Trace element abundances in sulfide and phosphide bearing inclusions in iron meteorites

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In recent years the model that some iron meteorite parent bodies might be older than chondrites and chondrules has become a frequently discussed proposition. Precise dating of iron meteorites using short-lived nuclide systems remains challenging though. Sulphide and phosphide rich inclusions in iron meteorites have exsolved from metal and may be promising for chronometric applications.

Here we present trace element abundances and element ratios of sulfide and phosphide bearing inclusions and metal from a suite of magmatic and non-magmatic iron meteorites. We focus on alkaline metals and alkaline earth metals, in particular on Cs and Ba abundances, to estimate the feasibility of the ^{135}Cs-^{135}Ba chronometer to date irons and/ or the formation of inclusions. For each meteorite, metal phase and sulphide or phosphide rich inclusions were separated mechanically. After digestion in aqua regia and dilution, trace element abundances were analyzed by sector field ICP-MS using external standardization. Prior to digestion, the mineralogy was determined by XRD and Rietveld refinement. Troilite and pyrhotine are the main sulfide species, schreibersite is a primary phosphide mineral.

The majority of inclusions exhibit an enrichment of alkaline metals compared to metal by a factor of 1 to 3, although abundances are generally low between 1 ppm and 20 ppm for Na, K and less than 1 ppm for Sr and Cs. However, one iron meteorite has significanlty higher Na and K contents and shows an enrichment of these elements in the metal phase. Inverse to the trend in absolute concentration CI normalized abundances of alkalies tend to be low for Na and K, but with 0.1 to 0.3 relatively high for Rb and Cs.

The content of alkaline earth metals in the inclusions is in the range between 1 and 10 ppm for Mg and Ca, and around 1 ppm for Sr and Ba. When normalized to CI chondrites, Sr and Ba are enriched in the inclusions relative to Mg and Ca. The potential of these inclusions for chronometry will be studied in more detail.

Carbon isotope evidence for a strong biological pump in the aftermath of end-Permian mass extinction

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Abundant geochemical, biomarker, and sedimentological evidence indicate large perturbations to the global carbon and sulfur cycles at the Permian-Triassic (P-T) boundary and throughout the Early Triassic, including widespread euxinia (anoxic and sulfidic conditions). According to Earth system model results, increased nutrient availability and enhanced export production are necessary to sustain elevated H_2S concentrations in the deep ocean. Therefore, a vigorous biological pump would be required despite the extinction of approximately 90% of marine animals at the P-T boundary. One predicted consequence of this scenario is the generation of large vertical and lateral gradients in the $\delta^{13}C$ of dissolved inorganic carbon. To examine the nature of the end-Permian and Early Triassic biological pump, we measured the carbon isotopic composition of carbonates from an exceptionally preserved carbonate platform in the Nanpanjiang Basin of south China.

Multiple carbon isotope shifts of up to 8‰ across the P-T boundary and in the Lower Triassic are recorded in 5 stratigraphic sections arranged along an environmental gradient from platform interior to basin margin. $\delta^{13}C$ values are enriched in the platform interior relative to coeval slope and basin margin deposits. The Lower Triassic $\delta^{13}C$ gradient from shallow to deep water strata is as great as 4‰, but collapses to less than 1‰ in the Middle Triassic. This pattern appears unrelated to lithofacies variation within sections, suggesting that the $\delta^{13}C$ gradient may reflect a vertical gradient in $\delta^{13}C$ of dissolved inorganic carbon due to the invigoration of the biological pump. The temporal trend of this putative $\delta^{13}C$ gradient is consistent with the predictions of Earth system modelling and with an environmental control on the timescale of biological recovery.