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Archaeal methanogenesis at the onshore serpentinite-hosted Chimaera seeps, Turkey

Jennifer Zwicker (1), Daniel Birgel (2), Wolfgang Bach (3), Sylvain Richoz (4), Susanne Gier (1), Daniel Smrzka (1), Anna Neubeck (5), Magnus Ivarsson (6), Christa Schleper (7), Simon Rittmann (7), Bernhard Grasemann (1), Jörn Peckmann (1,2)

(1) Department of Geodynamics and Sedimentology, Center of Earth Sciences, Universität Wien, 1090 Vienna, Austria, (2) Institute for Geology, Department of Earth Sciences, Universität Hamburg, 20156 Hamburg, Germany, (3) MARUM, Center for Marine and Environmental Sciences, 28359 Bremen, Germany, (4) Institute of Earth Sciences, Karl-Franzens Universität Graz, 8010 Graz, Austria, (5) Department of Geological Sciences, Stockholm University, SE-114 18 Stockholm, Sweden, (6) Department of Paleobiology, Swedish Museum of Natural History, SE-114 18 Stockholm, Sweden, (7) Archaea Biology and Ecogenomics Division, Universität Wien, 1090 Vienna, Austria.

Serpentinite-hosted ecosystems have attracted the interest of the scientific community, as they are considered to be likely environments where life first evolved on Earth. Serpentinization reactions produce strongly reducing and highly alkaline fluids that are typified by high concentrations of molecular hydrogen and methane, which can be used as an energy source by chemotrophic microbial communities. Moreover, carbonate formation is a common late-stage alteration process that is induced by the serpentinization of peridotite at the seafloor and on land. It is well established that low-temperature serpentinization at slow-spreading mid-ocean ridges provides an ideal environment for rich microbial communities, including anaerobic archaea and bacteria. Recent studies of lipid biomarkers and their isotopic compositions have suggested that some Euryarchaeota are able to perform methanogenesis and methanotrophy, depending on the prevailing environmental conditions. However, no evidence for archaeal methanogenesis or methanotrophy has yet been reported for similar environments on land. This study is the first to present lipid biomarker evidence for archaeal methanogenesis at the terrestrial, peridotite-hosted Chimaera seep in Turkey. The analyzed Chimaera rock samples are serpentinites that are cross-cut by veins composed of brucite and hydromagnesite. Pentamethylicosane and squalane with δ13C values of +10‰ and +14‰ respectively, were identified within the brucite-carbonate veins. Furthermore, archaeol, sn2-hydroxyarchaeol, squalane and squalenes as well as unusual distributions of glycerol dialkyl glycerol tetraether (GDGT) lipids were found. Archaeol and sn2-hydroxyarchaeol also show high compound-specific δ13C values of up to +7‰Ṫhese isotope signals combined with the absence of crocetane – a biomarker for methanotrophic archaea – reveals that the microbial communities at the Chimaera Seep performed methanogenesis rather than methanotrophy. Our results suggest that biological methane production may play a more significant role during terrestrial low-temperature serpentinization than previously recognized.