Eating Rocks! Cultivation and Physiology of Microbes Using Cathodes as an Electron Donor.

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Little is known about the importance of mineral oxidation processes in sediment, and part of this stems from the difficulties associated with culturing microbes with this capacity from the environment. We demonstrate that electrochemical techniques, using an electrode poised at a given redox potential to mimic minerals and/or a specific redox condition, is a feasible approach to enrich and facilitate isolation of microbes capable of gaining electrons from insoluble minerals. To this end we constructed marine sediment microcosms and incubated electrodes at varied and controlled redox potentials. The negative current production observed increased as the redox potential (lowest tested potential-203 mV vs. SHE). The enriched biomass from these incubations was further cultivated under sediment free conditions, testing variety of different possible anaerobic terminal electron acceptors that could drive electrode oxidation. Nitrate reduction demonstrated the most prominent electrochemical relationships with negative current production. Solid substrate electron donor enrichments were later used to test potential substrates of electrode-oxidizing microbes. Enrichments with elemental sulfur, elemental iron and amorphous iron sulfide coupled to nitrate as a terminal electron acceptor demonstrated products indicative of sulfur or iron oxidation. Electrode oxidizing microbes were isolated from these enrichments from the genera *Halomonas, Idiomarina, Thalassospira,* and *Pseudamonas*; organisms commonly detected in marine sediments but not generally associated with mineral oxidation. Electrochemical analysis of these microbes has demonstrated that, though these organisms have similar physiologies (either sulfur or iron oxidation), they likely have different biochemical mechanisms demonstrated by the variability in dominant electron transfer modes or interactions (i.e., biofilm, planktonic or mediator facilitated interactions) and the wide range of midpoint potentials observed for dominant redox active cellular components (ranging from -293 to +50 mV vs. Ag/AgCl). In general, organism isolated on sulfur tended to have higher midpoint potentials than iron-oxidizing microbes. This works supports the ability to enrich microbes capable of solid substrate oxidation, many of which are from groups not known oxidize mineral and/or known to be electrochemically active. Comparative genomics is being used to better understand the physiology driving the electrode-oxidizing capabilities in these microbes. The insight gained from these experiments is not limited to the physiology of the organisms isolated but also their potential ecologic importance and the role solid substrates may play in there metabolism. Given the abundance of reduced mineral in sediments and the earths subsurface this approach holds vast potential for increasing our understanding of the importance and abundance of lithotrophic reactions.