The carbon budget and its delivery way to the Earth

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The carbon budget in the Earth interior is currently not well constrained. Besides, how and when carbon was delivered to the Earth is still an open question. The timing of carbon delivery to the Earth has different consequences. If the agents of carbon delivery arrived before the cease of Earth's core formation, most of carbon would have the opportunity to pass through the magma ocean and enter the Earth's core, according to the results of equilibrium carbon partitioning experiments. Otherwise, the delivery is just a part of late veneer contributions and the carbon can hardly go into the Earth's core.

Recently, using isotope signals to solve budget problems of the Earth's interior reservoirs becomes an alternative way. Here, Equilibrium carbon isotope fractionation factors of silicate melts, liquid iron, magnesite, diamond, moissanite and various iron-carbides are provided by first-principles methods. We find that the pressure sensitivities on carbon isotope fractionations for melts and crystals are different. Using crystalline analogues to study carbon isotope fractionations between melts at high pressure may lead to defective conclusions.

The calculated carbon isotope fractionations, which are under the bottom conditions of proto-Earth's magma ocean, cannot compromise the equilibrium or Rayleigh distillation isotope fractionation way of Earth's mantle-core differentiation and to explain the mantle's carbon isotope signals (i.e., around -5 to -7.2 per mil). However, the enrichment of ^{13}C in bulk silicate Earth (BSE) relative to chondrites can be explained by the core-mantle differentiation of other planetary embryo, rather than that of Earth. We suggest that the delivery agent of BSE's major carbon may be a Mars-like body. We also use SPH- and MFM-based simulation to find out the conditions required for such core-core merge giant impacts.