Retention of biosignatures associated with phosphate in Fe-oxide mineralized bacterial mats

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O-isotope fractionation in phosphate driven by biological activity depends on temperature [1], and when this fractionation is preserved in phosphate adsorbed to Fe-oxides it can be used as a biomarker for temperature in ancient environments [2]. We have studied how biological phosphate signatures are retained within bacterial mats associated with stalk- and sheath-forming Fe-oxidizing bacteria using modern mat samples from the E/V Nautilus expedition to the Kickem' Jenny seamount, leg NA039. State-of-the-art focused ion beam scanning electron microscopy-assisted nanotomography and nanoscale secondary ion mass spectrometry were conducted on a sample that showed extensive mineralization. These techniques demonstrated that the internal structure of the mineralized bacterial stalks was complex, with organic material localized within the Fe-oxide minerals. Phosphate was preferentially retained close to the organic material. These findings suggest that temperature-related biogenic signatures in phosphate deposited on the organic material during the initial mat mineralization should be the dominant phosphate signature in the geological record, even if further abiotic mineralization and seawater phosphate adsorption occurred at different conditions. This was confirmed by bulk analysis of the same sample, which led to a comparable temperature estimate to those determined from Fe-oxidizing bacterial mats from other seamounts where the degree of mineralization was much less extensive.

[1] Chang & Blake (2015) Geochim. Cosmochim. Acta, 150, 314-329.
[2] Blake et al. (2010) Nature, 464, 1029-1032.