chondrule from NWA 3358 (H3.1) composed of magnesian olivine and high-Ca pyroxene phenocrysts embedded in a Na-rich glassy mesostasis.

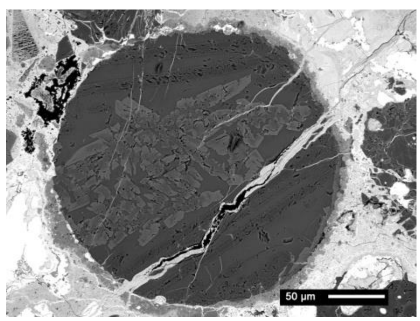

Figure 2: Na-Al-rich chondrule from NWA 3358 (H3.1) composed of magnesian olivine and high-Ca pyroxene phenocrysts embedded in a Na-rich glassy mesostasis.

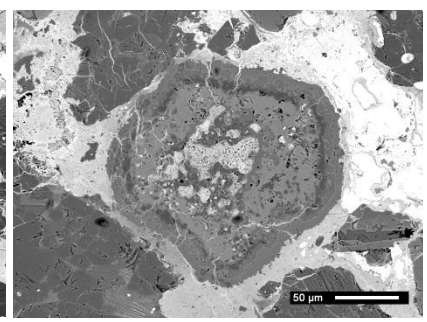

Figure 3: CAI from NWA 3358 (H3.1) consists of nepheline and anorthite (partly altered), melilite, spinel, and perovskite; it is rimmed by Al-diopside.

Discussion and Conclusions: (Na-)Al-rich chondrules and refractory inclusions are rare in ordinary chondrites [e.g., 2–4]. Therefore, a large number of these objects identified in UOCs provides an important dataset for investigating a genetic relationship between the Al-rich chondrules and refractory inclusions in these meteorites. The mineralogy and petrology of these objects combined with O- and Al-Mg-isotope measurements will help to reveal more information about their refractory precursors, which differ in their ^{50}Ti compared to those of known CAIs and Na-Al-rich chondrules in CCs [6].

References: [1] MacPherson G. J. (2014) *Treatise on Geochemistry* 1:139-179 [2] Ebert S. and Bischoff A. (2016) *Geochimica et Cosmochimica Acta* 177:182–204. [3] Bischoff A. and Keil K. (1983) *Nature* 303:588–592. [4] Bischoff A. and Keil K. (1984) *Geochimica et Cosmochimica Acta* 48:693-709 [5] Mason B. and Martin P. M. (1977) *Smithsonian Contribution to the Earth Sciences* 19:84-95 [6] Ebert S. et al. (2018) *Earth and Planetary Science Letter* 498:257–265.