Utah and Czech Mars analog concretions; Aquatic hematite and goethite characterization

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Terrestrial Jurassic Navajo Sandstone concretions from Utah show resemblance to the hematite spherules ("blueberries") imaged by the Mars Exploration Rover (MER) Opportunity. Both the NASA MER team and terrestrial analog studies interpreted the Mars hematite spherules to be concretions precipitated from diagenetic aqueous solutions in the sediment.

Magnetic analyses of Utah and Czech hematite concretions show unusual and complex behavior of antiferromagnetic hematite-goethite composition. We developed a method allowing us to separate the magnetic signature of goethite from hematite and further show that although hematite saturates in 1-2 Tesla range, goethite continues to acquire magnetization even above 10T. Parallel Mossbauer spectra confirm the presence of both hematite and goethite in these terrestrial samples. Magnetic separation allows using the terrestrial concretions as paleofield recorders.

Magnetic signature is tied to aqueous hematite/goethite formation in the sediment. Hematite and goethite (occasionaly also magnetite), carry a record of past magnetization events. Such magnetic signatures help interpretation of their formation.

Based on field observation and laboratory analysis, we suggest that concretions may have formed along the fluctuating water table, that periodically left behind water saturated volumes. Slow evaporation of these volumes initiated precipitation of goethite/hematite from the aquatic solution. Fe isotope data reveal some lighter isotopic iron inside the concretions pointing towards biomediation assistance in iron precipitation.

Future Mars Rover and sample return missions should include instrumentation for in situ magnetic measurements. Hematite and goethite are well-studied terrestrial magnetic minerals and have magnetic properties suitable for resolving the origin of the spherules. Ferromagnetism of hematite and goethite should record ancient magnetic fields, and has magnetic grainsize in the range that can be used efficiently as a paleotemperature recorder. Thus the magnetic signatures give us tools to study the origin of "blueberries".

Nd isotope records of the deep south Atlantic and the intepretation of Neogene $\delta^{13}C$ gradients

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Records of the past Nd isotope composition of the deep ocean can resolve ambiguities in the interpretation of other palaeocirculation tracers. For example, recently published records of Neogene $\delta^{13}C$ gradients from the deep Atlantic [1, 2] can be interpreted either in terms of changes in the strength of deep water export from the North Atlantic, or as due to variation in the pre-formed $\delta^{13}C$ of southern-derived deep water in response to shifts in the surface paleoceanography of the Southern Ocean. Here we present the first Nd isotope data for benthic foraminifers and apply down-core deep water Nd records from this and other substrates to the resolution of ambiguities in nutrient-based tracers.

Comparison of the ε_{Nd} of core-top foraminifers from a depth transect on the Walvis Ridge to published seawater data suggests that benthic foraminifera represent a reliable archive of the deep water Nd isotope composition. Though data obtained through leaching of Fe-Mn coatings often record the Nd isotope composition of local inputs to the ocean, in this case paired down-core leaching and foraminiferal analyses usually yield identical results, giving confidence in their paleoceanographic significance.

The new ε_{Nd} datasets, along with Cd/Ca and Nd/Ca ratios from the same foraminiferal samples, are interpreted in the context of debates over the Neogene history of North Atlantic Deep Water (NADW) export to the south Atlantic. Our data suggest strong NADW export from 9 to 5.6 Ma, mostly in congruence with one interpretation of published $\delta^{13}C$ gradients [1]. Where the ε_{Nd} record differs from the nutrient-based records, such as between 7 and 6 and at 4 Ma, changes in the pre-formed $\delta^{13}C$ or Cd/Ca of southern-derived deep water might account for the difference. Maximum NADW-export in the last 9 Ma is suggested by all proxies at around 4 to 3.5 Ma. Chemical conditions between 3 and 1 Ma are different suggesting, on average, the lowest NADW export of the entire record. Modern-day values are similar to average values from 9 to 4 Ma, implying NADW export today as strong as at any stage over the past 9 Myr.

Reference

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