CHEMICAL AND HF-W ISOTOPIC COMPOSITION OF CV METACHONDRITE NWA 3133

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Introduction: A variety of achondrites with metamorphic textures have been recognized by Irving et al. [1,2] as having genetic affinities to carbonaceous chondrite parent bodies on the basis of oxygen isotopic compositions. These *metachondrites* include examples related to CR, CV and possibly CO chondrites, and it has been further proposed that winonaites and acapulcoites/lodranites bear an analogous relationship to chondritic precursors and/or associated rocks on other parent bodies present in the very early Solar System [3]. It is possible that some metachondrites may be recrystallized equivalents of chondritic protoliths, whereas others may be mantle residues from partial melting on bodies that subsequently accreted chondritic regoliths. We have begun a systematic study of selected examples of these early Solar System materials utilizing bulk chemical data and Hf-W chronology, and here we report the first results on NWA 3133.

CV Metachondrite Northwest Africa 3133: This specimen, discovered and first described in 2004 [4], was the one that led to the recognition of metachondrites, mainly because of the remarkable similarity in its oxygen isotopic composition to those of Allende and other CV3 chondrites. The rock has no chondrules, but has a metamorphic texture with ~120° triple grain junctions (mean grain size 0.28 mm) – see Figures 1 and 2.

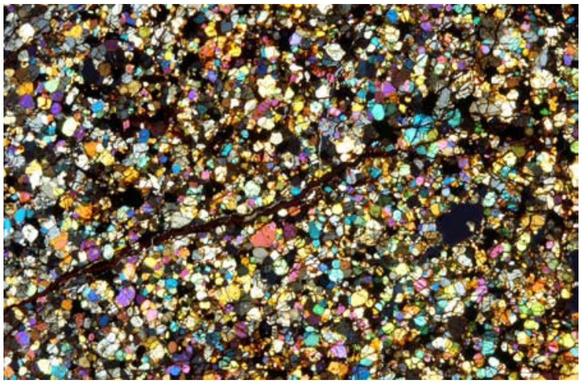

Figure 1. Cross-polarized thin section image (width of field = 10 mm).

It is composed mainly of olivine (46 vol.%; $Fa_{22.2\text{-}22.6}$, FeO/MnO = 56-69) and orthopyroxene (28 vol.%; $Fs_{18.6\text{-}19.2}Wo_{2.8\text{-}2.1}$, FeO/MnO = 38-49), with less amounts of intermediate plagioclase ($An_{50.1\text{-}53.5}Or_{2.3}$), Cr-diopside ($Fs_{7.3\text{-}8.7}Wo_{44.6\text{-}42.2}$, Cr_2O_3 = 0.71 wt.%, FeO/MnO = 21-33), chromite (Cr/(Cr+Al) = 0.73, TiO_2 = 2.6 wt.%), Na-Mg-bearing merrillite, troilite (1-5 wt.% Ni) and Fe-Ni metal (15-20 wt.% Ni). Clinopyroxene, chromite and merrillite are inhomogeneously distributed as relatively large grains.

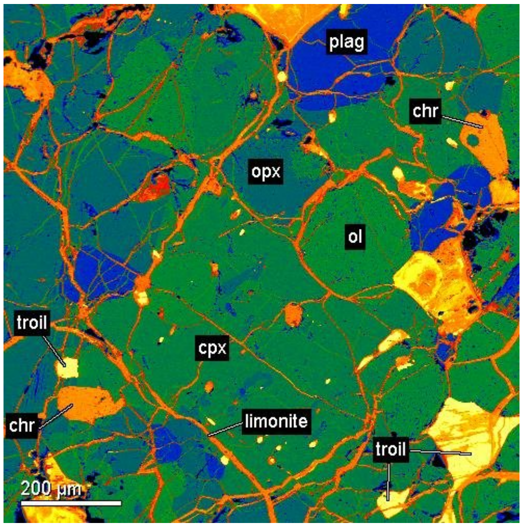

Figure 2. False-color, back-scattered electron image.

Unfortunately, like many metachondrites from Northwest African desert regions, this specimen has moderate but pervasive secondary, terrestrial alteration in the form of iron hydroxides around primary metal grains and along grain boundaries. Despite this, the oxygen isotopic compositions for acid-washed bulk rock ($\Delta^{17}O$ = -3.357, -3.542 per mil), and hand-picked olivine ($\Delta^{17}O$ = -3.844, -4.088, -4.159 per mil) all plot right on the best fit line for bulk CV chondrites [3 – 5].

Bulk Chemical Compositions: The recognition of NWA 3133 and other metachondrites as being potentially related to carbonaceous chondrites came initially from observations of elevated FeO/MnO ratios in olivine and pyroxene and of more calcic plagioclase relative to corresponding phases in ordinary chondrites (including the so-called "Type 7 chondrites"). These mineral compositional traits follow logically from the bulk chemical systematics of these various chondrite groups, notably their Fe/Mn and Ca/Na ratios (see Figure 3).

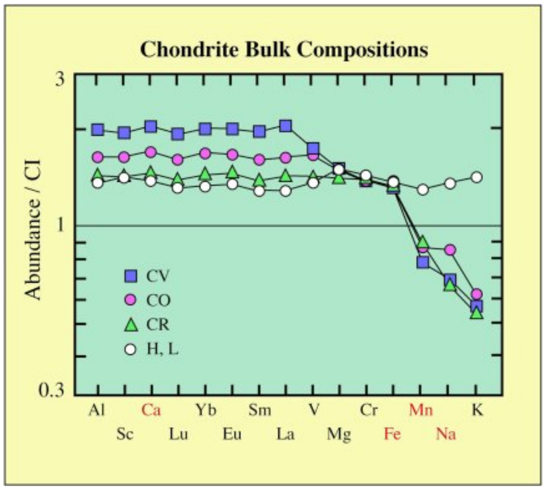

Figure 3. CI-normalized bulk compositions of chondrites (data from [6, 7]).

Replicate bulk chemical analyses of three separate aliquots of NWA 3133 by XRF at University of Cologne (for analytical details see [8]) gave the following mean results (in wt.%): SiO_2 32.80, TiO_2 0.15, Al_2O_3 2.96, Cr_2O_3 0.51, FeO 29.64, MnO 0.20, MgO 22.49, NiO 1.78, CoO 0.07, CaO 2.92, Na_2O 0.49, K_2O 0.07, P_2O_5 0.26, Sum 94.33. As can be seen from Figure 4, the composition of NWA 3133 plots within the field of CV chondrites, thus providing excellent confirmation of the affinity of this specimen based upon oxygen isotopes. Despite the occurrence of terrestrial weathering, the Al/Mg ratio remains essentially unchanged and provides an opportunity to clearly distinguish CV chondrites from other carbonaceous chondrites and ordinary chondrites.

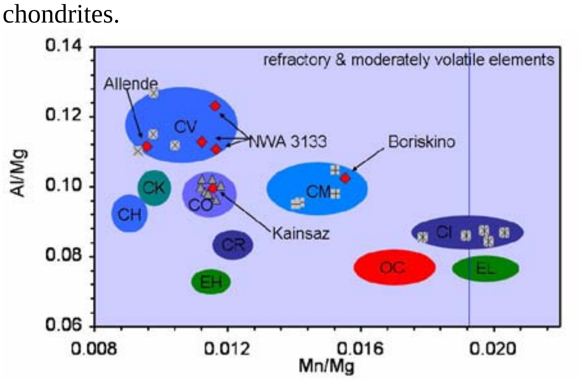

Figure 4. Mn/Mg – Al/Mg correlation plot for chondrite groups. Grey symbols represent data from [9]; colored areas are compiled from data of [9, 10, 11]. NWA 3133 bulk samples plot within the field for CV chondrites. Samples of Allende, Kainsaz and Boriskino were analyzed concurrently.

Hf-W systematics: Hf-W data have been obtained for metal and non-metal fractions as well as one whole-rock sample utilizing methods of [12]. The enrichment of W in the metal (~1.4 ppm W) is similar to that observed in metals from equilibrated ordinary chondrites, indicating W transfer from silicates into metal during metamorphism of NWA 3133. The W isotopic composition of the NWA 3133 metal appears to be slightly more radiogenic than the initial $^{182}W/^{184}W$ of Allende CAIs [13] and is similar to the W isotopic composition of metals from ordinary chondrites [14]. Both Hf/W ratio and W isotopic composition of the NWA 3133 whole-rock [Hf/W=1.23, ε_W=-1.8±0.2; ε_W is the deviation of $^{182}W/^{184}W$ from the terrestrial standard value in parts per 10,000] are indistinguishable from those of Allende [12], providing further evidence for a carbonaceous chondrite bulk composition of NWA 3133. At this stage the Hf-W data do not allow a precise age to be determined but nevertheless indicate metamorphism of NWA 3133 within the first ~10 Myr of the solar system. Further Hf-W analyses are in progress.

References: [1] Irving A. J. et al. (2005) *68th Met. Soc. Mtg.*, #5218. [2] Irving A. J. et al. (2005) *LPS XXXVI*, #2308. [3] Rumble D. et al. (2005) *68th Met. Soc. Mtg.*, #5138. [4] Irving A. J. et al. (2004) *EOS, Trans. AGU*, *85*, #P31C-02. [5] Clayton R. N. and Mayeda T. K. (1999) *GCA*, *63*, 2089-2104. [6] Wasson J. T. and Kallemeyn G. W. (1998) *Phil. Trans. Roy. Soc. London*, *A325*, 535-54. [7] Kallemeyn G. W. et al. (1994) *GCA*, *58*, 2873-2888. [8] Schoenbeck T. et al. (2006) *LPS XXXVII*, this volume. [9] Wolf D. and Palme H. (2001) *MAPS* 36, 559-571. [10] Lodders K. and Fegley B. (1998) *The Planetary Scientist's Companion*, Oxford University Press. [11] Koblitz J. (2005) *MetBase 5.0*. [12] Kleine T. et al. (2004), *GCA*, *68*, 2935-2946. [13] Kleine et al. (2005), *GCA*, *69*, 5801-5815. [14] Kleine et al. (2006), *LPS XXXVII*, this volume.