CA,AL-RICH INCLUSIONS IN RUMURUTI CHONDRITES. S. S. Rout and A. Bischoff, Institut fuer Planetologie, Wilhelm-Klemm-Str. 10, 48149 Muenster, Germany (suryarout@uni-muenster.de).

Introduction: Rumuruti chondrites (R chondrites) are a group of chondritic meteorites that are highly oxidised, poor in metals, olivine-rich (with high Fa content of ~39 mol%), and have high $\Delta^{17}O$ values. Barely any description of Al-rich inclusions within the R chondrite has been reported till now [1-3]. Here, we present the results of our search and analysis of CAIs and Al-rich objects in R chondrites.

We studied 20 R chondrites (NWA 053, 753, 755, 1471, 1472, 1476, 1477, 1478, 1566, 2446, 3364, Rumuruti, Dhofar 1223, Acfer 217, Dar al Gani 013, Dar al Gani 417, Hughes 030, Hammadah al Hamra 119, Sahara 99537, Sahara 99531) and found 126 Ca,Al-rich objects (101 CAIs, 19 Al-rich chondrules and 6 spinel-rich fragments). In general, (a) most of the inclusions and fragments are very small, <50 µm - 100 µm, with the largest being 600 x 200 µm in size. (b) They are rare; probably slightly more abundant to CAIs in ordinary and enstatite chondrites [4,5]. (c) There is a marked difference in mineralogy between the CAIs in the R chondrites of petrologic type 3 (or breccia fragments of type 3) compared with inclusions within types R4-R6 (or breccia fragments of types 4-6).

Results: Based on the mineralogical characterisation by SEM and electron microprobe the inclusions can be grouped into six classes:

(1) Concentric spinel-rich inclusions (42). These CAIs have abundant spinel and based on the presence or absence of major different phases can be subdivided into four groups:

(a) Three inclusions have hibonite along with dominant spinel. These inclusions are very rare within the R chondrites and have a monomineralic rim of diopside (Fig. 2). (b) 14 CAIs dominantly consist of a spinel core rimmed by Al-rich diopside which sometimes overlies a thin fassaitic rim. (c) Thirteen spinel-rich CAIs also contain abundant fassaite. These CAIs have a rim of diopside occasionally including olivine (Fig. 1). (d) Within twelve inclusions besides spinel abundant Na- and/or Cl-rich alteration products (probably nepheline and/or sodalite) were observed within the cores rimmed by diopside and, rarely, by olivine. Ilmenite or perovskite are occasionally present within the concentric spinel-rich inclusions.

(2) Concentric fassaite-rich spherules (3) have no rims and contain either hibonite or spinel (one inclusion has olivine and ilmenite along with spinel) within a groundmass of fassaite (Fig. 3).

(3) Complex spinel-rich CAIs are the most abundant variety of CAIs (53): Based on their mineral abundances these CAIs can be subdivided into four other groups:

(a) Two inclusions have also abundant hibonite. (b) 27 inclusions are rich in plagioclase (anorthite and/or oligoclase), and have sometimes fassaite (Fig. 4). All the oligoclase-rich CAIs are devoid of any rims, but others generally have an Al-rich diopside rim. (c) 18 of the complex spinel-rich CAIs have major fassaite and Na- and/or Cl-rich alteration products mainly showing a complex mixture of spinel, fassaite, and alteration products (Fig. 5). All CAIs have a diopsidic rim. (d) Six complex spinel-rich CAIs with abundant Na-,Cl-rich alteration products were detected occasionally having a diopsidic rim.

(4) Three complex diopside-rich CAIs with minor fassaite and/or alteration products in the core and having a complex texture were found.

(5) 19 Al-rich chondrules were analysed (Fig. 6).

(6) Six Al-rich (spinel-rich) fragments were found, whose relationship to other types of inclusions described above is uncertain.

Discussion: There is a strong difference in mineralogy of CAIs within the metamorphosed and the unmetamorphosed rocks/fragments. Inclusions within the metamorphosed fragments have dominant oligoclase, replacing the Na,Al-rich alteration products or anorthite, and the iron content in spinels is high (~20-26 wt%). Minor ilmenites are observed in place of perovskite. CAIs in unmetamorphosed lithologies have sometimes very low iron content within the spinels (as low as 0.3 wt%) and no oligoclase. Instead, they sometimes have dominant Na,Al-rich, fine-grained alteration products. Most of the CAIs are very similar to the inclusions within the Moss CO3 chondrite [6] and other CO3 chondrites [7]. CM chondrite CAIs also have some similarity with the R chondrite CAIs [8]. Distinct similarity also occur with the ordinary and enstatite chondrite CAIs with respect to their relative abundance and mineralogy [4,5]. Almost all of the CAIs, except very few, have suffered severe alteration which may be either due to nebular or parent body processes or a combination of both. As discussed by various authors [9-11] the fine-grained secondary mineral assemblage of nepheline, sodalite, and other phases in many CAIs from carbonaceous chondrites could have formed by decomposition mainly of melilite as a result of reactions with the nebular gas. We also suggest that the Na,Al-(Cl)-rich fine-grained alteration products in R chondrites also formed by nebular alteration due to the replacement mainly of melilite. However, the effect of parent body thermal metamorphism in the alteration process cannot be completely ruled out. The formation of abundant oligoclase within the metamorphosed lithologies, the complete replacement of perovskite by ilmenite, and the high concentrations of ZnO and FeO within the spinels are probably due to additional parent body thermal alteration.

References: [1] Bischoff A. and Srinivasan G. (2003) MAPS 38, 5-12. [2] Berlin J. (2003) Diploma Thesis, Museum für Naturkunde, Berlin, Germany. [3] Russell S. S. (1998) MAPS 33, A131-A132. [4] Bischoff A. and Keil K. (1984) GCA 48, 693-709. [5] Bischoff A. et al. (1984) Meteoritics 19, 193-194. [6] Bischoff A. and Schmale K. (2007) LPSC XXXVIII, abst.#1561. [7] Russell S. S. et al. (1998) GCA 62, 689-714. [8] MacPherson G. J. (1983) GCA 47, 823-839. [9] Allen J.M. et al. (1978) Proc. LPSC IX, 1209-1233. [10] Wark D. A. (1981) LPSC XII, 1145-1147. [11] MacPherson G. J. et al. (1981) Proc. LPSC XII, 1079-1091.

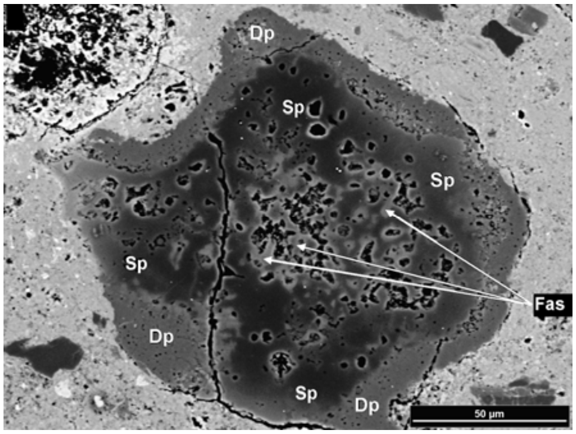

Fig. 1: Inclusion D013/44: Concentric spinel- and fassaite-rich CAI having fassaites (Fas) within the spinel (Sp). A uniform monomineralic diopside (Dp) layer mantles the spinel-rich core; BSE-image.

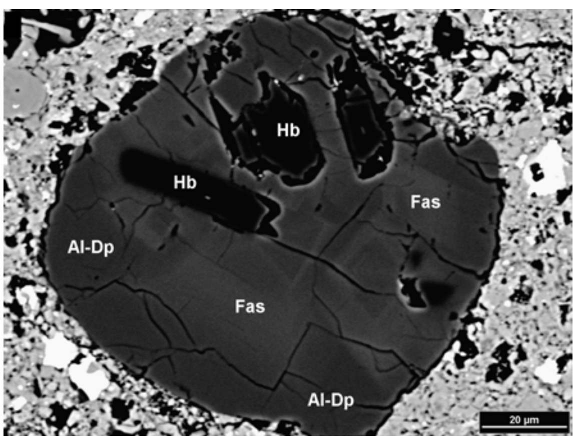

Fig. 3: 1476/124: Fassaite-rich spherule. Laths of hibonite (Hb) are present within a crystalline groundmass consisting of an intergrowth of aluminous-diopside (Al-Dp) and fassaite (Fas); BSE-image.

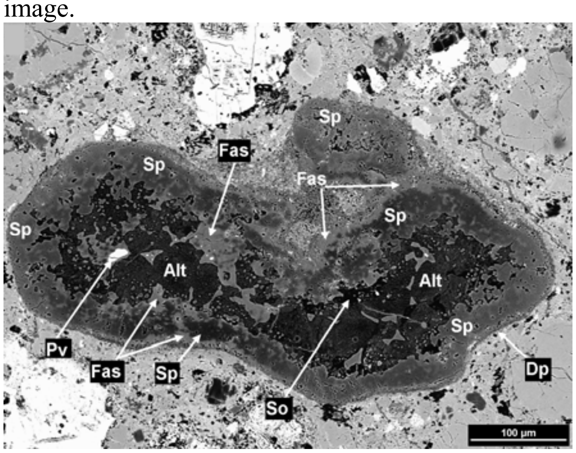

Fig. 5. Inclusion Dfr/53: A complex spinel- and fassaite-rich inclusion with fassaite (Fas) intergrown with spinel (Sp). Abundant fine-grained alteration products (Alt) and some sodalites (So) occur as well

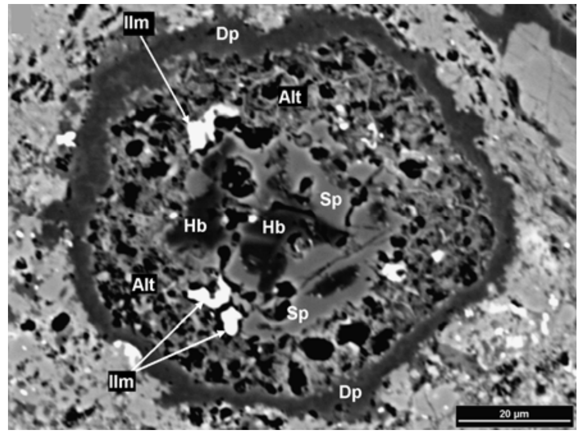

Fig. 2: 2446B/8L: Concentric spinel- and hibonite-rich CAI with abundant alteration products (Alt). Abundant spinel (Sp) overgrows the hibonite (Hb). Minor ilmenite (Ilm) is white. The whole CAI is rimmed by a uniform layer of diopside (Dp); BSE-image.

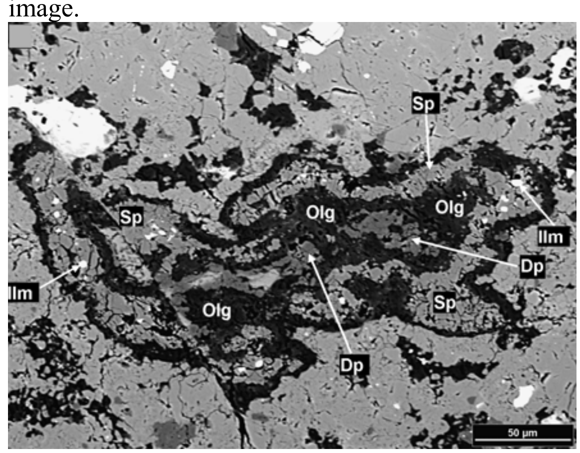

Fig. 4: Inclusion D417/43: Complex spinel- and plagioclase-rich CAI having abundant oligoclase (Olg) and spinel (Sp) along the rim. Minor ilmenites (Ilm) and diopside (Dp) are also present; BSE-image.

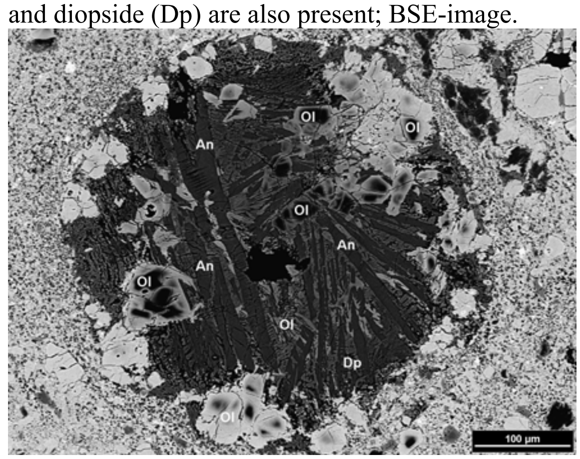

Fig. 6. Object 2446D/71: Al-rich chondrule showing grains of olivine (Ol) within an anorthitic (An) groundmass. Also porphyritic grains of zoned olivine are present within the chondrule. Minor diopside (Dp) also occurs; BSE-image.