MEAN ATOMIC WEIGHT, GRAIN DENSITY, AND POROSITY OF FLENSBURG UNIQUE CARBONACEOUS CHONDRITE.

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Introduction: Mean atomic weight, bulk and grain densities, and porosity are physical properties important to characterize minerals, rocks, planets, moons and asteroids, and are important to classify meteorites. Recenty interrelationships between mean atomic weight *(Amean),* grain density *(dgr),* and iron to silicon ratio for planetary materials were revealed and applied for predicting and verifying mean atomic weight, *Fe/Si* atomic ratio, and grain density of ordinary and enstatite chondrites, Earth, Venus, Mars, Mercury, Moon, and Vesta [1-6]. The aim of the paper was to determine mean atomic weight, grain density and porosity of Flensburg chondrite. Flensburg meteorite fell on September 12, 2019, in Northen Germany, and has been classified as a unique, ungrouped C1 carbonaceous chondrite [7, 8].

Literature data on chemical composition of Flensburg meteorite, its mineral and modal composition [7], and bulk density *(db)* [7,8] were used to calculate *Amean, dgr,* and porosity *(P)* values for the whole rock of meteorite. *Amean(Bulk composition), Amean(Modal composition),* and *Amean(Fe/Si)* relationships were used to predict mean atomic weight. Grain density was predicted using relationships: *dgr(Fe/Si), dgr(Amean),* and *dgr(Modal* composition*).* Porosity was calculated applying relation $P = 1 - db/dgr$.

Results and discussion: Two new relationships valid for three groups of CC chondrites: CI, CM, and CR were derived and used in the calculations:

$$Amean(Fe/Si) = 1.434\cdot10^{7}\cdot\exp(-18.44\cdot Fe/Si) + 13.78, \quad (1)$$

$$dgr(Fe/Si)(g/cm^3) = 2.439\cdot10^{4}\cdot\exp(-12.63\cdot Fe/Si) + 2.091. \quad (2)$$

RMSE values for these equations are following: 0.72 (eq.(1)), and 0.06 g/cm^3(eq(2)).

It was calculated that iron to silicon atomic ratio for the whole rock of Flensburg meteorite is equal to *Fe/Si* = 0.818. The following values of mean atomic weight of Flensburg chondrite were obtained: *Amean (Bulk composition)* = $\sum wi/\sum(wi)/Ai)$ = 18.33, *Amean(Modal composition)* = $\sum(Vi\cdot Ai)/\sum Vi$ = 17.70, and *Amean(Fe/Si)* =17.81±0.72. Here, *wi/(wt%),* and *Vi(vol%)* represent mass and volume fraction of *i*-th constituent, *Ai* is the mean atomic weight of *i*-th constituent of the meteorite. The range of *Amean* values obtained is between 17.7 and 18.4, and the average value of mean atomic weight of Flensburg is 18.00 ± 0.35. Flensburg *Amean* and *Fe/Si* values are comparable with the *Amean* and *Fe/Si* mean values established for Murchison CM2 carbonaceous chondrite: *Amean(Bulk composition)* = 18.31, *Fe/Si* = 0.819.

It was established that the *dgr(Amean)* relationship [1,4]

$$dgr(Amean) = 0.133\cdot Amean + 0.37, \quad (3)$$

leads to the grain density value: 2.81±0.03 g/cm^3 of Flensburg chondrite (*Amean* = 18.33), and dependence *dgr(Fe/Si)* (eq.(2)) predicts the value of grain density for the whole rock of Flensburg chondrite: 2.89±0.06 g/cm^3. The modal composition leads to the value of grain density *dgr(Modal composition)* = $\sum(Vi\cdot di)/\sum Vi$ = 2.73 g/cm^3. All the predictions lead to the range of values: 2.73-2.92 g/cm^3, and to the average value of grain density for zero weathering degree W0: 2.84±0.07 g/cm^3 for the whole rock of Flensburg chondrite. Mean grain density of the whole rock of Flensburg meteorite is somewhat lower than the mean grain density of Murchison CM2 chondrite [9,10]. Macke measurements indicated for Murchison mean grain density value: 2.96±0.05 g/cm^3 [9], and the range of values: 2.87-3.05 g/cm^3 [9], and generalized relationship between bulk density and porosity *db(porosity)* applied recently by Szurgot [10] predicted for Murchison chondrite *dgr* = 2.93±0.10 g/cm^3 [10].

Measured bulk density of the Flensburg meteorite *db* = 1.984 g/cm^3 [7,8], and predicted average grain density *dgr* = 2.84±0.07 g/cm^3 lead to the mean value of porosity *P* = 30±2% for the whole rock of Flensburg meteorite. Predicted porosity value for Flensburg is higher than that measured for Murchison: 22.1%, range: 18.7-24.9% [9].

Conclusion: Grain density and porosity predicted for the whole rock of ungrouped C1 Flensurg carbonaceous chondrite are somewhat lower than values of *dgr* and *P* measured for Murchison CM2 chondrite, and Flensburg mean atomic weight is comparable with the *Amean* value established for Murchison carbonaceous chondrite.

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