From carbon in meteorites to carbonatite rocks on Earth

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The composition of the early Earth's atmosphere is believed to result from significant magma outgassing during the Archaean eon. It has been widely debated whether the oxygen fugacity (fo_2) of the Earth's mantle has remained constant over the last ~3.8 Ga to levels where volatiles were mostly in their mobile form [1,2], or whether the mantle has experienced a gradual increase of its redox state [3]. Both hypotheses raise fundamental questions on the effect of composition of the early Earth's accreting material, the origin and availability of primordial carbon in Earth's interior, and the migration rate of CO_2-rich magmas. In addition, the occurrence in nature of carbonatites (or silicate-carbonatitic rocks), diamonds and carbides indicate a dominant control of the mantle redox state on the volatile speciation over time and, maybe, on mechanisms of their formation, reaction and migration through the silicate mantle.

A recent model has been developed that combines both experimental results on the fo_2 of preserved carbonaceous chondrites at high pressure and thermodynamic predictions of the the temporal variation of the mantle redox state, with the CO_2-bearing magmas that could form in the early asthenospheric mantle. Since any variation in melt composition is expected to cause significant changes in the physical properties (e.g., viscosity and density), the migration rate of these magmas has been determined using recent in situ viscosity data on CO_2-rich melts with the falling sphere technique.

Our results allow determining the composition of CO_2-bearing magmas as function of the increasing mantle redox state over time, and the mechanisms and rate for exchange of carbon between mantle reservoirs.

[1] Li et al. (2004) *Earth Planet. Sci. Lett.* **228**, 483-493. [2] Scaillet et al. (2011) *Nature* **480**, 48-49. [3] Aulbach et al. (2016) *Geology* **44**, 751-754.