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Formation of Deep Sea Umber Deposits Linked to Microbial Metal Oxidation at the South Atlantic Ridge

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Umber deposits are important metalliferous deposits, which occur in off-axis half-graben structures at ancient and modern ocean floor. The genesis of umber deposits has remained controversial for several decades. Recently, microbial Fe(II) oxidation associated with low-temperature diffuse venting has been identified as a key process for the formation of umber deposits, but the exact biochemical mechanisms involved to the precipitation of Mn oxides and co-precipitation of Fe oxyhydroxides and Mn oxides in umber deposits still remain unknown. Here, we used nano secondary ion mass spectrometer, synchrotron-based X-ray absorption spectroscopy, electron microscopy, and molecular techniques to demonstrate the coexistence of two types of metal-oxidizing bacteria within deep-sea hydrothermal umber deposits at the South Atlantic Ridge, where we found unique spheroids composed of biogenic Fe oxyhydroxides and Mn oxides in the deposits. Our data suggest that Fe oxyhydroxides and Mn oxides are metabolic by-products of lithotrophic Fe(II)-oxidizing bacteria and heterotrophic Mn(II)-oxidizing bacteria, respectively. The hydrothermal vents fuel lithotrophic Fe(II)-oxidizing bacteria, which constitute a trophic base that may support the activities of heterotrophic Mn(II)-oxidizing bacteria. The biological origin of umber deposits underscore the importance of geomicrobiologcial interaction in triggering the formation of deep-sea deposits, with important implications for the generation of submarine Mn deposits and crusts.