# Getting the time right: using simple stochastic models to estimate the long-term properties of stratigraphic successions.

John C. Tipper
Geologisches Institut, Albert-Ludwigs-Universität Freiburg
Freiburg im Breisgau, Germany

The relationship that is of the most fundamental interest to the stratigrapher is certainly that between time and thickness; that relationship is also the one that is the hardest to reconstruct correctly from the preserved stratigraphic record. The importance of 'getting the time right' – i.e. of determining which time-thickness relationship is correct for a given stratigraphic succession – is not purely an intellectual one. Quite the contrary, for successions whose depositional and erosional histories are interpreted using incorrect time-thickness relationships will usually end up being poorly correlated internally, with incorrect geometries and connectivities. The economic consequences of not getting the time right can be truly substantial!

It is never possible to determine, in detail, the true time-thickness relationship in a stratigraphic succession. But it is possible to predict the relationship that probably will result from the long-term operation of a known sedimentation system. To do this it is necessary that that system's thickness transition probability distribution be estimated, for instance by using some suitable model of the sedimentation system in question. One such model that proves to be particularly useful is the 'stochastic river', a two-dimensional budget-capacity model that can be thought of as representing an idealised single-channel river. The 'stochastic river' is composed of a large number of similar sedimentation systems linked together in a chain, with each system fed exclusively from its upstream neighbour. The systems are continually perturbed by having their capacities altered by various external processes; these might include long-term regional-scale processes such as tectonically-induced basement subsidence and isostatic adjustment, as well as short-term local-scale processes such as changes in river discharge. The capacity perturbations are driven by a random process, and the perturbations of adjacent systems are spatially and temporally coupled. The 'stochastic river' reproduces many of the patterns of transport, deposition and erosion characteristic of modern river systems. In particular, it reproduces the irregularly alternating, downstream-migrating patterns of deposition and erosion that result, for instance, in the development, migration and amalgamation of bars in gravel-bed rivers.

The 'stochastic river' can be used to synthesise the one-step transition probability distribution for the thickness changes in a sedimentation system for which the budget-capacity relationship is given. This distribution is a probabilistic encapsulation of the stratigraphic results that that system will be expected to produce over the long term. From this distribution, synthetic stratigraphic successions can be constructed. Analysis of these successions allows long-term regularities in the stratigraphic time-thickness relationship to be predicted, regularities that enable the stratigrapher finally to 'get the time right'.