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Timing and processes of Earth's core differentiation

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Small ^{182}W abundance excess of terrestrial W relative to W in bulk chondrites has been recently established (1-3). Rapid terrestrial accretion and early core formation, with completion of the bulk metal-silicate separation within $<$30 Myr have been proposed on this basis. These studies underline how much this ^{182}Hf-^{182}W time scale agrees with dynamic accretion models (4-6) that predict a $\sim$10 Myr interval for the main growth stage of terrestrial formation.

This W model time scale for terrestrial accretion is shorter than current estimates based on Pb isotope systematics of mantle-derived basalts and terrestrial Xe isotope systematics. The end of metal/silicate differentiation and large scale mantle degassing has been defined $\sim$10^8 Myr after beginning of the accretion. These studies also indicate agreement of this time scale with dynamic accretion models that predict 10^8 Myr for the end of terrestrial accretion (4).

The Hf-W time scale for terrestrial accretion and core formation assumes total equilibration of incoming metal and silicate of impactors with the bulk silicate Earth (BSE) during planet's growth. If this equilibation has not been systematically achieved, W terrestrial signature does not date the differentiation of the terrestrial core, but it furnishes an intermediate age between the time of early metal segregation in Earth's impactors and segregation of the Earth's core.

Recently, the assumption of incomplete equilibration of metal and silicate components with BSE has been investigated (Y). It is proposed that impacting core material has not always mixed efficiently with the silicate portions of the Earth before being added to the Earth's core

Our approach considers also that equilibration between metal and silicate has not been complete in BSE during Earth's growth, and we argue that early part of the Earth's core has segregated through unmelted silicate material.

When the baby Earth was large enough, the increase in temperature's has induced Fe-FeS eutectic melting. The liquid metal segregated through the crystalline silicate matrix and formed the early part of the Earth's core. Recent experimental study (Za) indicates the percolation threshold for molten iron-sulphur compounds of 5 vol% solid olivine, through channel on tripel junction between minerals. This study allows us to reconsider the precedent proposition (Zb) based on experimental and theoritical considerations suggesting that percolation of metallic iron rich liquid through a mostly solid silicate matrix is largely prevented because of the high surface tension of iron. During formation and segregation of the Fe-FeS eutectic, W isotopic equilibration is limited by the diffusion through the solid silicate matrix.

During the further Earth's growth, impact melting increased and has induced a progressive melting of BSE up to the formation of magma ocean at the end of the planet's accretion. Before the occurrence of the magma ocean, W equilibration between impactors and BSE has not been complete

This uncomplete isotopic exchange betweeen terrestrial metal and metal originating from impactors with solid part of BSE during early accretion of the Earth leads to the observed excess of ^{182}W of present BSE. It occurs when the^{182}W production in BSE is most significant, due to the short half-life of ^{182}Hf. Change of segregation mecanisms of Earth's core during planet's growth and short-sightedness of Hf-W chronometer focused to the early segregation of Earth's core make the divergence with the U-Pb and I-Xe terrestrial records.

References

1)Yin Q.Z. et al. (2002),2) Kleine et al. (2002), 3) Schönberg et al. (2002),4) Wetherill (1986), 5)Chambers (2001), 6) Kortenkamp et al. (2001)