Sponge silicon isotopes as a tracer of Southern Ocean water in the Atlantic

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There is evidence for changes in the volume of Southern Ocean waters in the Atlantic over glacial cycles. A switch between northern and southern dominated deep-water production, and associated heat transport, explains asynchronous temperature records between hemispheres over glacial cycles. Changes in intermediate water composition influences nutrient supply to the surface through upwelling and mixing. For example, an increase in the dissolved Si content of intermediate depth mode waters originating in the Southern Ocean during glacials may have promoted diatom productivity in the Atlantic resulting in a draw down of atmospheric pCO_2.

We have shown that the silicon isotopes ($\delta^{30}Si$) of live-collected sponge spicules reflects ambient silicic acid concentration in a transect across the Southern Ocean. Here, we corroborate this modern calibration by showing that the $\delta^{30}Si$ of sponges grown in low-Si water off Iceland fall on the same trend, and are isotopically heavier ($\delta^{30}Si$ -0.8 to -2.1 ‰) than sponges grown in high-Si Southern Ocean waters ($\delta^{30}Si$ -3 to -4 ‰). We have used the $\delta^{30}Si$ of sponge spicules extracted from sediment cores to reconstruct the Si-acid composition of Antarctic deep waters over the last 20, 000 years and to reconstruct the presence of Si-rich and Si-poor waters in the Atlantic. We present the first such downcore record of sponge $\delta^{30}Si$ from the Argentine Shelf (1048m), and discuss the variation in export of Si from the Southern Ocean over the last glacial cycle.

Solute transport in a thick, two-layered aquitard system

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Solute transport in clay-rich aquitards can be controlled by both advective transport (driven by hydraulic gradients) and diffusive transport (driven by concentration gradients).

Several aspects of solute transport in aquitards remain to be better defined or characterized. These include the accurate and representative quantification of large-scale (time and space) diffusive and advective transport parameters critical to understand and predict the long-term migration of contaminants in clay media. To increase our understanding of solute transport in aquitards, we present and interpret the results of: (1) field- and laboratory based studies to measure the effective diffusion coefficient (De); (2) field-based studies to define the transition from advective dominated to diffusive dominated transport; and (3) a field-based study to assess if solute transport through an aquitard system can be considered regionally consistent. All experiments were conducted using the conservative tracer δD. Field-based studies were conducted at a study area (290 km^2) located 120 km southeast of Saskatoon, Saskatchewan, Canada. The aquitard system in the study area consisted of 10-100 m of Quaternary glacial till and clay overlying 35-110 m of upper Cretaceous Snakebite Member (claystone).

Experiments showed De values determined from *in situ* testing were similar but slightly lower than the average De values measured in the laboratory. *In situ* experiments demonstrated that the transition from diffusive to advective dominated transport occurs at a Peclet mumber of approximately unity when the characteristic length is taken to be the plume length. Lastly, transport modeling of several high-resolution δD depth profiles through the aquitard system showed that solute transport throughout this regional aquitard system is controlled by diffusion, and that the timing of geologic-climatological events responsible for the δD profiles were consistent across lateral distances of approximately 25 km in spite of considerable variation in the thickness of individual aquitards.