Global distribution of sulfate reduction rates in marine sediments

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Sulfate is the dominant terminal electron acceptor in marine sediments. Sulfate reduction proceeds under anoxic conditions and is supported by a variety of electron donors (e.g. hydrogen, acetate, methane, propane, and butane), most of which are supplied by the decomposition of sedimentary organic matter. Consequently, a combination of primary productivity and water column depth is often thought to control sulfate reduction throughout most of the ocean's seafloor [1, 2]. However, global models of sulfate reduction do not resolve the many different physical and ecological parameters that are encountered on a global scale, and that ultimately play a major role in driving local and regional sulfate reduction rates. We sought to better determine sulfate reduction rates on a global scale, irrespective of region or location by 1) including sulfate profiles from diverse settings and 2) compiling multiple geochemical parameters that are relevant to sulfate reduction and can help discern the magnitude of sulfate reduction rates. All available sulfate concentration profiles from DSDP/ODP/IODP (to Exp. 312) and additionally those in the database Pangaea (www.pangaea.de) were compiled reaching a total >600 non-repetitive concentration profiles. Basic metadata describing the cores was included, such as water depth and distance to shore. Water column data such as minimum percent O_2 saturation, bottom water O_2, NO_3^-, PO_4^{3-}, and concentrations of surface water chlorophyll a and POC [3, 4] were included as additional variables that describe the biogeochemical setting of the cores. All compiled data and concentration profiles were applied to a training algorithm to estimate global sulfate reduction rates. The result was the most precise depiction of global sulfate reduction rates at the highest resolution to date. Our model serves as a platform for the examination of biogeochemical processes on the global scale and lets us predict energetic constraints for microbial metabolism in the subseafloor.

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Geometry of carbon and oxygen isotope exchange fronts in the Alta aureole, Utah: Records of hydrodynamic dispersion and scale-dependent permeability during infiltration-driven metamorphism

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A carbon (C) isotope exchange front, periclase reaction front and an oxygen (O) isotope exchange front are developed with increasing distance from the igneous contact in dolomitic marbles of the south Alta aureole, Utah in response to infiltration-driven metamorphism of the marbles. Their relative distances from the igneous contact, approx. 100, 200 and 380 m, respectively, are consistent with down-temperature infiltration of water-rich fluid [$X(CO_2)$ <0.1 to 0.15] that was equilibrated isotopically with the adjacent Alta stock. At the aureole scale both the C and O isotope exchange fronts exhibit significant dispersion: there is significant variation in both $\delta^{18}O$ and $\delta^{13}C$ values at any given position for ≥50 to 100m to either side of the geometric centers of both fronts. Applications of one-dimensional models of advection-dispersion to these aureole-scale dispersed fronts yield a minimum dispersion coefficient of 2E-8 m^2/sec. However at outcrop and bedding scale, steep, coherent gradients in both $\delta^{18}O$ and $\delta^{13}C$ exist at or near bedding boundaries between marble layers of contrasting lithology and isotopic compositions; modeling of these profiles requires much lower diffusion/dispersion coefficients in the range of 7E-12 to 1E-14 m^2/sec.

The variable characteristics of the exchange fronts can be explained by scale-dependent heterogeneity and anisotropy in permeability of the marbles. Both C and O exchange fronts are characterized by significant dispersion at the aureole scale because of significant bed-to-bed variations in permeability, which are reflected by significant bed-to-bed variations in $\delta^{18}O$ and $\delta^{13}C$ values. These bedding-controlled variations in permeability lead to significant permeability anisotropy, with permeability parallel to bedding>>permeabillity normal to bedding. In contrast, permeability within individual beds appears to be relatively homogeneous, as suggested by relatively consistent mineral modes and homogeneous $\delta^{18}O$ and $\delta^{13}C$ values within individual beds, and by steep, highly coherent $\delta^{18}O$ and $\delta^{13}C$ gradients preserved at or near bedding boundaries.

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