Subseafloor microbial community in the Benguela upwelling area characterized by lipid biomarkers and intracellular DNA

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The subsurface biosphere in marine sediments is one of the least understood ecosystems on our planet. Currently, it is even subject to debate which domain of microbial life, Bacteria or Archaea, is dominant. So far, studies based on intact polar membrane lipids (IPLs) have indicated dominance of lipids associated with Archaea [1], while most DNA-based studies have suggested a higher proportion of Bacteria [2]. These contradictory results are thought to result from analytical and/or systematic biases of both techniques. In the case of IPLs, the associated organic matrix may hinder proper HPLC-MS detection due to ion suppression. In addition, both IPLs and DNA analysis may be affected by a potential pool of fossil compounds [3, 4]. To overcome these problems and achieve a more realistic view of the microbial subseafloor biosphere, novel methods were applied to samples of a transect across the Namibian Continental Margin.

We employed a new protocol for separating intracellular DNA (iDNA) from the remaining extracellular DNA-pool. For IPLs, a new method was developed and applied, based on solid phase extraction (SPE) of lipids with a phosphatic head group, resulting in strongly improved detection.

The analysis of iDNA and IPLs showed a distinct change of the microbial community. iDNA- and IPL-data were in good agreement. SPE clean-up of IPLs resulted in the detection of phospholipids that could be attributed to sulfate reducing bacteria. Previously it was not possible to detect any phospholipids in subsurface samples of upwelling areas [5]. Both iDNA and IPL analysis showed a dominance of Archaea in organic-rich sediments below the upwelling cell, while further offshore the sediments were dominated by Bacteria. Further interpretation of these trends and the downcore profile of iDNA and IPL distribution is ongoing.

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Revealing the 'blind spot': A simple physical model for the temporal evolution of silicate mineral weathering

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Closing the gap in the orders-of-magnitude difference between field and laboratory weathering rates has been considered essential to effectively modeling silicate mineral reactivity from centennial and millenial to geologic timescales[1]. However, what if finding the rates in the mid-range (i.e. $10^{1.5}$-$10^{3.5}$ yr) between far-from-equilibrium conditions in laboratory experiments and near-equilibrium conditions in the field is just as useful as what we now know about the two time-dependent rate extremes? We test this hypothesis by comparing the effects of two models ("gap" or blind spot and "filled") of weathering rate constants k to a mineral dissolution model driven only by the physics of reaction-diffusion dynamics. The explicit neglect of intrinsic factors, like chemical composition and mineralogical structure, in this simple model is an attempt not only to put an emphasis on the frequency and, in effect, duration of time with which a mineral surface interacts with pore fluids; but also to test if the reported agreement in phenomenological effective rates $K(t)$ between numerical and analytical solutions in comparable decay systems [2] also hold true for silicate weathering rates. Preliminary findings from our model simulations indicate that (1) there is no marked difference in effective silicate weathering rates $K(t)$ (yr^{-1}) between the two models of rate constants ($4.86x10^{-2}$ t^{-1} and $4.88x10^{-2}$ t^{-1} for "filled" and "gap" distributions, respectively), suggesting that the apparent "blind spot" within the centennial to millennial range may not preclude our ability to predict mineral dissolution at these timescales; (2) the subsequent weathering beyond $t \sim k^{-1}$ exhibits a fall in rates of up to ~3 orders of magnitude since the effective cessation of logarithmic decay, possibly reflecting the onset of a progressively refractory stage due to finite-size effects; and (3) a simple reaction-diffusion model may be able to predict the temporal evolution of silicate weathering as an integral of both field- and lab-derived rate constants, putatively identified by a lognormal distribution and therefore the kinetic heterogeneity associated with mineral dissolution.

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