Xenon isotope evidence for UV irradiation in the Hadean and the Archean

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Stable isotope (H and N) systematics of documented cosmochemical reservoirs indicate that volatile elements of Earth and Mars were supplied from a cosmochemical reservoir which vestiges are found in chondrites [1]. However, this possibility faces the long-standing problem of the xenon paradox : the isotopic composition of this element is neither solar nor chondritic, and is under-abundant relative to chondritic volatile elements. Any supply of water and nitrogen by a chondritic source should have resulted in the addition of chondritic Xe in abundance much higher than presently seen in the atmosphere and the mantle, and with an isotopic composition drastically different from that of air Xe. Martian atmospheric Xe is elementally and isotopically similar to air Xe, which casts doubt on the possibility to fractionate Xe by terrestrial processes. Instead we propose that the xenon paradox is the result of atmospheric processing. Xenon has the lowest ionization energy compared to other noble gases, N_2 or O_2. Recent experiments indeed show significant Xe isotope fractionation in xenon by 1.4 % per amu during UV irradiation and trapping in condensed matter [2]. The non radiogenic, non fissiogenic Xe isotopic composition of xenon trapped in Archean barite and quartz is intermediate between Chondritic and Atmospheric [3], suggesting that the process that fractionated atmospheric Xe lasted for long periods of geological time. Tests of this possibility will include further ionisation experiments with other volatiles, and analysis of noble gases in sedimentary rocks from different epochs.

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Solid core as relic of protocore

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We suggest that the Earth's solid core has never been formed from liquid core crystallization, but represents the protocore relict on which accretion has begun. The minimal initial mass of the protocore is equivalent to about 0.5 that of the whole modern core and can be estimated on the basis of Earth's iron excess in comparison with its chondrite content. According to this estimation the protocore have to be dissolved. It results in increasing the mass of the liquid core. It is possible to suggest that the protocore is heterogeneous in composition and along with some admixture of such light elements as P and S contains a material of a chondrite silicate component. Floating-up of this component in liquid core during protocore decomposition is accompanied by release of energy and causes concentration-iduced covection providing geodynamo. If the concentration of chondrite component in modern solid core exceeds critical value ~ 8% then energy of such process is enough for the magnetic field generation. If the content of a light admixture is well below this critical value the dissolution of protocore stops and the liquid core crystallization can begin. Distribution of this admixture in the protocore is modeled on the basis of PREM (Preliminary Reference Earth Model) and on the estimation of the integrated density of light and heavy components in the solid core. The obtained results demonstrate that the ratio of silicate component to iron was increasing up to the chondritic value at the distance ~ 3000 km from the center. Thereby, some time ago energy of protocore differentiation could be enough to compensate the heat loses of the core as a whole and even to heat it up. The model conforms to the estimations of Archaean rocks remnant magnetization which contradicts the hypothesis of late beginning of the inner core crystallization. All the above mentioned corresponds to the concept of heterogeneous accretion under which the liquid core formation by the volume melting is replaced by the directed chemical and thermal erosion of protocore. According to the discussed model the solid core of the Earth contains primary noble gases and thus it represents the hidden reservoir which allows to resolve the xenon isotopic paradox formulated by I. Tolstikhin and A. Hofmann.

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