MODAL COMPOSITION OF JEZERSKO CHONDRITE. CONTRIBUTION OF MINERALS TO THE BULK COMPOSITION. M. A. Szurgot, Lodz University of Technology, Center of Mathematics and Physics, Al. Politechniki 11, 90 924 Lodz, Poland (mszurgot@p.lodz.pl).

Introduction: Quantitative data on elemental and mineral composition of meteorites, relative abundance of constituent minerals, their density and porosity enable ones to estimate physical properties of meteorites and their parent bodies. Mineralogy, petrology and selected physical properties of Jezersko chondrite (H4, S2(3), W2, find in 1992 in Slovenia) have been studied [1-5]. The aim of the study was to determine modal composition of the Jezersko meteorite, verify its bulk composition, mean atomic weight, and grain density, and to predict contribution of elements present in minerals to the global elemental content of the meteorite.

Methods: Literature data on elemental composition of the Jezersko meteorite, and composition of minerals [1], and trial and error method have been used to determine relative abundance of minerals in the chondrite, and contribution of minerals to the bulk composition. To calculate mean atomic weight *Amean*, and grain density *dgrain* of the meteorite the following formulas have been used:

$$Amean = \sum wi/\sum(wi/Ai), \quad (1)$$
$$dgrain = \sum wi/\sum(wi/di), \quad (2)$$

where *wi*(wt %) is the mass fraction of i*th* mineral, *Ai* is the atomic weight, and *di* is the grain density of i*th* constituent mineral. Experimental data on composition of Jezersko's ten minerals: olivine ($Fo_{80.6}Fa_{19.4}$), orthopyroxene ($En_{82.1}Fs_{16.7}Wo_{1.2}$), clinopyroxene ($En_{48.2}Fs_6Wo_{45.8}$), plagioclase ($Ab_{83}An_{11}Or_6$), troilite (FeS), kamacite ($Fe_{92.8}Ni_{6.6}Co_{0.6}$), taenite ($Fe_{69.2}Ni_{30.7}Co_{0.1}$), chromite ($FeCr_2O_4$), ilmenite ($FeTiO_3$), and merrillite ($Ca_{18}Na_2Mg_2(PO_4)_{14}$) have been used [1].

Results: Our data indicate that Jezersko chondrite consists of the following minerals (wt %): olivine 30%, orthopyroxene 28%, clinopyroxene 8%, plagioclase 10%, troilite 4.1%, kamacite 10%, taenite 8.4%, chromite 0.8%, ilmenite 0.2%, and merrillite 0.5%.

Modal composition of Jezersko expressed in volume %: olivine 32%, orthopyroxene 32.1%, clinopyroxene 9.2%, plagioclase 13.6%, troilite 3.2%, kamacite 4.7%, taenite 3.9%, chromite 0.6%, ilmenite 0.2%, and merrillite 0.6%.

The comparison of the Jezersko's abundance of minerals with the literature data for H chondrites [6,7] shows a satisfactory agreement. For example, the modal composition of Marilia H4 chondrite established by Dunn and coworkers [6] is as follows (wt %): olivine 29.7%, orthopyroxene 28.2%, clinopyroxene 6.5%, plagioclase 9.4%, troilite 6%, metal (Fe, Ni, Co) 18.7%, other minerals (chromite, ilmenite and merrillite) 1.6%.

Quantitative data on abundance of constituent minerals in Jezersko chondrite together with the composition of minerals [1] gave the possibility to determine mean atomic weight and grain density of the chondrite. The calculations show that mean atomic weight *Amean(modal)* = 24.84, and grain density of the Jezersko *dgrain*(*modal)* = 3.66 g/cm^3. These theoretically predicted values are close to those recently determined: *Amean(Bulk composition)* = 24.68, and *dgrain* = 3.67±0.03 g/cm^3 [2].

Comparison of the predicted bulk composition of Jezersko chondrite by its modal composition, represented by *Wipredicted*(wt %) values, with the experimental data on abundance of elements *Wiexper(*wt%) reveals a relatively good agreement (Fig. 1). *Wipredicted(Wiexper)* relationship is expressed by the linear fit:

$$Wipredicted = 1.008\ Wiexper + 0.19, \quad (3)$$

for which $R^2 = 0.9992$.

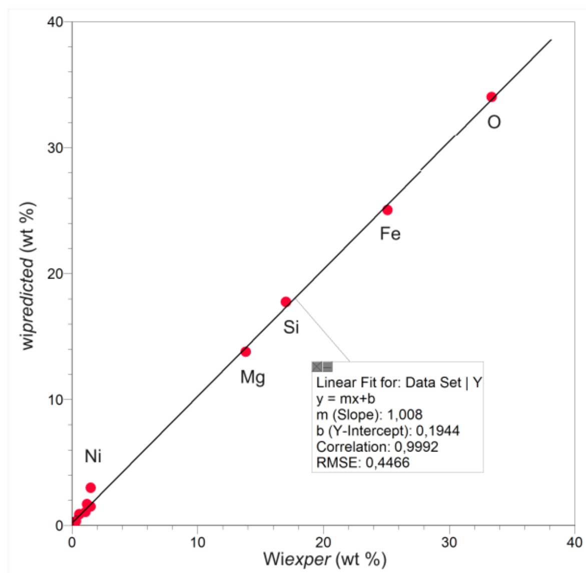

Fig. 1. Relationship between elemental content *Wipredicted*(wt %) for Jezersko chondrite predicted by modal composition, and experimental data *Wiexper(*wt%) [1] concerning the bulk composition of the meteorite.

The following values of *Wipredicted(wt* %) have been obtained for the Jezersko chondrite: Si = 17.75 (17.02), Ti = 0.089 (0.0594)), Al = 1.07 (1.09), Cr = 0.334 (0.331), Fe = 25.05 (25.1)), Mn = 0.254 (0.237), Mg = 13.79 (13.82), Ca = 1.70 (1.19), Na = 0.90 (0.59), K = 0.08 (0.0996), P = 0.1035 (0.1047), Ni = 3.0 (1.5), Co = 0.0734 (0.0727), S = 1.50 (1.49), O = 34.03 (33.38). The experimental values of abundance of elements *Wiexper(wt%)* presented above are in parentheses. These data indicate that the modal composition leads to the value of *Fe/Si* atomic ratio: *Fe/Si(modal)* = 0.710, which is close to the *Fe/Si* ratio determined by bulk composition: *Fe/Si(Bulk composition)* = 0.742 [2].

Knowledge of distribution of elements in minerals forming meteorites and in meteorite parent bodies, and their contribution to the total content is important for planning space missions for astro mining purposes.

The results of an analysis of the mineral contribution to the global bulk composition of Jezersko chondrite presented below was based on Miler and coworkers data [1] on presence and content of elements in minerals of Jezersko chondrite. The presence of elements indicated below in minerals of H4 Jezersko chondrite is expected for H chondrites [8].

Oxygen, the major element in Jezersko chondrite is present in olivine (OL), orthopyroxene (Opx), diopsode (Cpx), plagioclase (PL), chromite (Chr), ilmenite (Ilm), and in merrillite (Mer), according to the inequality:

O: Opx(36.9%)≥OL(36.5%)>PL(15.2%)>
>Cpx(10.1%)>Chr(0.8%)>Mer(0.3%)>Ilm(0.2%),

where the percent represents the contribution of a given meteorite to the global content of an element.

Iron, the major element in Jezersko chondrite is present in kamacite (Ka), taenite(Tae), troilite(Tr), olivine (OL), orthopyroxene (Opx), diopsode (Cpx), plagioclase (PL), chromite (Chr), ilmenite (Ilm), chromite (Chr), and in ilmenite (Ilm):

Fe: Ka(40.8%)>Tae(20.4%)>OL(16.9%)>Opx(9.8%)>
>Cpx(0.9%)>Chr(0.7%)>Ilm(0.3%)>PL(0.2%).

Magnesium, another major element is present in olivine (OL), orthopyroxene (Opx), diopsode (Cpx), and in chromite (Chr):

Mg: OL(55.7%)>Opx(38.4%)>Cpx(5.8%)>Chr(0.1%).

Nickel, and cobalt are present in kamacite (Ka), and in taenite (Tae):

Ni: Tae(75.7%)> Ka(24.2%),

Co: Ka(89.9%)>Tae(10.1%).

Calcium, the minor element in Jezersko chondrite is present in diopside clinopyroxene (Cpx), in orthopyroxene (Opx), in plagioclase feldspar (PL), and in merrillite (Mer):

Ca: Cpx(74.1%)>Mer(8.9%)≥Pl(8.8%)>Opx(8.2%).

Potassium is present only in plagioclase feldspar (100%), phosphorus only in merrillite (100%), and sulfur only in troilite (100%).

Aluminum, a minor constituent of Jezersko chondrite is present almost entirely in plagioclase (PL), also in diopside (Cpx), and in chromite (Chr):

Al: PL(94.7%)>Cpx(3%)>Chr(2.3%).

Chromium, a minor constituent is present in chromie (Chr) and partly in diopside (Cpx):

Cr: Chr(87.9%)>Cpx(12%).

Titanium, a minor constituent in stony, and in stony iron meteorites is present in several phases [8]. In Jezersko chondrite titanium is present in ilmenite (Ilm), chromite (Chr), and in diopside (Cpx):

Ti: Ilm(71.2%)>Cpx(18%)>Chr(10.8%).

Manganese, a minor element in Jezersko chondrite is present in olivine (OL), orthopyroxene (Opx), diopside (Cpx), and in chromite (Chr):

Mn: OL(47.2%)>Opx(44%)>Cpx(6.3%)>Chr(2.5%).

Sodium in Jezersko chondrite is present in plagioclase (PL), in diopside (Cpx), and in merrillite (Mer):

Na: PL(72.2%)>Cpx(26.7%)>Mer(1.1%).

Conclusions: Relative abundance of constituent minerals established for Jezersko H4 chondrite is within the range of modal mineralogy of H chondrites. Grain density and mean atomic weight of the chondrite can be precisely predicted by modal mineralogy. Bulk chemical composition of Jezersko chondrite and contribution of minerals to the bulk composition can be predicted using elemental composition of minerals, and modal composition of meteorite.

References: [1] Miler M. et al. (2014) *Meteoritics & Planet. Sci.*, *49*, 1875-1887. [2] Szurgot M. (2019) *Acta Societatis Metheoriticae Polonorum*, *10*, 140-159. [3] Szurgot M. (2020) *Acta Societatis Metheoriticae Polonorum*, *11*, 98-109. [4] Szurgot M. A. (2020) *Przegląd Geologiczny*, *68*, 54-59. [5] Szurgot M. A. (2021) *Nafta-Gaz*, *1*, 10-19. [6] Dunn T. L. et al. (2010) *Meteoritics & Planetary Science*, *45*, 123-134. [7] McSween H. Y. Jr. et al. (1991) *Icarus*, *90*, 107-116. [8] Mason B. (1979) *Cosmochemistry* [in:] *Data on Geochemistry*, Fleischer M. (Ed.), Washington.