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Magnetic evidence of bacterial alteration in oceanic basalts

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To address possible signatures of bacteria within the oceanic crust we conduct in vitro laboratory batch experiments using natural, very recent, oceanic basalts and marine bacterial strains. Anaerobic sulfate-reducing bacteria were chosen for experiments as they are ubiquitous and abundant at or close to ridge axis. Systems with the bacterial strains, natural sea water, nutriments and basalts were incubated in a low field environment at 28°C, analogous abiotic systems were also incubated as a controlled batch. A magnetic parameter, the Natural Remanent Magnetization, was regularly measured on samples. On a one year time scale magnetization of systems incubated with bacteria showed a decrease on the order of 15 to 30%. These results suggest that the iron oxides carrying the remanence are significantly altered by the bacteria. To better understand the processes involved we characterized the samples by scanning electron microscopy combined with X-ray Energy Dispersive Spectrometry (XEDS). The surface of samples revealed important textural differences between control samples and samples incubated with bacterial strains. In particular, filamentous structures of few tens of microns long were observed locally at the surface of the bio-weathered sample. XEDS analyses made on several filaments showed important amount of iron and sulfur. In addition, spheroidal pyrites were found in holes and cracks within the sample but no alteration could be detected by SEM on iron oxides themselves. Still ultra thin (<100 nm thick) cross-sections across the filaments were obtained by Focused Ion Beam milling (FIB). The cross-sections were observed by Transmission Electron Microscopy showing the presence of alteration rims around the titanomagnetites, which suggest the gradual substitution of the crystal structure by an amorphous Fe-S phases. Scanning Transmission X-ray Microscopy analyses providing XANES spectroscopy at the 20 nm scale were carried out at the carbon K-edge and Fe L2,3 edge. They

provided Fe redox maps at the scale of the cross-sections and showed unambiguously that the filamentous structures were bacterial remains associated with a Fe-S crust. We will discuss how these results offer a new insight in the evolution of the magnetic signal hosted by seafloor basalts.