Nonstationary heat transfer and interstitial solute diagenesis in disturbed sediments

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It is well documented that the exchange of solutes between sediments and overlying water is mediated not only by molecular diffusion but also by bioturbation. Bell jars have proven to be a powerful technique to study the effect of bioturbation (Luedtke, Bender, 1979; McCaffrey *et al.*, 1980; Rutgers van der Loeff *et al.*, 1984). Since bell jars influence the natural currents and turbulence of the bottom water, they are not suitable to quantify the effect of physical mixing on the sediment-water exchange. Both for this study of physical mixing and for the calibration of the turbulence regime within bell jars with the situation outside, there is an urgent need for methods that can quantify the pore water mixing in the surface sediment without interfering with the *in situ* conditions in any way.

As an approach to investigating the effect of bottom water turbulence on the sediment-water exchange of solutes, Michel and Caschetto (1985) used the natural temperature variation of the bottom water to measure the heat transfer in surface sediments. The resulting values for the *in situ* bulk sediment thermal diffusivity are not significantly different from values of about 3.5×10^{-3} cm^2.s^{-1} reported for heat transfer in the absence of physical mixing (*a.o.* by Matisoff (1980), who used a similar procedure), and the authors suggest that this result could invalidate the effect of pore water mixing on the sediment-water exchange of solutes.

Unfortunately, the measured thermal diffusivity is more than an order of magnitude higher than the reported values for the diffusivity of solutes resulting from pore water mixing in disturbed sediments: modelling of interstitial nitrate and silicate profiles has shown that effective diffusion coefficients are in the order of 10^{-4} cm^2.s^{-1} in surface sediments of the southern bight of the North Sea (Vanderborght *et al.*, 1977; Billen, 1978). Similar results were obtained from the diffusion of chloride into tidal flat sediments after an artificial reduction of the interstitial chloride concentration (Rutgers van der Loeff, 1981). Turbulent diffusion of this magnitude in the pore water is slow compared to the thermal diffusivity of water (1.4×10^{-3} cm^2.s^{-1}), and consequently it does not cause a significant increase in bulk sediment thermal diffusivity. Therefore, rather than questioning the existence of a turbulent exchange of solutes at the sediment-water interface, we have to conclude that heat transfer is a too rapid process to serve as a suitable tool for the study of pore water mixing. High energy environments may form an exception, provided that reference values for the thermal diffusivity in the undisturbed sediment are accurately known.

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