MODAL MINERALOGY OF CR CHONDRITES BY PSD-XRD: ABUNDANCE OF AMORPHOUS FE-SILICATE.

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Introduction: Position Sensitive Detector X-ray Diffraction (PSD-XRD) allows us to quantify the mineralogy of bulk CR chondrite powders down to the nano-scale for all phases >1wt%.

Samples and method: We studied 7 CRs. Weathering complicates interpretations in 3 finds, so we report on: GRO 03116; GRA 06100; MET 00426 and Al Rais (fall). Data were collected by PSD-XRD and quantified using a pattern stripping technique [2]. Here each mode is for an 80mg sample, < in [2]. Cu radiation induces Fe- fluorescence that is used to quantify the Fe-rich amorphous component [2]. XRD data were crosschecked using Co radiation. Average values are reported in volume %.

Results and discussion: Olivine (35%) and pyroxene (40%) exist in nearly equal volumes in all samples. In samples like MET 00426, these phases show no evidence for peak broadening in XRD patterns: a common feature of even minor aqueous alteration. Our total anhydrous silicate (ol+pyx) abundance (75%) is less than reported in petrographic studies (85-95%) [3,4]. XRD shows CRs typically contain 3-4% metal, 1-2% magnetite and rare carbonate (<1%). Al Rais has a distinct mineralogy reflecting a greater volume of dark inclusions [3] and more advanced aqueous alteration, it contains abundant magnetite (17%) and only rare metal. XRD patterns for Al Rais show obvious diffraction peaks from crystalline serpentine (20%). All other samples show no evidence for diffraction from phyllosilicate, indicating it is not present in well crystalline form. Transmission Electron Microscopy (TEM) also shows only rare nano-crystalline phyllosilicate in MET 00426 [1]; if this contributed significantly (>1%) to the bulk composition, XRD would resolve it in broad reflections.

Meteorite dark matter: Subtraction of crystalline phases in pattern fitting reveals large residual X-ray counts in all samples but Al Rais. These residual counts are fluorescence from Fe-rich X-ray amorphous material, typically: FeNiS, Fe_xO_x, FeOOH(±$_xH_2O$) and potentially also Fe,Mg phyllosilicates. Modelling the residual component in XRD patterns, using background intensities [2] of these phases, fails to account for the required counts or requires unrealistic abundances ruled out by mass balance calculations. TEM shows that amorphous Fe-silicate is common in the matrices of MET 00426 and QUE 99177 (CR) [1]. Modelling the XRD residuals with large volumes (≤15%) of this amorphous Fe-silicate [1] and less FeNiS (5-10%) and Fe_xO_x/FeOOH(±$_xH_2O$) (≤10%) yields good agreements with bulk compositions. Petrographic studies counting amorphous material as silicate also explains discrepancies with XRD estimates of total silicate volume.

Conclusion: Amorphous Fe-silicate can be a significant component of CRs. It appears to be destroyed by the progression of aqueous alteration, hence its absence in Al Rais. The question remains: is it a pristine product of the solar nebular [1], or a proto-alteration product of early stage parent body processing?

References: [1] Abreu N.M and Brearely A. J. 2010. *GCA* **74**: 1146-1171. [2] Howard K.T. et al. 2010. *GCA* **74**: 5084-5097 [3] Weisberg M. K. et al. 1993. *GCA* **57**: 1567-1586. [4] Schrader D. L. et al. 2011. *GCA* **75**: 308-325.