**MEAN ATOMIC WEIGHT OF L/LL AND H/L INTERMEDIATE ORDINARY CHONDRITES.**
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**Introduction:** Knowledge of mean atomic weight is important to characterize minerals and rocks, planets, moons, and asteroids [1-9]. Certain ordinary chondrites are classified as intermediate H/L, and L/LL meteorites. The aim of the paper was to determine and analyze mean atomic weight of selected H/L and L/LL chondrites. All the selected meteorites represent falls. For comparison with intermediate groups average values of mean atomic weight of LL, L, and H groups of chondrites have been also analysed. Literature data on mean bulk elemental and oxide composition of the meteorites [10-16], and grain density of meteorites [17, 18] have been used to calculate mean atomic weight.

**Results and discussion:** Recent results by Szurgot [5-9] show that mean atomic weight *Amean* of planets, protoplanet Vesta, moon and meteorites can be determined using chemical composition, atomic *Fe/Si* ratio, and density *d (g/cm³)*:

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

$$Amean = 5.72\cdot Fe/Si + 20.25, \quad (2)$$

$$Amean = 7.51\cdot d - 2.74, \quad (3)$$

where *wi*(wt%) is the mass fraction of i*th* element, and/or i*th* oxide, *Ai* is atomic weight of i*th* element, and/or mean atomic weight of i*th* oxide, and *d (g/cm³)* is planetary uncompressed density of planets, moons and asteroids, and grain density of meteorites.

Tables 1 and 2 collect values of *Amean*, calculated by eqs. (1-3) employing chemical composition established by various researchers [10-16].

**Table 1** Mean atomic weight *Amean* of individual L/LL meteorites determined by eqs. (1)-(3).

| Meteorite | Class | Amean Eq. (1) | Amean Eq. (2) | Amean Eq. (3) |
|---|---|---|---|---|
| **Albareto** | L/LL4 | **23.30** | 23.33 | 23.62 |
| **Bjurböle** | L/LL4 | **23.52*** | 23.33 | 23.47 |
| **Cynthiana** | L/LL4 | **23.15** | 23.24 | 23.47 |
| **Inman** | L/LL3 | **23.49*** | 23.08 | n.d. |
| **Knyahinya** | L/LL5 | **23.24** | 23.21 | 23.54 |
| **Nyirábrany** | L/LL4-5 | **23.38** | 23.37 | n.d. |
| **Sultanpur** | L/LL6 | **23.65** | 23.71 | 24.07 |
| *Median* | *L/LL* | ***23.4*** | *23.4* | *23.8* |

**Amean* values for meteorite composition without $H_2O$. n.d. = not determined.

**Table 2** Mean atomic weight *Amean* of individual H/L meteorites determined by eqs. (1)-(3).

| Meteorite | Class | Amean Eq. (1) | Amean Eq. (2) | Amean Eq. (3) |
|---|---|---|---|---|
| **Bremervörde** | H/L3 | **24.38** | 24.59 | 24.30 |
| **Cali** | H/L4 | **24.25** | 24.47 | n.d. |
| **Tieschitz** | H/L3 | **24.32*** | 24.14 | 24.30 |
| *Median* | *H/L* | ***24.3*** | *24.4* | *24.3* |

**Amean* value for meteorite composition without $H_2O$.

Table 3 compiles average values of *Amean* representing LL, L, H, L/LL, and H/L meteorite groups. Data concern falls, and bulk composition of meteorite groups specified in Table 3 includes $H_2O$ [10].

**Table 3** Average values of *Amean* of meteorite groups.

| Group | Amean Eq. (1) | Amean Eq. (2) | Amean Eq. (3) |
|---|---|---|---|
| **LL** | **22.90*** | 23.22* | 23.70# |
| **L/LL** | **23.34**±0.19 | 23.33 | 23.62# |
| **L** | **23.67*** | 23.65* | 24.15# |
| **H/L** | **24.32**±0.07 | 24.40 | 24.60# |
| **H** | **24.63*** | 24.87* | 25.12# |

**Amean* of LL, L, and H falls for bulk composition according to Jarosewich [10]. # *Amean* of LL, L, and H falls calculated for *dgrain* according to Macke [17].

**Table 4** Average values of *Fe/Si* atomic ratio, *dgrain*, and log χ of meteorite groups determined for falls.

| Group | Fe/Si | dgrain | logχ |
|---|---|---|---|
| **LL** | 0.520* | 3.52 [17]<br>3.54 [18] | 4.11±0.30 [17] |
| **L/LL** | 0.538±0.034 | 3.51±0.03 | 4.66±0.21 |
| **L** | 0.594* | 3.58 [17]<br>3.56 [18] | 4.87±0.10 [19] |
| **H/L** | 0.726±0.041 | 3.64±0.09 | 5.01±0.10 [17]<br>4.98±0.01 |
| **H** | 0.807* | 3.71 [17]<br>3.72 [18] | 5.32±0.10 [19] |

* For bulk composition of LL, L, and H falls given in [10]. *dgrain(g/cm³)* and logχ of LL, L, and H falls [17, 18]. For calculation of average values of *dgrain* and logχ of L/LL and H/L chondrites, *dgrain* and logχ of individual meteorites were used [19].

Tables 1-3 reveal that using *Fe/Si* and eq.(2) leads to the good prediction of *Amean*, and using *dgrain* and eq.(3) leads to the satisfactory prediction. Tables 1 and 2 show that, in general, *Amean* data confirm the petrological classification of intermediate chondrites. As concerns Nyirábrany it was first classified as LL5 chondrite [16], and recently as L/LL4-5 chondrite [21]. *Amean* data support this new intermediate class for Nyirábrany.

Table 4 present data on average values of *Fe/Si* atomic ratio, *dgrain*, and logχ of meteorite groups represented falls. Tables 3 and 4 show that *Amean*, *Fe/Si* ratio, *dgrain*, and *logχ* follow the inequalities:

$$Amean_{LL}<Amean_{L/LL}<Amean_{L}<Amean_{H/L}<Amean_{H}, \quad (4)$$

$$(Fe/Si)_{LL}<(Fe/Si)_{L/LL}<(Fe/Si)_{L}<(Fe/Si)_{H/L}<(Fe/Si)_{H}, \quad (5)$$

$$dgrain_{LL}\approx dgrain_{L/LL}<dgrain_{L}<dgrain_{H/L}<dgrain_{H}, \quad (6)$$

$$\log\chi_{LL}<\log\chi_{L/LL}<\log\chi_{L}<\log\chi_{H/L}<\log\chi_{H}. \quad (7)$$

Tables 1-4 and inequalities (4)-(7) show that average values of *Amean*, *Fe/Si*, *dgrain*, and *logχ* for intermediate L/LL chondrites are between L and LL chondrites, and those for intermediate H/L are between H and L chondrites. This means that *Amean* and *Fe/Si* are useful for classification of ordinary chondrites. Grain densities of LL and L/LL are comparable, but H/L chondrites are distinguishable from L and H chondrites.

Magnetic suscebility is now well verified property to classify meteorites [19,20], and present data (Table 4) confirm that intermediate meteorites exhibit transitional magnetic properties. Relationship between *Amean* and *logχ* can be expressed by the equation

$$Amean = 1.49\cdot \log\chi + 16.6, \quad (8)$$

for which $R^2$ = 0.95, and RMSE = 0.24. This relationship is presented in Fig. 1.

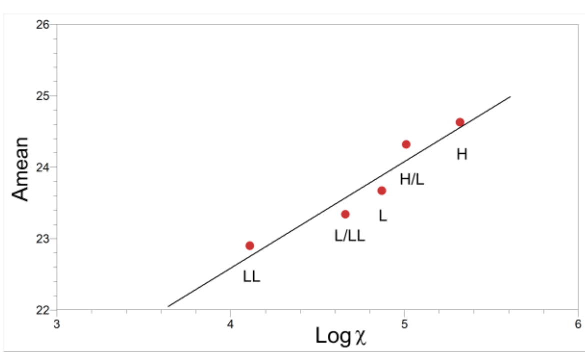


**Fig. 1** Relationship between mean atomic weight and logχ for ordinary chondrites.

Eq. (8) predicts *Amean* = 24.08 for Bremervorde (logχ =*5.02* [17]), for Cali *Amean* = 24.21 (logχ =*5.11* [14]), *Amean* = 23.92 for Tieschitz (logχ =*4.91* [17]), and *Amean* = 23.99 for Sultanpur (logχ =*4.96* [17]).

The comparison of *Amean* values determined in this paper for OC's (Tables 1-4) with *Amean* value established recently for Chelyabinsk (*Amean* = 23.47 for dominant light lithology, and 23.52 for light and dark lithologies [8]), indicates intermediate L/LL5 class of this meteorite rather than LL5. Magnetic susceptibility of Chelyabinsk is also intermediate between LL and L group [22].

**Conclusions:** Mean atomic weight, *Fe/Si* ratio, grain density, and magnetic susceptibility of intermediate L/LL and H/L chondrites confirms their transitional nature. Relationships between *Amean* and *Fe/Si* ratio, *Amean* and *dgrain*, and *Amean* and *logχ* have been successfully verified for OC's chondrites. This means that *Amean* values predicted by *Fe/Si* ratio, grain density and magnetic susceptibility are in good agreement with *Amean* values determined by bulk chemical composition of meteorites and can be used for classification of ordinary chondrites. Certain physical properties of parent body of H/L meteorites can be predicted: *Amean* = 24.3 ± 0.1, *Fe/Si* = 0.73 ± 0.04, *dgrain* = 3.64 ± 0.09, and logχ = 5.0 ± 0.1.

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