Geophysical Research Abstracts
Vol. 18, EGU2016-18372, 2016
EGU General Assembly 2016

Marine phages as excellent tracers for reactive colloidal transport in porous media

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Question: Here we evaluate marine phages as specific markers of hydrological flow and reactive transport of colloidal particles in the Earth's critical zone (CZ). Marine phages and their bacterial hosts are naturally absent in the CZ, and can be detected with extremely high sensitivity. In the framework of the DFG Collaborative Research Center AquaDiva, we asked the following questions: (1) Are marine phages useful specific markers of hydrological flow and reactive transport in porous media? and (2) Which phage properties are relevant drivers for the transport of marine phages in porous media?

Methods: Seven marine phages from different families (as well two commonly used terrestrial phages) were selected based on their morphology, size and physico-chemical surface properties (surface charge and hydrophobicity). Phage properties were assessed by electron microscopy, dynamic light scattering and water contact angle analysis (CA). Sand-filled laboratory percolation columns were used to study transport. The breakthrough curves of the phages were analyzed using the clean bed filtration theory and the XDLVO theory of colloid stability, respectively. Phages were quantified by a modified high- throughput plaque assay and a culture-independent particle counting method approach.

Results: Our data show that most marine tested phages exhibited highly variable transport rates and deposition efficiency, yet generally high colloidal stability and viability. We find that size, morphology and hydrophobicity are key factors shaping the transport efficiency of phages. Differing deposition efficiencies of the phages were also supported by calculated XDLVO interaction energy profile.

Conclusion: Marine phages have a high potential for the use as sensitive tracers in terrestrial habitats with their surface properties playing a crucial role for their transport. Marine phages however, exhibit differences in their deposition efficiency depending on their morphology, hydrophobicity and availability.