Compositional information for the bulk S-contents of metallic cores of iron meteorite parent bodies. Implications for the sulphur abundance of the metallic core of the Earth.

P. Futó[1], A. Gucsik[2]

[1]University of Debrecen, Cosmochemical Research Group, Department of Mineralogy and Geology, Debrecen, Egyetem tér 1. H-4032, Hungary (dvision@citromail.hu)

[2]Institute of Low Temperature Science, Hokkaido University; Kita-19, Nishi-8, Kita-ku, Sapporo, 060-0819, Japan.

It is known that central metallic cores are common in the differentiated planetary bodies of the Solar System. Iron meteorite samples provide an unique opportunity to study the composition of the metallic cores of asteroid – sized parent bodies, which had been disrupted by collision of roughly similar sized objects. Moreover, the iron meteorite parent asteroids are the earliest accreted planetary bodies, thus they preserve the original elementary composition of the early Solar System.

The isotopic signatures in iron meteorites suggest that they had been formed in two distinct formation reservoirs, which are proposed to be separated by Jupiter: thus inner (ISS) and outer Solar System (OSS) formation regions can be distinguished (Kruier et al. 1994). The two types of the parent asteroidal cores formed in carbonaceous (CC) (OSS) and noncarbonaceous (NC) (ISS) reservoirs in the early Solar System. In the outer Solar System, the parent asteroids of CC – type irons have formed in more oxidized formation conditions than the parent asteroidal bodies of NC – type iron meteorites, resulting in less Fe and higher Ni and Co concentrations in the metallic core (Chabot 2018). Zhang et al. (2022) found that CC – type iron cores have lower S, higher Ni content than NC – cores.

An abundance analysis have been performed for lighter elements by applying a simple modeling approach to obtain results, which may helps to understand the compositions of the terrestrial planetary cores in the Solar System.

Assuming the abundances of several elements in materials that made up the cores of Earth and other terrestrial planets are similar to determined meteoritic compositions, we aim to estimate the bulk S - content in the Earth's core having implications for the S – budgets in the metallic cores of the inner Solar system planets. The differentiated planetesimals have formed from chondritic materials therefore we also consider the chondritic bulk compositions. This study is based on the magmatic / non – magmatic iron meteorite, CI – chondrite and cosmochemically estimated abundances. One part of abundance data used in this study are listed in Table 1. and are taken from the literature.

	IID; IVB CC - irons[1]	Canyon Diablo[2]	IIAB NC - iron[3]	Planetary materials	CI - chondrites[4]	1. Earth's core[5]	2. Earth's core[6]
S (wt%)	0.5±0.5; 0.5±0.5	1	17±1.5		5.40	1.7	2.3

Table 1. Sulphur abundance data of several planetary materials. [1] Zhang et al. (2022); [2] Buchwald (1975); [3] Chabot (2004); [4] McDonough and Sun (1995); [5] Dreibus and Palme (1996); [6] Allegre et al. (1995).

The modeled S elemental abundance of the Earth's core are thought to be approximately higher than the S content of the most CC – iron asteroidal cores, however it is essentially lower than the relevant values of CI – chondrites. Based on cosmochemical and geochemical considerations and the analysis of the early formation of the terrestrial planetary bodies in the Solar system,we proposed that the metallic core made mostly of Fe 80 – 85 wt% - Ni 5 – 10 % alloyed with ~ 10 % lighter elements. In terms of our study, S is suggested to be the third most abundant light element of the core. The S content in the bulk core of the Earth is between 1.7 – 4 %, O – 3 – 5 % and Si – 2 – 4 % by weight. Among the chondritic type meteorites, the Earth's core is closer to CM chondrites (3.3 wt %, Wasson and Kallemeyn, 1988) rather than CI chondrites for bulk S content.

The geochemical models assume strong devolatilization of sulphur during Earth's core formation. The present – day core concentration of S is lower than the CI chondritic S – abundance, but its estimated value is similar to that of the CM - chondrites. Note that the different effects can modify the bulk S, P and other lighter element contents after the accretion of planetary bodies.These effects are expected to have been caused by processes during the core formation and the early planetary evolution. Accordinghly, a small amount of the core S content is delivered by a giant impactor during the early evolution of Earth.

References

Allegre, C. J., Poirier J-P., Humler E., Hofmann A. W. The chemical composition of the Earth, Earth and Planetary Science Letters, 134, 515 – 526, 1995.

Buchwald W. F., Handbook of Iron Meteorites, University California Press, 1418 pp., 1975.

Chabot N. L., Sulfur contents of the parental metallic cores of magmatic iron meteorites. Geochimica et Cosmochimica Acta, 68, 3607 – 3618, 2004.

Chabot N. L., Understanding iron meteorites and early Solar System metallic cores of asteroid parent bodies, European Planetary Science Congress Abstracts, EPSC 2018-108, 2018.

Dreibus G., Palme H., Cosmochemical constraints on the sulfur content in the Earth's core. Geochimica et Cosmochimica Acta, 60, 1125 – 1130, 1996.

Kruier T. S., Burkhardt C., Budde G., Kleine T. Age of Jupiter inferred from the distinct genetics and formation times of meteorites, Proceedings of the National Academy of Sciences, 114, 6712 – 6716, 1994.

McDonough W. F.; Sun S.s., The Composition of the Earth. Chemical Geology, 120, 223 – 253,1995.

Wasson, J. T., Kallemeyn G. W., Compositions of chondrites. Philosophical Transactions of the Royal Society A 325, 535–544, 1988,

Zhang B., Chabot N. L., Rubin A. E., Compositions of carbonaceous-type asteroidal cores in the early solar system, Science Advances, 8, eabo5781, 2022.