Microbial uptake and methylation of dissolved elemental mercury

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Introduction

Mercury [Hg] bioaccumulation in fish is critically dependent on the conversion of inorganic Hg to methylmercury [MeHg]. In aquatic ecosystems, Hg is primarily methlyated by anaerobic sulfate- and iron-reducing bacteria. These microbes are known to methylate mercuric Hg [Hg^{2+}] to form MeHg. The formation of dissolved elemental mercury [$Hg^0_{(aq)}$] is thought to limit the concentration of Hg available for methylation. However, the uptake and transformation of Hg^0 by anaerobic bacteria has never been tested. Here, we conducted experiments to determine if the sulfate-reducing bacterium *Desulfovibrio desulfuricans* ND132 and the iron-reducing bacterium *Geobacter sulfurreducens* PCA can produce MeHg when provided with $Hg^0_{(aq)}$ as their sole mercury source.

Materials and Methods

Strains PCA and ND132 were grown to exponential phase and subsequently exposed to a constant source of $Hg^0_{(aq)}$ under strict anaerobic conditions. Heat-killed cells (80°C for 30 min), bacterial exudates (growing culture passed through a 0.2 μm filter), and sterile medium were incubated under identical conditions. Samples were acidified and frozen for MeHg analysis and purged with N_2 gas at ~800 mL/min to remove all volatile $Hg^0_{(aq)}$ prior to total Hg analysis.

Results and Discussion

After ~24 h of exposure to $Hg^0_{(aq)}$, strains PCA and ND132 converted $Hg^0_{(aq)}$ to non-purgeable total Hg at rates of ~30 μg/L/d and ~1500 μg/L/d, respectively. Control experiments conducted with heat-killed cells, bacterial exudates, or sterile medium could not account for the Hg retention, suggesting an active role by the microorganisms. When provided with $Hg^0_{(aq)}$ as the sole mercury source, strains PCA and ND132 produced MeHg at rates of ~0.2 μg/L/d and ~0.3 μg/L/d, respectively. These experimental results indicate that iron-reducing and sulfate-reducing bacteria are able to uptake and methylate elemental Hg. The implications of this process in the terrestrial mercury biogeochemical cycle will be discussed.

An integrated approach to estimate the U and Th content of the Central Apennines continental crust

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A study for estimating the Th and U content of Central Italy continental crust was undertaken for evaluating the geo-neutrino flux, which is currently measured through Borexino experiment at LNGS (Laboratori Nazionale Gran Sasso). Three main layers were identified: Sedimentary Cover, Upper Crust and Lower Crust, only the first one outcropping in the Gran Sasso area. Sampling of the other two layers was performed in the Valsugana area and in the Ivrea-Verbano zone, assuming rock abundances and composition of the south Alpine basement fairly homogeneous.

U and Th abundances of the main lithotypes belonging to the Mesozoic and Cenozoic were grouped into four main "Reservoirs" based on similar paleogeographic conditions and mineralogy. Irrespective of magmatic or metamorphic origin Upper and Lower Crust lithotypes were also subdivided into a mafic and an acid reservoir, with comparable U and Th abundances. Based on geological and geophysical properties, relative abundances of the various reservoirs were calculated and used to obtain the weighted U and Th abundances for each of the three geological layers. Using the available seismic profile as well as the stratigraphic records from a number of exploration wells, a 3D modelling was developed over an area of 2°x2° centered at LNGS. This allows to determine the volume of the various geological layers and eventually integrate the Th and U contents of the whole crust beneath LNGS.

On this base the local contribution to the geo-neutrino flux was calculated and added to the contribution given by the rest of the world. This new calculation predicts a geoneutrino signal at Borexino detector about 4 TNU lower than that previously obtained based on general, worldwide assumptions. The considerable thickness of the sedimentary rocks, mainly represented by U- and Th-poor carbonate, is responsible for the difference. These results suggest that worldwide average of continental crust cannot be extrapolated to young terrains without taking into account composition and thickness of lithotypes within the Sedimentary Cover.