Investigation of preservation potential of sedimentary structures by ruled-lattice model for bioturbation

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Bioturbation is a mixing process of sediment and soils by activities of benthic animals, such as their nest building or foraging. In many places, bioturbation causes the time-averaging effect on fossil records, and it disturbs preservation of primary sedimentary structures. Therefore, in order to reconstruct paleo-ecosystem or paleo-environmental information from geologic records, it is necessary to quantify the degree of loss of the initial information by bioturbation . Here, we examined preservation potential of sedimentary structures by using a lattice model of bioturbation based on simple rules. The model implied that (1) a threshold of the sediment mobility parameter to make sedimentary structures massive exists and that (2) bioturbation may work as a band-pass filter against preservation of sedimentary structures, by which lamination showing the high-frequency oscillation in grain-size distribution becomes obscured whereas the low-frequency fluctuation is preserved.

In order to conduct numerical experiments of sediment-diffusion processes by activities of benthic animals, we developed the lattice model based on the simple rules. The probabilistic lattice model of bioturbation has advantages that it can easily incorporate the observations of both the behavior of benthic animals and the morphology of ichnofossils as the model parameters. In this model, sedimentary successions are discretized vertically to the lattice cells containing multiple sediment particles. Sediment particles in each lattice cell are assumed to move upward or downward following the prescribed probabilistic model at each time step. Lengths of particle migration are decided by the normal probability distribution. Thus, governing parameters of this lattice model are: the active-range of bioturbation, the probability of occurrence of particle migration, the average length of particle migration, and the probability of downward (upward) migration of particles. In addition to these rules employed in the lattice model of Schiffers et al. (2011), we added the effects of bed aggradation to the model, which are represented by the sedimentation rate and the primary sedimentary structures. Schiffers et al. (2011) suggested that the bioturbated structures observed in their experiments were well approximated by this lattice model.

Using our lattice model, we conducted the numerical experiments of bioturbation of parallel-laminated sediment, in which the initial concentration of tracer particles varies vertically following (1) single- or (2) multi-spectral curves. The degree of conservation of the primary sedimentary structures was quantified by the Fourier-analysis of the resultant concentrations of tracer particles preserved in the intervals deeper than the active-range of bioturbation.

Keywords: Bioturbation, Sedimentary structure, ruled-lattice model

