

XRD-DERIVED MODAL ABUNDANCES OF CK CARBONACEOUS CHONDRITES. T.L. Dunn¹ and A.J. King² ¹Department of Geology, Colby College, Waterville, ME 04901 (tdunn@colby.edu). ²Department of Earth Science, The Natural History Museum, London, England, SW7 5BD.

Introduction: The CK chondrites are one of the most oxidized groups of carbonaceous chondrites, as evidenced by the absence of Fe-Ni metal, high abundances of magnetite and Ni-rich sulfide minerals, and FeO-rich olivine [1,2]. CK chondrites are dominated by olivine, which is present both in the matrix and in chondrules [1,3]. Though estimates of abundances of components in the CK chondrites have been made [e.g., 4,5], no measurements of modal mineral abundances exist. Such data could provide insight into petrogenesis of the CK chondrites, particularly in regards to their possible genetic relationship with the CV chondrites [e.g., 6].

In this study, we measure the modal abundances of eight CK chondrites using a position-sensitive detector X-ray diffraction technique (PSD-XRD). PSD-XRD was first applied to phase quantitation of chondrites by [7,8]. It has since been applied to ordinary chondrites [9,10], CV chondrites [11], CM chondrites [12-14], and most recently, CI chondrites [15]. Provided well-matched standards are available, mineral abundances can be determined with a relative accuracy of ~1% [7].

Methodology: We determined the modal abundances of five unequilibrated (petrologic type 3) and three equilibrated (types 4-6) CK chondrites (Table 1). Because neither of the two CK chondrite falls could be obtained for this study, all samples analyzed here are finds, mostly from Northwest Africa (NWA). Thus, all samples have experienced some degree of terrestrial weathering. According to the Meteoritical Bulletin, Hart and NWA 6047 are the most weathered samples. However, our detailed scanning-electron microscopy work suggests that NWA 5956 has experienced the most extensive terrestrial alteration.

Phase quantification was achieved using a whole-pattern fitting procedure in which the abundances of individual phases are determined by comparing peak intensities of a standard to those in the mixture [16]. Each standard phases is decreased by the appropriate factor and subtracted from the mixture pattern. Patterns were fitted using a set of standards representative of CK chondrite mineralogy: olivine (Fa₀₋₆₀), pyroxene, plagioclase, magnetite, troilite, pentlandite, and iron oxides (limonite and goethite) to represent terrestrial weathering products.

Modal abundances CK chondrites: Olivine abundances range from 65.8 vol% (Hart) to 85.5 vol% (NWA 6047). Average olivine abundances are 75.6 vol%. Most olivine was fitted using the Fa₀ and Fa₂₀ standards, with lesser amounts fitted using the Fa₄₀ and

Table 1. CK chondrites analyzed in this study.

Sample	Petrologic type	Weathering grade	Weathering index
Hart	CK3	W2/3	
NWA 1559	CK3		wi-3
NWA 5343	CK3	W2	
NWA 5956	CK3	W1	
NWA 6047	CK3	W3	
NWA 5515	CK4	W1	
NWA 8672	CK5	W1	
NWA 8670	CK6	W1	

Weathering grade from the Meteoritical Bulletin

Fa₆₀ standards. The next most abundant mineral is pyroxene, with abundances ranging from 4.3 vol% (NWA 6047) to 19.4 vol% (Hart). Pyroxene in Hart was best-fitted using an enstatite standard; all other samples were fitted using a diopside standard. Both low-Ca and high-Ca pyroxene have been observed in CK chondrites. However, [1] analyzed several equilibrated CK chondrites in which only high-Ca pyroxene (diopside and augite) was present. Other minor phases include plagioclase (1.9 – 8.4 vol%), magnetite (2.5 – 7.2 vol%), pentlandite (0 – 5.5 vol%), and troilite (< 2 vol%). NWA 5956 contains 4.3 vol% limonite, while goethite is present in Hart and NWA 6047 at abundances of 7.4 vol% and 0.7 vol%, respectively. Hart also contains 0.4 vol% Fe-Ni metal. Modal abundances of the CK chondrites analyzed in this study are shown in Figure 1.

Modal trends during metamorphism: Mean abundances of plagioclase and pentlandite are higher in the equilibrated CK chondrites than in the unequilibrated CK chondrites. This supports the observation that plagioclase recrystallizes from glass during progressive metamorphism, and is thus not unexpected. The slightly higher mean abundance of pentlandite in the equilibrated CKs may suggest that sulphides are becoming more Ni-rich during metamorphism. However, if this was the case, we would expect to also see a decrease in troilite abundances. Such a decrease was not observed.

Terrestrial alteration of NWA 5956: The type 3 CK chondrites all have very similar modal mineralogies. The only significant difference is that NWA 5956 contains limonite and less magnetite than the others. Terrestrial hydration would account for the low abundance

of magnetite and the presence of limonite, and is consistent with petrographic observations that NWA 5956 is heavily weathered.

Classification of Hart: CK3 chondrite Hart has a unique mineralogy among the samples analyzed (Fig. 1). Abundances of olivine are lower in Hart than in the other samples, while abundances of pyroxene are higher; goethite is present at the expense of magnetite; and, Fe-Ni metal is present rather than pentlandite. While the presence of goethite can be attributed to terrestrial alteration of magnetite (as described in NWA 5956), these other mineralogical differences are likely

indicative of parent body conditions. For example, the lower abundances of magnetite and presence of Fe-Ni metal suggest that Hart formed under different oxidizing conditions than the other samples. The presence of both magnetite and Fe-Ni metal is a characteristic of the CV chondrites [11]. This may suggest that Hart has been misclassified as a CK chondrite and is a CV chondrite instead. The closest mineralogical match for Hart is with the reduced CV chondrites, which do not contain phyllosilicates [11]. This possible misclassification needs to be explored in further detail.

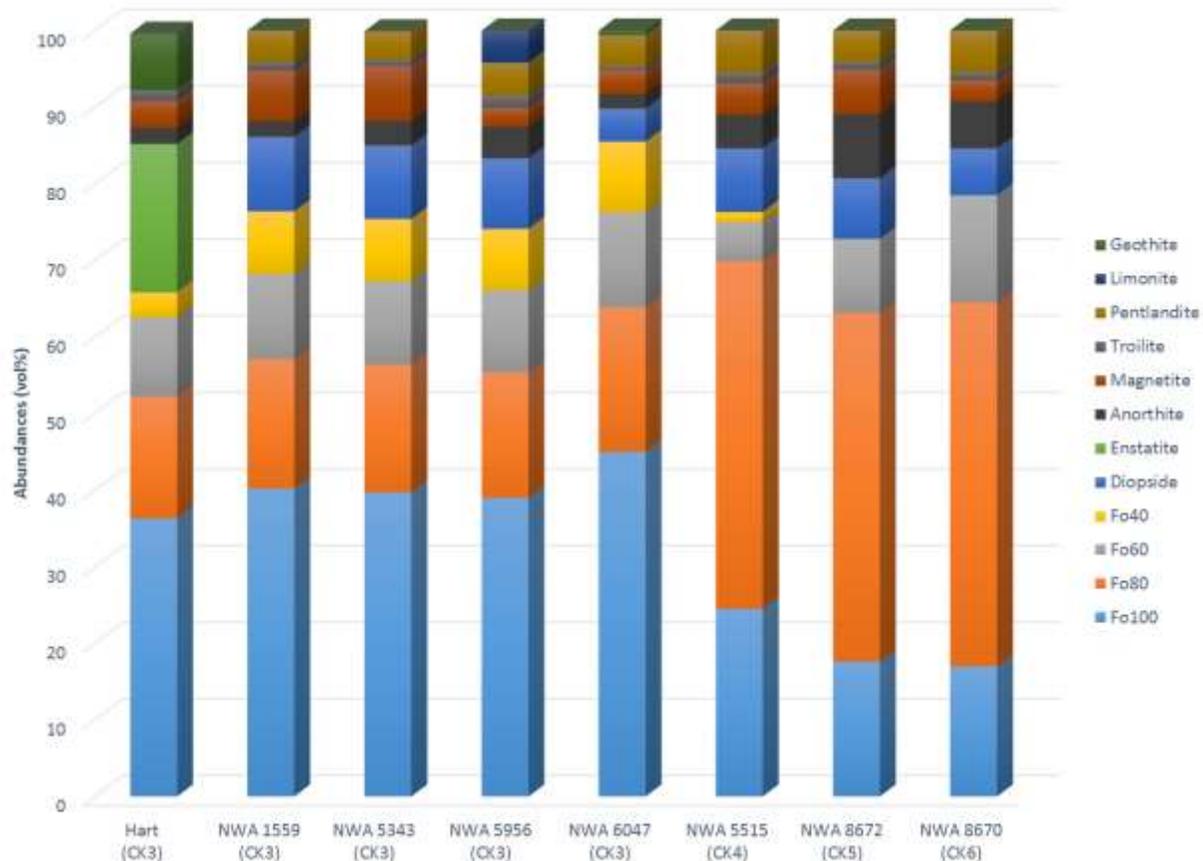


Fig 1. XRD-derived modal abundances of five samples classified as unequilibrated (type 3) CK chondrites and three samples classified as equilibrated (types 4-6) CK chondrites.

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