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The Record of Thermal and Shock Metamorphism in Selected H Chondrites

Jakub HALODA and Patricie TÝCOVÁ

Department of geochemistry, Faculty of Science, Charles University, Prague, Albertov 6, 12843, Czech Republic

Chondritic meteorites of H chemical class belong to an ordinary chondrite compositional group. They represent chemically primitive and less modified material formed by condensation from a cooling solar nebula, occurring about 4.5 billion years ago. H chondrites originated in the surroundings of protoplanets by agglomeration of small bodies of chondritic composition. Furthermore, these parent-bodies experienced the processes of thermal metamorphism. The heat source was probably the decay of short-lived radionuclides (²⁶Al, ⁵³Fe). The experienced metamorphic P-T conditions were 300–950 °C and less than 1.5 kbar, related to the stratification and size of the parent-body (200–400 km in diameter). It is possible to simulate the P-T conditions of formation and to estimate the physical properties of parent-bodies by studying the metamorphic record affecting distinct H chondrites

Chemical classification of ordinary chondrites is based on the oxidation state (the presence of Fe in silicates). Petrological classification is defined by grades of metamorphism in chondrites (type 3–6) based on observable textural and mineralogical changes (from the individual mineral grains and chondrule recrystallization, chemical and mineralogical equilibration of primary components, devitrification and recrystallization of glass to form feldspar (> 500 °C), chondrule-matrix integration, to partial melting and formation of primitive achondrites). Mineral assemblage of H chondrites contains silicate minerals (cpx, opx, ol, plg and glass), reduced metal (the Fe-Ni alloy) and sulphides (troilite – FeS). Present accessory minerals are chromite, chlorapatite and merrillite.

The effects of thermal metamorphism were studied on three selected H chondrite samples of distinct petrological type, after the accomplishment of classification: 1) H3 chondrite from the Libyan desert, less affected, 2) H4 chondrite of unknown origin, 3) observed fall – Morávka (H5) meteorite (Fig. 1). The polished sections were made and studied using optical and elec-

tron microscopy. All chemical analyses were obtained using electron microprobe CamScan S4 with EDX analytical system Link ISIS 300 (Laboratory of electron microanalysis, Faculty of Science, Charles University in Prague) and the data were processed by the ZAF method. Structural identification of several phases was realized by measuring on the FTIR spectrometer Magna-IR 760 E.S.P. (Laboratory of specialized polymers, Faculty of Science). The record of thermal metamorphism was stud-

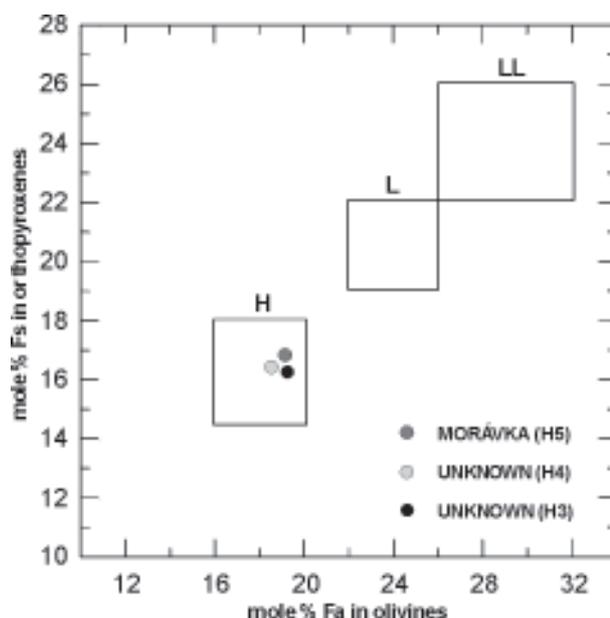


Fig. 1. Classification diagram for ordinary chondrites of Baily & Jones (1998), with the three studied samples falling in the field of H chondrites.

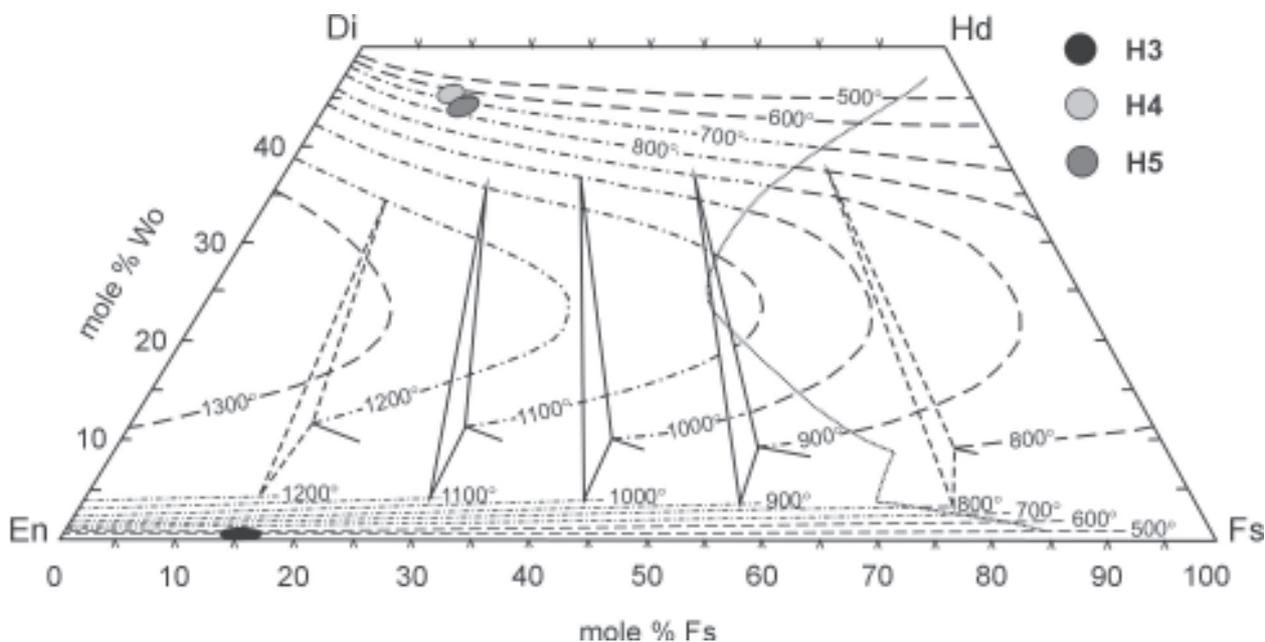


Fig. 2. Diagram showing the polythermal pyroxene phase relations at 1 atm, contoured at 100 °C intervals for use in geothermometry (Lindsley, 1983) with compositions of low-Ca pyroxenes and high-Ca pyroxenes from the H3, H4 and H5 chondrites. The resultant temperature < 500 °C, 650 ± 50 °C and 730 ± 50 °C corresponds to the metamorphic conditions for chondrites of petrologic type 3, 4 and 5.

ied under optical microscope on the basis of mineral assemblage relations, the degree of chondrule recrystallization and the presence of glass. We have determined the metamorphic conditions using the two-pyroxene thermometry by Lindsley (1983). The exact microprobe analyses of clinopyroxene were made (total 99.9–100.15 wt%) using exposition time 300 sec. and calibration on corresponding standards. The obtained metamorphic temperatures correspond to the observed degree of phase equilibration and recrystallization in the order of H3 (less than 500 °C) < H4 (650 ± 50 °C) < H5 (730 ± 50 °C). Compared temperatures indicate the progressive metamorphism with the increasing petrological type (Fig. 2).

Parent bodies have experienced the fragmentation processes as a result of impact events. These impacts caused the shock effect resulting in chondrite metamorphism (shock pressures 5–90 GPa). The degree of shock metamorphism (the shock stages S1 - S6 respectively) is characterized by the microstructural effects in olivine and plagioclase. The presence of PDF's and undulatory extinction in olivine indicate the shock level S3 in studied H4 sample (Stöffler et al., 1991).

The observed characteristics and measured data from the selected H chondrites correspond to the present-day models of metamorphic P-T conditions of their parent-bodies. Convenient is the concept of the "onion shell" model of concentric layered body where the degree of metamorphism is related to burial depth. This model is based on the metallographic cooling rate of minerals (Ganguly and Tirone, 2001). From the micro-

structural features observed in olivine we suggest the shock pressures of the H4 chondrite to be 15–20 GPa, similar pressures occur in the Earth's upper mantle.

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