

The sedimentation rate controls microfossil preservation

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One of the greatest challenges to finding definitive evidence for life on early Earth is the discovery of well preserved fossils. The microscopic, soft bodied organisms that are expected to dominate early or extreme environments do not preserve well. Several laboratory studies have recreated microbial "fossils" [1, 2], but the conditions under which microfossils are formed in natural environments are still poorly understood. Knowing these conditions and being able to predict where they occur are key factors to discovering preserved microorganisms. Exposure to iron in particular appears to control the formation of microfossils in many terrestrial and marine environments [3].

We present new data from oolitic ironstones at the Callovian-Oxfordian boundary in the eastern Jura mountains of northern Switzerland linking the preservation of fossil microorganisms to the depositional environment and to the concentration of iron. The lowest Oxfordian deposits contain litho- and bioclasts, which are indicative of a highly condensed sequence with reworking and a sedimentation hiatus. In this sequence, filamentous, tubular structures of 1-2 μm are found in ferriferous encrustations and goethitic ooids. The filaments appear identical to those formed by a recently characterized modern analog, the NO_3^- reducing, iron-oxidizing bacteria. Depositional sequences from the upper Callovian stage exhibiting a higher sedimentation rate do not contain the same structures. We hypothesize that 1) the activities of iron-oxidizing and -reducing bacteria contributed to the form of iron that was accumulated and 2) a hiatus in sedimentation during development of the sequence enabled the microbial structures to be preserved. In contrast, when the sedimentation rate was increased, the burial of the microorganisms facilitated the breakdown of their associated structures. We suggest that this environment provides a model system for establishing the relationship between sedimentation and the preservation of soft bodied, microscopic organisms.

References

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Single crystal X-ray refinement and thermodynamic properties of stoichiometric jarosite, $\text{KFe}_3(\text{SO}_4)_2(\text{OH})_6$

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Jarosite and related minerals are invariably found in natural environments acidified either through the action of acid rain or by acidic mine drainage. In spite of their importance and common occurrence, the data which could describe the solubility, precipitation, and distribution of elements between jarosite and aqueous solutions are fragmented or questionable.

The first goal of this study is to prepare stoichiometric jarosite samples for further thermodynamic investigation. We have synthesized only jarosite samples which have been prepared according to the published procedures (Grohol *et al.*, 2000) by oxidizing metallic iron in acidic K^+ and SO_4^{2-} -containing solutions under hydrothermal conditions. Iron was added in the form of an iron wire. Synthesis was carried out in a Teflon cylinder placed into a conventional oven at 200°C. The yellow product was readily identified by X-ray diffraction (XRD) as jarosite and no other crystalline phases were detected. The yield of the synthesis was 230 mg. The single-crystal XRD refinement for the sample with $R_1=0.0316$ for the unique observed reflections ($|F_o| > 4\sigma_F$) and $wR_2=0.0423$ for all data gave the unit-cell parameters $a = 7.288(1)$ and $c = 17.203(4)$ Å. The Fe site occupancy in this sample is 97(1) %, significantly higher than the ~85 % reported from a conventional synthesis routes.

The second goal of this study is to determine thermodynamic properties of the jarosite sample. The thermodynamic measurement will be carried out using acid-solution calorimetry to obtain the enthalpy of formation. Heat capacity and entropy at standard temperature and pressure will be measured by adiabatic calorimetry. The measured enthalpy and entropy will be combined to a Gibbs free energy of formation. Then we will proceed to refine the existing values by comparing them to phase equilibria data, either in nature or laboratory.

The data which will be presented can be used to calculate phase diagrams for this group of phases at conditions relevant to low-temperature geochemical processes (25 °C, 1 bar), metallurgical treatment (75 – 110 °C), and stability of phases on the surface of planets.

Reference

- Grohol D., Nocera D., and Papoutsakis D. (2000), *Phys Rev B* **67** 064401.