

Bulk composition of the Kaba meteorite by ICP OES and ICP MS

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The Kaba fell on 15th of April 1857, at the vicinity of Kaba village, in Bihar county, Hungary. Kaba, which is the least metamorphosed meteorite, belongs to the oxidized subgroup of the CV3 carbonaceous chondrite class (McSween 1977, Peck 1984, Bonal et al. 2006, Rubin 2012). The first chemical analysis of the meteorite was performed by a German chemist Friedrich Wöhler, in 1858 (Wöhler 1858, 1859). The first modern geological study was done by Sztrókay et al. in 1961 (Sztrókay et al. 1961). He and his co-authors obtained the mineral composition and the major and minor element concentrations of the bulk. Since then more than hundred scientific papers dealt with the mineralogical, physical and chemical properties of the meteorite, including the compositional analysis of the bulk or certain components (chondrules, CAIs, matrix), and if we consider the number of scientific papers published in the last ten years in this topic, we can conclude that the scientific interest has not decreased yet. The aim of this presentation is to confirm the results of previous chemical analysis based on the analysis of a new sample obtained from Kaba, furthermore to perform trace elemental analysis of the studied sample using highly sensitive analytical techniques.

A black, irregular chip of 0.1197 g showing no visible internal structure was used for the digestion. The sample was gradually dissolved in different acid mixtures for subsequent atomic spectrometric studies. M1 solution: the sample was dissolved in 2 ml concentrated analytical grade nitric acid. M2 solution: the solid residue was further dissolved in aqua regia and 0.5 ml concentrated hydrogen fluoride. M3 solution: the residue was further digested in a closed Teflon vessel with the aid of microwave digestion, in the presence of 2 ml concentrated hydrochloric acid, 1 ml concentrated nitric acid and 0.5 ml 40 percent hydrogen fluoride using microwave digestion system (Milestone Ethos Up microwave digestion system equipped with SK15 rotor). Finally, the remaining sample had been almost completely dissolved, except the 2 mass percent residue that is supposed to be carbon powder. During the analysis analyte-free blank samples (reagent blank) also have been prepared and measured. The result values obtained during analyses of the samples were corrected by the average values of the reagent blanks.

The major components of the meteorite were measured using Thermo Scientific iCAP 6300 Dual view inductively coupled plasma optical emission spectrometer (ICP-OES). Trace element analysis was carried out using a high sensitivity Thermo Scientific X-Series II inductively coupled plasma mass spectrometer (ICP-MS).

After the treatment with concentrated nitric acid, 42 mass percent of the sample had been dissolved (M1 fraction). Other 45 mass percent were dissolved after the subsequent treatment with the mixture of nitric acid, hydrochloric acid and hydrogen fluoride under atmospheric pressure (M2 fraction), the remaining part was digested in the same mixture of nitric acid, hydrochloric acid and hydrogen fluoride by microwave assisted digestion in a closed vessel (M3 fraction).

Following the concentrated nitric acid treatment all sulfides, some oxide minerals and probably a part of the glass had been dissolved. Larger part of REEs also were connected to these mineral phases. Silicon was leached into M2 samples only, when the silicates and the remnant glass were in soluble fluoro-silicate complex form. The elements determined in the sample M2, probably were connected to the silicate minerals and/or glass. The presence of major elements (e.g. Al, Mg, Fe) in the M3 fraction supports the occurrence of Mg-Al and Fe-Al mixed oxides (spinel group) (sample M3). The major elements of the meteorite sample are in the concentration range between 1 and 30 mass percent. Some other elements, such as Na, Cr, Mn, K, Ti, Co and Zn are presented in the concentration range of tenth or hundredth mass percent. Further 37 elements can be found in ppm or ppb range, and 10 of the studied elements are below the limit of detection of the applied instrumental techniques.

Though the results show quite diverse chemical composition, the concentrations of the major elements show good agreement with the elemental constituents of main mineral phases determined by Sztrókay et al. (1961). Good correspondence can be observed between the literature and the new results in the case of Al, S, Ca, Ni, Mn, Co, Zn and Cu, while Fe, Mg, Na, Ti, Cr, K, Sr, and As show poor agreement. Sequential digestion indicates that Ni, Cu, Hg and Fe in part are close connection with sulphide minerals. Na and K may come from smectite minerals, while Ca, Al, Mg, Cr and Ti are related to oxides and silicates, too. Relatively high Ag concentration requires further investigation, however, SNMS analysis carried out on thin section also showed relatively high Ag concentration (Takács et al. 2018). LREE, Tb and Tm indicate 4-5 fold enrichment compared to CI chondrites, however, other HREE show good agreement with other CVs. The abundance pattern of REEs may be caused by

volatility differences between REEs, especially in the case of Tb and Tm, however preferential concentration of LREEs in certain minerals (such as feldspar, perovskite), compared to the matrix also could play important role.

Based on major, trace and rare earth element distribution of Kaba it seems more likely that the smaller chips may not be representative for the whole bulk, however it may provide valuable information about the chemical and mineralogical composition of certain textural components (e.g. matrix, mineral fragments, etc).

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