The relationship between CK and CV chondrites: a single parent body source?

THE RELATIONSHIP BETWEEN CK AND CV CHONDRITES: A SINGLE PARENT BODY SOURCE?

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Introduction: CK chondrites are highly oxidized meteorites containing abundant magnetite and trace amounts of Fe,Ni-metal [1,2]. The group is dominated by equilibrated meteorites (types 4 to 6), whereas all other carbonaceous chondrite groups contain only unequilibrated material [3]. This is in marked contrast to ordinary chondrites in which equilibrated and unequilibrated meteorites form a continuum within each of the main groups (H,L,LL) [3].

When first described the CK group contained only one type 3 example, namely Ningqiang [1,4]. Subsequently a number of meteorites have been classified as being either CK3 or CK3-anomalous. These often display a close affinity with members of the CV3 oxidized subgroup. CKs and CV3s (ox. subgroup) may therefore form a continuum and by implication could be derived from a single common parent body. This intriguing possibility has led us to look in more detail at the relationship between these two important carbonaceous chondrite groups.

Analytical techniques: Mineral analyses were undertaken on Allende (CV3 ox. subgroup), Vigarano (CV3 reduced Subgroup), Watson 002(CK3), Sleeper Camp 006(CK4), DaG 250(CK4/5), DaG 275(CK4/5) using a Cameca SX-50 WDS microprobe operated at 20kV and 20nA. Oxygen isotope analysis by infrared laser-assisted fluorination [5] was undertaken on the following samples: DaG 055(CK3), DaG 431(CK3-An), Karoonda(CK4), Maralinga(CK4), DaG 250(CK4/5), DaG 275(CK4/5), DaG 1030(CK4/5), NWA 1905(CK5).

Results: *Oxygen isotopes*: The results obtained in this and previous studies are plotted on figure 1. The oxygen isotope composition of equilibrated CK chondrites overlap the CO and CV fields. CK3 and related chondrites display significantly greater variation than the equilibrated CKs. The variation displayed by CK3s is essentially identical to that seen in the CV3s (ox. subgroup).

Magnetite composition: Magnetite is the dominant opaque phase in both CK and CV3 (ox. subgroup) chondrites [3,6]. Data obtained as part of this study is plotted in terms of MgO v. Cr_2O_3 variation on figure 2. This plot has previously been used as a means of discriminating between the CK and CV groups [7]. However, it is clear from figure 2 that variation in Allende magnetites alone is considerably greater than the field labelled "CV" from [7]. In addition, analyses for Watson 002(CK3) fall within the field defined by analyses from Allende CV3 (ox. subgroup). On this basis there appears to be little difference between magnetites in CV3 (ox. subgroup) and CK3s. Magnetites in equilibrated CKs form a relatively tight cluster at the high Cr_2O_3 end of figure 2. This variation presumably reflects the effects of metamorphic recrystallization.

Discussion: *Primary features or metamorphic overprint?* As originally defined [1] CKs have the following characteristic features: (1) they are highly oxidized; (2) have low C contents; (3) very low contents of refractory inclusions; (4) an absence of coarse-grained rims around chondrules; (5) a high groundmass to chondrule ratio; (6) a chondrule size intermediate between the CO and CV groups; (7) refractory lithophile abundances intermediate between CO and CV groups; (8) O-isotope composition overlapping the CO and CV groups.

Many of the above characteristics may not be primary features, but instead represent a later metamorphic overprint. Thus, decreasing C content with increasing grade is a feature seen in both the ordinary [8] and CO chondrites [9]. Refractory inclusions are present in at least some CK4 chondrites [10], their relatively low abundance in higher grade CKs may reflect metamorphic alteration and recrystallisation. CKs have high refractory lithophile abundances [1], indicating that type 3 CKs should contain abundant refractory inclusions (see next section). Coarse-grained chondrule rims are present in many CK chondrites, but due to recrystallisation are less obvious than in the lower grade CV3s. Recrystallisation would also have had an important influence on both measured chondrule size distributions and on the apparent groundmass to chondrule ratio.

Type 3 CK chondrites: Breaking the rules? A number of meteorites have been classified as being either CK3 or CK3-anomalous (Camel Donga 003 [11], Watson 002 [12], DaG 055 [13], Dhofar 015 [14], DaG 431 [15], NWA 772 [16], NWA 1559 [17], NWA 1694 [18]). A further group of samples has been identified as having CK3-like properties i.e. SaU 085 [7], NWA 1665 [19]. These type 3 samples generally do not display the typical CK features discussed previously. Thus, they often contain abundant chondrules and/or refractory inclusions, display distinct coarse-grained chondrule rims and may have oxygen isotope compositions that plot away from other equilibrated members of the CK group (figure1).

Conclusions: *Should CK and CV (ox. subgroup) chondrites be in the same group?* With the identification of increasing numbers of CK-like type 3 samples the distinction between CKs and CV3s (ox. subgroup) appears evermore blurred. Most of the criteria which separate the two groups are explicable in terms of later metamorphic processes, rather than a reflection of more fundamental compositional differences. It is therefore tempting to suggest that rather than representing distinct groups CV3 (ox. subgroup) and CK chondrites may form a continuum in which progressive changes in mineralogical and chemical characteristics are due to post formational metamorphic reprocessing. A situation analogous to that seen in the ordinary chondrites. In order to test this model we are currently carrying out bulk compositional analyses of samples from both groups by ICP-MS. The ultimate goal of this work is to assess whether reprocessing of the CKs and CV3s (ox. subgroup) took place on either a single or multiple parent bodies.

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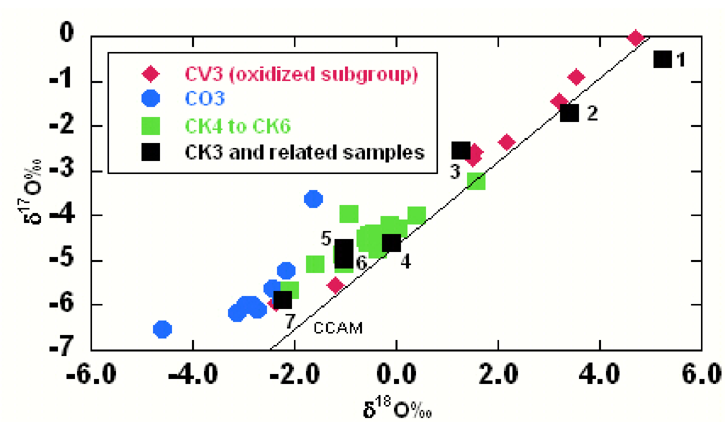

Figure 1. Whole-rock oxygen isotope compositions of CK, CO and CV(ox. subgroup) chondrites. (1) Watson 002, (2) SaU 085, (3) DaG 431, (4) Ningqiang (5) DaG 055, (6) NWA 1665, (7) Dhofar 015; Data: CO3s[9], CV3s(ox. subgroup)[20], CK4-6[20] and this study, CK3s[7,14,19,20,] and this study.

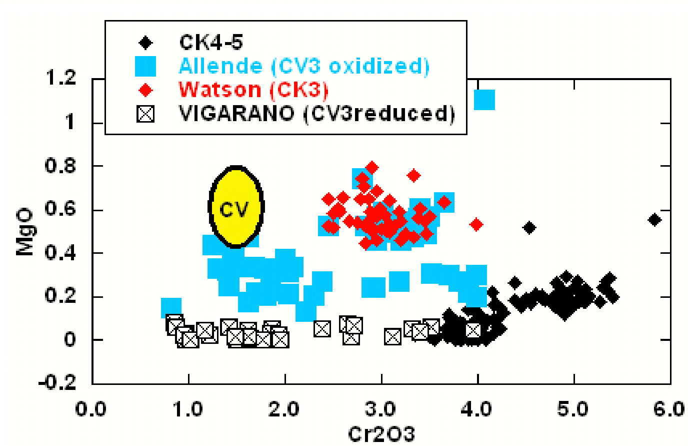

Figure 2. Magnetite conpositions. Field labelled "CV" from [7], all other data thia study.