On Mercury in Meteorites

Astronomy

1970

SovietRxiv

Fig. 1. Diagram of mercury contents in meteorites. 1 —our analyses, 2 —literature data

Figure 1: Fig. 1. Diagram of mercury contents in meteorites. 1 —our analyses, 2 —literature data

Abstract

Full Text

UDC 550.42;523.51

Astronomy

N. A. Ozerova, N. Kh. Aidin’ yan, L. G. Kvasha, N. D. Shikina

On Mercury in Meteorites

(Presented by Academician V. G. Fesenkov, 27 III 1970)

Data on the distribution of elements in cosmic bodies are widely used to elucidate the composition of the deep parts of our planet. On the Sun, mercury has not been observed; its characteristic spectral lines lie in the inaccessible ultraviolet region. W. J. Claas’ s indication of its presence is erroneous ([1]). A study of lunar samples collected by Apollo 11 showed that the mercury content lies within the range from $6 \cdot 10^{-8}$ to $1.3 \cdot 10^{-6}\%$ ([2]).

Fig. 1. Diagram of mercury contents in meteorites. **1** —our analyses, **2** —literature data

The mercury content in meteorites is known from the data of V. D. Ehmann and G. V. Reed with coauthors ([3]-[6]); for some others there are individual determinations ([7], [8]); some data were published by us ([9]).

Unlike other investigators, except for I. and V. Noddack, we analyzed mercury not by activation methods of analysis, but by a chemical method ([10]). This made it possible to establish the mercury content also in iron-

···and in stony-iron meteorites, which was impossible with activation analysis. Mercury was usually determined from 1 g, with a sensitivity of $1 \cdot 10^{-6}\%$.

Determination of the mercury content was carried out on material from the meteorite collection of the Committee on Meteorites of the Academy of Sciences of the USSR. Samples from 50 meteorites were analyzed. Mercury was determined mainly in bulk samples representing the average sample of a given meteorite. In addition, in some cases separate fractions were analyzed—magnetic and nonmagnetic, chondrules, intermediate mass, and monomineralic samples. In all, about 100 determinations were performed, which constitutes approximately half of all known values for this element.

Fig. 2. Histogram of mercury contents in meteorites of all classes

Figure 2: Fig. 2. Histogram of mercury contents in meteorites of all classes

Fig. 3. Histogram of mercury contents in meteorites as a function of their metallic-iron content (a–100% iron, b–70–8%, c–below 7%)

Figure 3: Fig. 3. Histogram of mercury contents in meteorites as a function of their metallic-iron content (a–100% iron, b–70–8%, c–below 7%)

The results of our investigations and the literature data are presented in the form of a diagram (Fig. 1) and histograms (Figs. 2-4). These data made it possible to outline the following features in the distribution of mercury in meteorites.

Fig. 2. Histogram of mercury contents in meteorites of all classes

In general, markedly higher mercury contents are clearly observed in meteorites as compared with its content in magmatic rocks of the Earth' s crust; about 60% of the meteorites studied contain considerably more than $1 \cdot 10^{-5}\%$ mercury (Fig. 2), whereas the clarke value according to A. A. Saukov ([11]) is $7.7 \cdot 10^{-6}\%$. At the same time, it should be noted that there is a fairly wide scatter of values within individual classes, groups, and subgroups of meteorites (see Fig. 1). Large fluctuations in mercury content have been established even for one and the same specimen.

There appears to be some dependence of mercury content on the composition of meteorites; a tendency is observed for the mercury content to increase as metallic iron decreases (Fig. 3). Iron meteorites are characterized by the lowest mercury contents (up to $1 \cdot 10^{-5}\%$); in them even troilite, the most favorable for mercury concentration owing to its chalcophile character, contains only $(1.5—7) \cdot 10^{-5}\%$ mercury. For stony-iron, iron-stony, and stony meteorites, arranged in order of decreasing nickeliferous iron content, an increase is characteristic in the number of samples with a mercury content exceeding its content in magmatic rocks (more than $1 \cdot 10^{-5}\%$). Thus, at a metallic-iron content of 70 to 8%, irrespective of the class and type of meteorites, the number of samples with a mercury content greater than $1 \cdot 10^{-5}\%$ is about 60%, while at a lower iron content it rises to 80-90%. It is necessary to note, however, the elevated mercury content in the stony-iron meteorite Pallasovo Zhelezo (mercury content $1.2 \div 3.6 \cdot 10^{-4}\%$, nickeliferous iron about 48%). Carbonaceous chondrites of the first type are distinguished by the highest mercury contents–up to 0.05%.

Fig. 3. Histogram of mercury contents in meteorites as a function of their metallic-iron content (*a*–100% iron, *b*–70-8%, *c*–below 7%)

It should be noted that indications of higher mercury contents in bronzite-olivine meteorites–group H–compared with hypersthene-olivine meteorites–group L ([12]) are not confirmed.

Fig. 4. Histogram of mercury contents in chondrites as a function of their structure and the nature of alteration (a—unaltered and crystalline, b—brecciated, c—shocked with signs of shock metamorphism, d—carbonaceous)

Figure 4: Fig. 4. Histogram of mercury contents in chondrites as a function of their structure and the nature of alteration (a—unaltered and crystalline, b—brecciated, c—shocked with signs of shock metamorphism, d—carbonaceous)

Among the achondrites, an increase in mercury contents is observed in the feldspathic group as compared with the feldspar-free group, as was noted ⋯

and earlier ([4]). In olivine-hypersthene achondrites the values of mercury contents are distributed relatively uniformly among the orders of magnitude $n \cdot 10^{-6}$, $n \cdot 10^{-5}$, and $n \cdot 10^{-4}$%, with some predominance of contents of $n \cdot 10^{-4}$%, whereas in hypersthene-free achondrites contents of $n \cdot 10^{-6}$–$n \cdot 10^{-5}$% clearly predominate, with a maximum of values at $n \cdot 10^{-6}$%. However, there are insufficient data for an unambiguous conclusion about such a difference; the numbers of analyses are, respectively, 7 and 12.

The dependence of mercury contents on the structure of meteorites and on the nature of its alteration is clearly observed in a series of chondrites divided according to this feature into unaltered and crystalline, brecciated, and "shocked," i.e., with signs of shock (impact) metamorphism. Chondrites with a brecciated structure (polymict breccia) are, in general, characterized by elevated mercury contents in comparison with unaltered and crystalline ones, while "shocked" chondrites are characterized by reduced contents of this element (Fig. 4). Thus, for unaltered and crystalline chondrites the largest number of samples has a content of $n \cdot 10^{-5}$%, for brecciated chondrites $n \cdot 10^{-4}$%, and for "shocked" chondrites $n \cdot 10^{-6}$%. It should be especially noted that in unaltered and crystalline chondrites the mercury contents are, in general, close.

Fig. 4. Histogram of mercury contents in chondrites as a function of their structure and the nature of alteration (*a*—unaltered and crystalline, *b*—brecciated, *c* —shocked with signs of shock metamorphism, *d*—carbonaceous)

If one draws certain analogies with terrestrial processes, such a distribution of mercury may be explained as follows. Recrystallization of chondrites and the formation of their crystalline varieties as a result of a kind of thermal metamorphism, which occurred at temperatures from 400 to 950° ([12], [13]), may in heating temperature be compared with the recrystallization of rocks during progressive metamorphism; and this process under terrestrial conditions does not lead to any substantial redistribution of mercury ([14]). Possibly, the closeness of the mercury contents in unaltered and crystalline chondrites can be explained by this circumstance.

In shocked chondrites, the lowered mercury contents may be explained by losses during heating caused by the action of shock waves. The low mercury content in these meteorites agrees with their small ages as determined from gas retention;

the loss of inert gases in them is due to the same cause ([15], [16]).

The highest mercury contents in carbonaceous chondrites, reaching values of 0.01–0.05%, can presumably be explained by processes analogous to pneumatolytic and hydrothermal ones, since similar alterations have been noted in this type of meteorite beginning with the investigations of A. N. Zavaritskii ([17]) and L. G. Kvasha ([18]).

Summarizing the existing data on the distribution of mercury in meteorites, it may be noted that the significantly higher contents of mercury in meteorites than in magmatic rocks of the Earth' s crust have no convincing explanation. Possibly, they are a consequence of nuclear reactions in the bodies of meteorites taking place under the influence of cosmic irradiation—in that case the extreme nonuniformity becomes understandable.

of the distribution of mercury in them, and in this case these data cannot be used to judge the distribution of mercury in the deep geospheres. But it is possible that the Clarke value of mercury for the Earth as a whole will be higher than for the Earth' s crust. This question, however, remains open for the time being.

Institute of the Geology of Ore Deposits,
Petrography, Mineralogy, and Geochemistry,
Academy of Sciences of the USSR

Committee on Meteorites, Academy of Sciences of the USSR
Moscow

Received
24 III 1970

CITED LITERATURE

[1] L. H. Aller, *Physics and Chemistry of the Earth*, **4** (1961).
[2] G. W. Reed, J. S. Jovanovich, L. H. Fuchs, *Science*, **167**, 3918 (1970).
[3] W. D. Ehmann, J. R. Huizenga, *Geochim. et cosmochim. acta*, **17**, 1–2 (1959).
[4] W. D. Ehmann, J. F. Lovering, *Geochim. et cosmochim. acta*, **31**, 3 (1967).
[5] G. W. Reed, K. Kigoshi, A. Turkevich, *Geochim. et cosmochim. acta*, **20**, 2 (1960).
[6] G. W. Reed, S. Jovanovich, *J. Geophys. Res.*, **72**, 8 (1967).
[7] I. and V. Noddack, in: *Basic Ideas of Geochemistry*, **2**, 1935.
[8] H. E. Suess, H. C. Urey, *Rev. Modern Physics*, **28**, 1 (1956).
[9] N. Kh. Aidinyan, N. A. Ozerova, in: *Problems of the Geology of Mineral Deposits, Petrology, and Mineralogy*, **1**, "Nauka," 1969.
[10] N. Kh. Aidinyan, *Trans. Inst. Geol. Ore Deposits, Petrogr., Mineral. and Geochem., Acad. Sci. USSR*, **46** (1960).
[11] A. A. Saukov, *Geochemistry of Mercury*, Publishing House of the Academy of Sciences of the USSR, 1946.
[12] R. Dodd, *Geochim. et cosmochim. acta*, **33**, 2 (1969).
[13] R. A. Binns, *Earth and Planetary Science Letters*, **2**, 1 (1967).

[14] N. Kh. Aidinyan, N. A. Ozerova, S. V. Golovnya, in: *Essays on the Geochemistry of Mercury, Molybdenum, and Sulfur in the Hydrothermal Process*, "Nauka," 1970.
[15] E. Anders, *Space Sci. Rev.*, **3** (1964).
[16] D. Heymann, *Icarus*, **6**, 2 (1967).
[17] A. N. Zavaritskii, *Proc. All-Union Mineralogical Society*, **77**, 2 (1943).
[18] L. G. Kvasha, *Meteoritika*, No. 4 (1948).

Note: Figure translations are in progress. See original paper for figures.