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Textural characterization of iron rich-phases in H-ordinary chondrites: A new parameter to quantify the thermal metamorphism and constrain the thermal history of the parent body

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Introduction: Ordinary chondrites represent the dominant group of stony meteorites. Among them, H-chondrites are inferred to come from a single parent body, accreted early in the history of the solar system. This class of iron-rich meteorites is subdivided into petrological types, inferred to reflect maximum temperatures reached during "thermal metamorphism", from unequilibrated H3s to the most equilibrated H6-7s. This subdivision may be related to the heating of the parent body by short-lived radioactive elements such as 26Al and/or 60Fe, (T1/2=700 ky and 1.5 Ma respectively). Within the framework of this idea, H3s would come from external regions of the parent body, and H6-7s from closer to the centre. The petrological classification is principally based on the chemistry of the silicate and iron rich-phases, while textural properties, in particular of opaque iron-rich phases, have received much less attention. We have therefore studied textures of iron-rich phases in 7 H-chondrites (one H4, three H5s and three H6s) in order to highlight and quantify the link between textures and thermal history of the parent body.

Results and discussion: In each sample the proportion of each phase has been quantified. Furthermore, various textural characteristics have been quantified: i) the length of contacts between FeNi and FeS, ii) the dihedral angle between iron rich phases and silicates, iii) the shape (circularity) and iv) Crystal Size Distribution (CSD) of FeNi and FeS. As expected, proportions of Kamacite-Taenite and troilite are constant from H4 to H6s, confirming that the system is closed, without metal/silicate segregation. The value of the dihedral angle does not evolve with metamorphic grade and has a value of $\sim$135°, typical for equilibrated textures. On the other hand, increasing metamorphic grade leads to a decrease in the length of metal-sulphur contacts, an increase in grain circularity, and an increase in average grain size. Variations in these parameters are always in the same order for the samples studied: Forest Vale (H4), Richardton (H5), Forest City (H5), Mishoff (H5), Kernouvé (H6), Guareña (H6) and Estacado (H6), consistent with an onion-shell structure of the parent body.

We also note that the evolution of textural parameters is identical for metal (Kamacite-Taenite) and sulphide (Troilite) suggesting that the processes which govern these variations act in an identical way for both phases. Correlations between textural parameters show that there is a thermal threshold below/above which one parameter becomes more/less efficient that another. Coupled with thermal models of the parent body assuming internal heating by Al26, it has been possible to use experimental grain growth laws to estimate the mechanisms for the grain growth of metal in this type of body.

Finally, we have also characterized two primitive achondrites (Acapulco and Lodran) for which partial melting occurred (respectively 1-5% and $\sim$20%). Although proportions of FeNi and FeS are not the same that those in H-chondrites all parameters evolve in the same way as before, but with more extreme variations, consistent with higher temperature and/or the presence of silicate melts.