Ordinary Chondrites and the Origin of the Earth

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Introduction. The paper presents evidence that giant planets sometime occurred near the sun and gave rise to silicate-metallic HH chondritic planets. The origin of the Earth and other terrestrial planets was related to the differentiation of these planets.

Some ordinary chondrites are richer in Fe than H chondrites, which can be referred to as HH chondrites [1]. The boundary line between them is defined by the Netschaevo chondrite, whose silicates have Fe/(Fe + Mg) = 15 (Fig. 1). HH chondrites provide insight into the very early evolution of the series of ordinary chondrites: HH (10-15) – H (16-20) – L (22-26) – LL (26-32), whose degrees of oxidation (the Fe mole fractions of their minerals are specified in parentheses) are controlled by the shift of the $MgSiO_3+Fe+H_2O= MgFeSiO_4+H_2$ oxidation reaction toward its right-hand side.

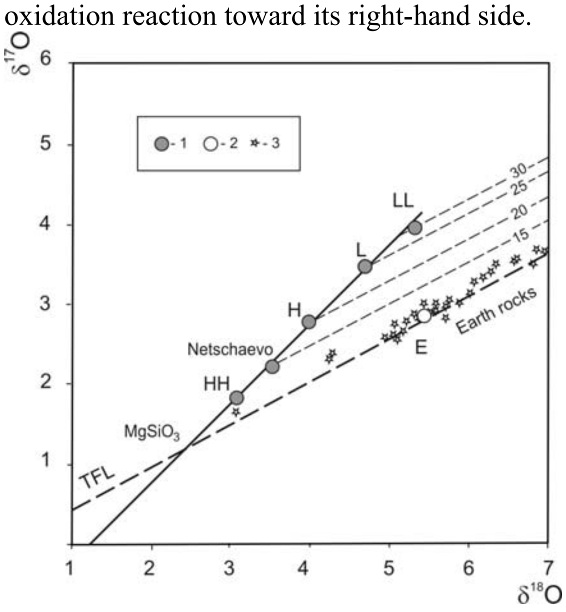

Fig. 1. Oxygen isotopic composition of ordinary chondrites (*1* - LL, L, H, chondritic constituent of the Netschaevo iron meteorite, and hypothetic HH chondrite) in comparison with (*2* - E) enstatite chondrites and (*3*) terrestrial rocks

According to Prior's rule, the Fe mole fraction of silicates in chondrites is negatively correlated with their total Fe concentrations, and hence, HH chondrites are Fe richest ordinary chondrites. These are the only chondrites whose Fe/Si ratio is the same as that of the bulk Earth (Fig. 2). In this context, another very important feature of these meteorites is their Ni-Fe matrix, which is replaced by olivine in the HH-H-L-LL succession because of an increase in the degree of chondrite oxidation. That is why only an HH chondritic planet that evolved under the tremendous fluid pressure of its giant parent planet could be the Earth's precursor and was able to form its vast fluid core and strong silicate layers in the course of differentiation. These layers prevented the breakup of the proto-Earth into asteroids during the transition from its protoplanetary to planetary evolution. Thereby the extremely large fluid reserves stored in the Earth's core maintained the endogenic evolution of the planet for 4.6 Ga.

The conclusion that the Earth's core was produced under a tremendous fluid pressure at a giant planet that was parental for the Earth and its chondritic precursor is crucial for chondritic magmatism. The parent planet selectively lost hydrogen under the effect of the sun, so that the H_2O/H_2 ratio in the fluid envelopes of the planets continuously increased. This stimulated oxidative chondrule-matrix interaction, which can be approximated by the chemical reaction presented above. The differentiation of the chondritic planet described by the left-hand part of the reaction was likely responsible for the origin of Mercury, whose Fe/Si ratio is very high. The initial - HH chondritic - step of the shift of the reaction to the right (the Fe mole fractions of the silicates are close to 10) corresponded to the origin not only of the Earth but also of Venus and Mars.

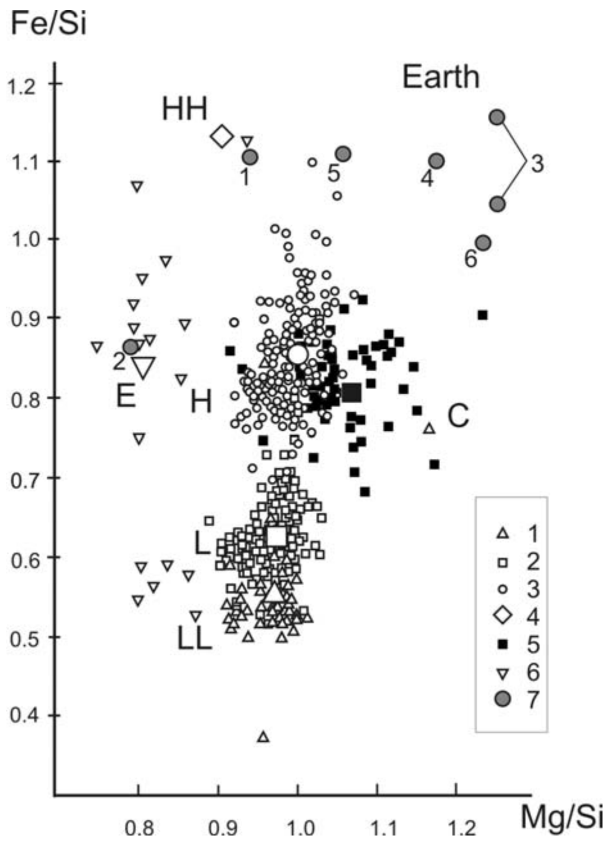

Fig. 2. Petrochemical diagram (atomic ratios of metals) for (1-6) chondrites in comparison with the calculated composition of the Earth. *1-4* - Ordinary chondrites: *1* - LL, *2* - L, *3* - H, *4* - HH (silicate inclusions in the Netschaevo HH chondrite); *5* - carbonaceous chondrites (C); *6* - enstatite chondrites (E), *7* - composition of the Earth. Numbers on the diagramm [1 - according to Marakushev and Bezmen, 1983, 2 - Javoy et al., 2010; 3 - McDonough and Sun, 1995; 4 - Kargel and Lewis 1993; 5 - Morgan and Anders, 1980; 6 - Murthy and Hall, 1970]. Large symbols correspond to the average composition of chondrites.

During the further enhancement of the oxidizing conditions in the H-L-LL succession, the metallic matrix of chondritic planets was replaced by an olivine matrix, and the planets lost their ability to differentiate into strong silicate layers and eventually explosively broke up into asteroids and chondrites. The driving force of this process was fluids stored in the cores of the planets during their protoplanetary evolution.

In contrast to the Earth, other terrestrial planets were consolidated and lost their endogenic activity and magnetic fields. The reason for this was that the fluid reserves stored in the cores of these planets were less significant. They have likely differentiated not in their giant parent planets, as the Earth did in the proto-Earth, but during the transition to their planetary evolution.

Thanks to its rapid rotation, the proto-Earth produced not only the Earth itself (in the form of its core) but also the Moon, which separated in the equatorial plane together with other satellites; they were lost from the proto-Earth when its giant fluid envelope was lost.

Conclusions. Our model suggested to account for the origin of the Earth and terrestrial planets, which were produced by precursor giant planets, is consistent with lately obtained astronomic data and the discovery of stellar-planetary analogues of the solar system. In these star-planet systems near stellar positions is occupied by giant planets (so-called high-velocity Jupiters), which are analogues of giant planets lost by the solar system.

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