DOCUMENTING THE MORPHOLOGICAL AND CHEMICAL EFFECTS OF MELT IMPREGNATION OF IRON SULFIDES INTO DUNITE: A TOOL FOR METEORITICS AND SHOCK METAMORPHISM.

J. Moreau[1], A. Jõeleht[1], C. Hamann[2], F. E. D. Kaufmann[2], P. Somelar[1], J. Plado[1], A. N. Stojic[3], S. Hietala[4], T. Kohout[5,6] [1]Department of Geology, University of Tartu (Ravila 14A, 50411, Tartu, Estonia, juulia.moreau@ut.ee), [2]Museum für Naturkunde, Leibniz-Institut für Evolutions- und Biodiversitätsforschung, Berlin, Germany, [3]Institut für Planetologie, Westfälische - Wilhelms Universität Münster, Germany, [4]Geological Survey of Finland, [5]Department of Geography and Geosciences, University of Helsinki, Finland, [6]Institute of Geology, The Czech Academy of Sciences, Czech Republic.

Introduction & Methods: We investigated the element fractionation of the sulfide mineral phase upon melt formation and its re-distribution within a silicate host rock during thermal exposure. Sulfide melt migration is responsible for a phenomenon termed shock-darkening (e.g., [1,2,3]) and the study material is an experimental analog to improve our understanding of pervasive shock melting processes of Fe-sulfides and metals in chondrites. Thereupon, we doped dunite rock fragments with synthetic troilite (FeS [4]) and heated them in a N_2(g) atmosphere at 1325°C for 60 min (Fig. 1, samples T601-2, T603-1, T603-3) or 120 minutes (Fig. 1, sample T1202-2). The interaction between Fe-sulfides and Mg-rich silicates during thermal exposure was examined closely by x-ray fluorescence (µ-XRF, Bruker S8 Tiger, Museum für Naturkunde) and electron microprobe analysis (EPMA, JEOL JXA-8500F, Museum für Naturkunde).

Results: The µ-XRF fluorescence data maps in Fig. 1a and 1b provide a comparison between the doped run products (Fig. 1b) with the light and shock-darkened lithologies of the Chelyabinsk LL5 chondrite (Fig 1a) and dunite (Fig. 1b). We observed that the sulfide phase migrated along pre-existing cracks in the host rock and darkened the lithology, comparable to what is observed in Fig. 1a (Chelyabinsk - dark [1]). EMPA analyses show that i) troilite was depleted in Fe, whereas olivine adjacent to cracks was enriched (Fig. 1c, Fe), ii) Ni was depleted from dunitic olivine and enriched troilite veins adjacent to olivine (Fig. 1c, Ni), and iii) troilite was enriched in Cr from dunitic Cr-spinel during migration and in turn enriched olivine in contact with troilite veins (Fig. 1c, Cr). Ni metals presumably fractionated and solidified from the Ni-enriched sulfide melt [5] during migration, clogged various cracks, and terminated the melt migration. Fluorescence effects from EPMA analyses were ruled out because adjacent olivine to troilite-emptied cracks still showed the typical Fe enrichment (Fig. 1c, Fe).

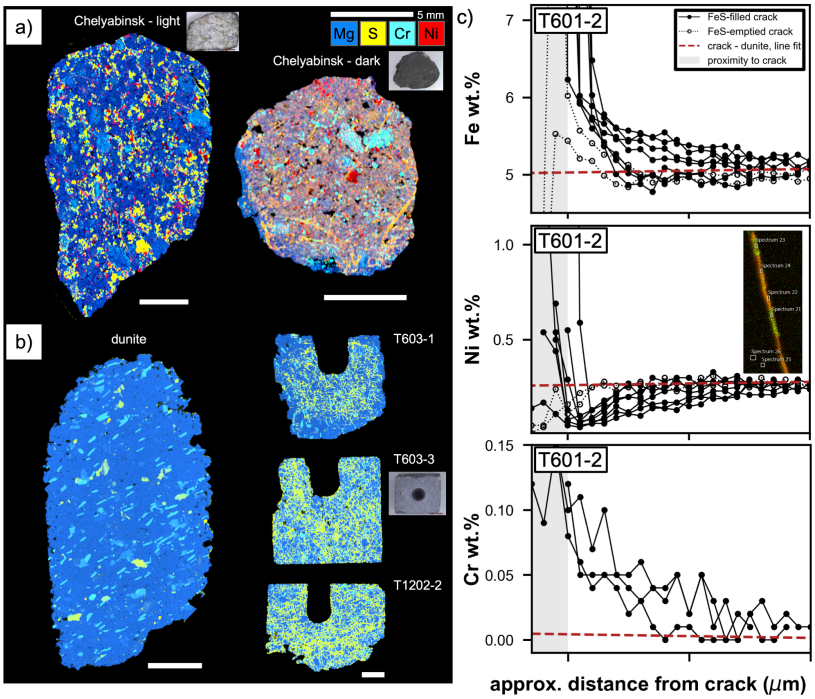

Fig. 1. a,b) µ-XRF elemental maps for a) Chelyabinsk LL5 meteorite slabs and b) for natural dunite and troilite-impregnated dunite heated at 1325°C for 1 hour (T601-2; T603-1,3) and 2 hours (T1202-2) in nitrogen atmosphere; c) electron microprobe analyses of iron, nickel, and chromium oxides at contact between troilite-filled cracks and olivine from a doped dunite sample (T601-2). In c), some cracks were emptied from troilite during migration (empty circles), and the red baseline is a linear fit of concentrations in elements about similar cracks in natural dunite. Scale bars width for a,b) is given at the top right corner. Picture inserts in a,b) are selected snapshots of the original samples of the corresponding thin sections,; rightmost snapshots document on the darkening effect by iron sulfide melt migration. Insert in c) is 30 microns across and shows a composite FeS-FeNi vein (S: orange, Ni: green) in sample T1202-2 analyzed with

Our observations hold valuable information about shock melting processes and related sulfide and FeNi metal fractionation within chondrites.

References: [1] Kohout T. et al. (2014), *Icarus*, 228:78-85. [2] Moreau J. et al. (2019), *Icarus*, 332:50-65. [3] Moreau J. and Schwinger S. (2021), *Physics of the Earth and Planetary Interiors*, 310:106630. [4] Moreau J. et al. (2021) *Meteoritics & Planetary Science*, 57(3):588-602. [5] Mare E. R. et al. (2014), Meteoritics and Planetary Science, 49:636-651.