AQUEOUS ALTERATION IN THE UNEQUILIBRATED H/L ORDINARY CHONDRITE TIESCHITZ.

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Introduction: The Tieschitz meteorite fall occurred on 15 July 1878 in Czech Republic and represented the first H/L chondrite known with a TKM of 28 kg [1]. Nonetheless, mineralogic, textural and compositional analyses are still being carried out today in the laboratory, because few H/L chondrites exist in meteorite collections. Tieschitz is of petrologic subtype 3.6 [1]. Its unique texture shows evidence of elemental redistribution associated with aqueous alteration, which encouraged us to perform additional petrographic studies. Our thin section has a significant micro- and macroporosity, and consists mainly of rounded and subrounded chondrules ranging from ~20 μm to 2 mm, most of them surrounded by rims either of kamacite-troilite, igneous silicates, or both, and a fine-grained matrix of two types: black matrix and white matrix [2,3]. The chondrule-matrix ratio is high, having about ~80% of chondrules. The meteorite is composed of a rich variety of chondrule types. We have studied these different chondrule types using petrographic microscopy and SEM in order to find evidence of aqueous alteration inside the chondrules. Previous studies have already documented the effects of aqueous fluids on Tieschitz [4,5], revealing the presence of water during the metamorphic evolution of the meteorite [6]. To gain additional insights into the formation scenario, we have examined the mineralogy and textures of the four major components of Tieschitz: chondrules, matrix, sulphides and metals.

Analytical techniques: Two thin sections of Tieschitz provided by the Natural History Museum, Vienna were studied. A high-resolution mosaic of one thin section was created from separate 50X images taken with a Zeiss Scope petrographic microscope in reflected light. The mosaic allowed us to identify areas of interest for detailed characterization by SEM/EDX analyses (analytical uncertainty for most elemental abundances are about ~ 1%).

Results and Discussion: Chondrules have a wide variety of textures, predominantly barred olivines (BO), radial pyroxenes (RP), and porphyritic pyroxene-olivine (POP) chondrules. Porphyritic chondrules typically have igneous and kamacite-sulphide rims (Fig. 1). Moreover, some chondrules have high-Ca pyroxene quench crystals embedded in a glassy phase rich in Al and Na. This is shown in Fig. 2, where the devitrified chondrule glass surrounds elongate euhedral crystals. On the other hand, other chondrules contain pores due to leaching of the chondrule glass, which migrated to form the white matrix. Thus, this meteorite contains two distinct types of fine-grained matrix as viewed by optical microscopy in plane polarized light: back and white matrices [6]. Using SEM/EDX we find that the white matrix contains a silicate rich in Al, Na, Ca and also low concentrations of P, but it does not have a uniform composition and the relative proportions of phases are not known for the bulk matrix [5]. The black matrix contains a high content of an FeO-bearing silicate, together with small amounts of Al, Ca and Na. White matrix occurs only rarely in OCs [e.g., 7] and has been interpreted as a component of chondrules which was leached out and redeposited by a halogen-bearing aqueous fluid [2,5]. In Fig. 3 we show the enrichment of Na and Al in the white matrix occurring interstitial to chondrules and filling most spaces between them [5].

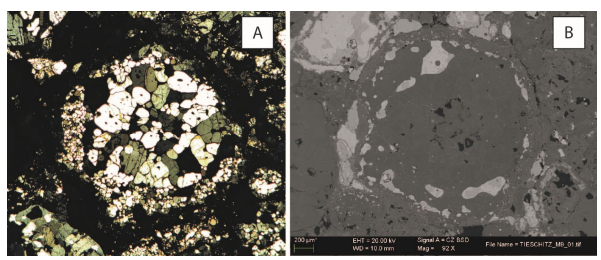

Fig. 1. Example of a porphyritic chondrule with a surrounding kamacite-sulphide rims in the Tieschitz meteorite. **A** is an optical microscope image using plane polarized light, and **B** is a BSE-SEM image.

Using SEM and EDX analyses we characterized the different metals and sulphides found. These grains have irregular shapes and metal-troilite phases are often associated, forming chondrule rims but also as inclusions in the matrix and inside chondrules. The Ni

content in FeNi metal varies between 3.0 to 7.8 wt%. We did not find any kind of alteration in them.

Conclusions: We have examined a thin section of the Tieschitz meteorite in order to find additional insights into the metamorphic and hydrothermal activity at work during the evolution of its parent body. At present, our observations are generally consistent with those of previous studies [5,6]. However, we have not observed the development of amphiboles, reported by [6], suggesting that their occurrence could be localized within certain regions of the meteorite. Our observations support the hypothesis that white matrix has a leachable component produced by interaction of the host rock with an aqueous fluid, resulting in the transport of Al and Na and silica, from the chondrules to the margins, filling interchondrule spaces. Voids are abundant and resulted from that leaching of primary chondrule glass [8] causing a redistribution of the elements [5]. Other techniques like Raman spectroscopy and EPMA should be carried out in order to complete the SEM/EDX results. The Tieschitz meteorite records the processes occurred in its parent body involving aqueous activity, which encourage us to keep investigating the origin of H/L chondrites, including the new Cali fall [9].

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References: [1] Sears, S. W. et al. (1980) *Nature, 287*, 791-795. [2] Christophe-Michel-Levy, M. (1976) *Earth & Planet. Sci. Lett., 30,* 143-150. [3] Ashworth, J. R. (1981) *Royal Soc. London Proceed. Series A374,* 179-194. [4] Kurat, G. (1970) *Earth. & Planet. Sci. Lett. 7*, 317-324. [5] Hutchison, R. et al. (1998) *MAPS 33,* 1169-1179 [6] Dobrică, E. and Brearley A. J. (2014) *MAPS 49*, 1323-1349. [7] Alexander, C. M. O'D. et al. (1989) *Earth and Planet. Sci. Lett., 95*, 187-207. [8] Brearley, A. J. and Krot, A. N. (2013) Lecture Notes in *Earth Sciences Series*, Ed. Dan Harlov and Håkon Austrheim, Springer Verlag, 653-782. [9] Trigo-Rodríguez J. et al. (2009) MAPS 44, 211-220.

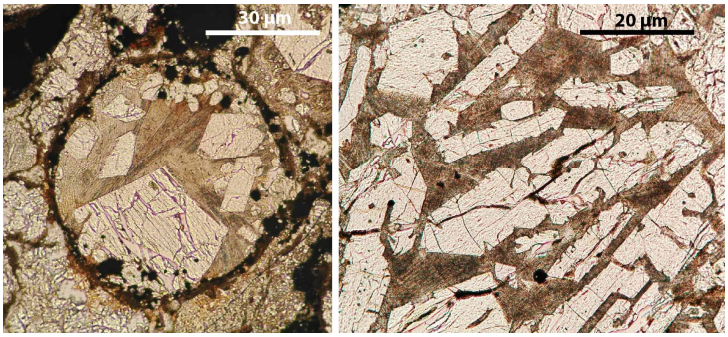

Fig. 2. Petrographic microscopy images with plane polarized light showing devitrified chondrule glass.

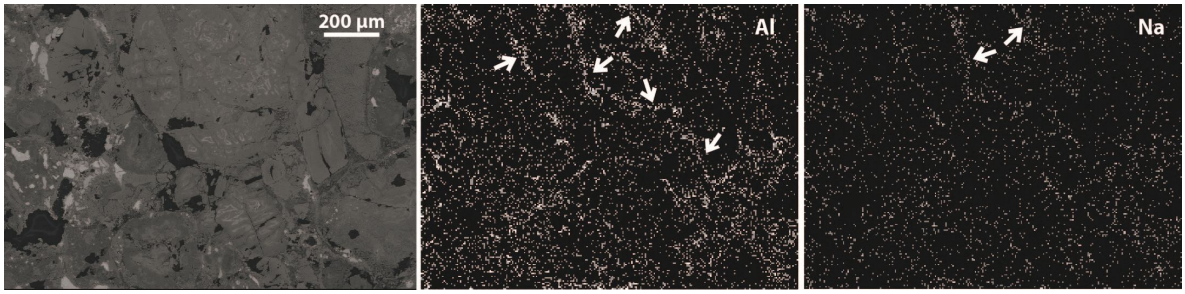

Fig 3. Back-scattered electron image and two elemental distribution X-ray maps (Al and Na) of a region of interest in Tieschitz showing that these elements are defining the white matrix that fills interstitial spaces between chondrules.