

## The Stratigraphy Machine

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### Summary

The stratigraphic record is constructed by multiple geological processes acting over time scales as short as a few seconds to as long as hundreds of millions of years. The probability of preservation of the products of high-frequency processes is very low. The full range of depositional and removal processes constitutes what may be termed a “Stratigraphy Machine.”

### Sedimentation rates and time scales

Peter Sadler (1981) generated a graph that has long puzzled geologists – he demonstrated that sedimentation rates vary inversely with the duration of the elapsed time over which these rates are measured, from the temporary flood-plain deposits beside a river to the complete fill of a major sedimentary basin. This relationship has been referred to as the “Sadler effect.” Lengthy sections representing long time periods include a large number of sedimentary breaks. In fact, Ager (1973) remarked that the sedimentary record is “more gap than record.” However, it has taken the maturation of sedimentology and stratigraphy to provide a complete explanation of the Sadler effect.

The science of stratigraphy has been revolutionized over the last fifty years. The emergence of sequence stratigraphy as the standard method for documentation and analysis, the increased sophistication of facies analysis and other sedimentological methods of documentation and interpretation, and the increasing accuracy and precision of the Geological Time Scale, have enabled ever more refined interpretations of geological processes. It can now be demonstrated that the sedimentary record is a product of the simultaneous action of a range of geological processes acting over a range of rates and time scales, ranging from seconds to hundreds of millions of years (Miall, 2015; Figure 1).

### The stratigraphy machine

The stratigraphic record does not represent a simple accumulation of sediment over millions of years, but is a complex amalgam of the products of short, intermediate, and long-term processes, interrupted by hiatuses and unconformities generated over a similar range of time scales. Unconformities and other sedimentary breaks may be informally grouped into four broad classes, reflecting their duration and processes of causation (Miall, 2016). In most sedimentary sections,

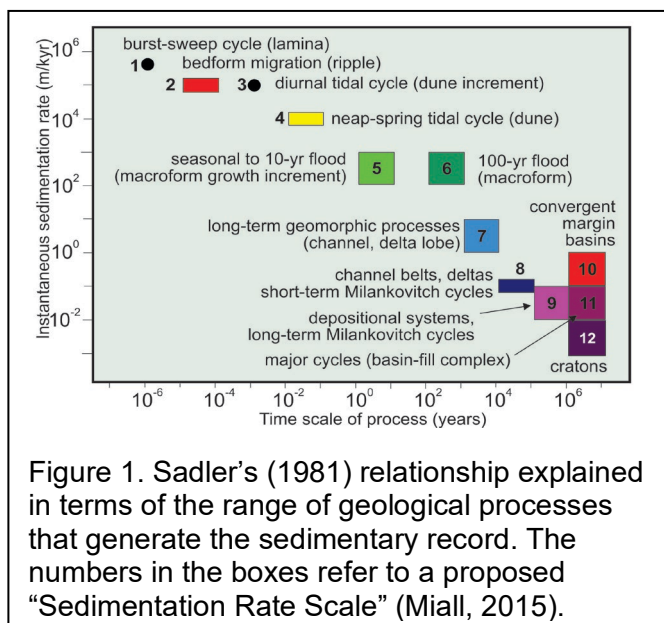


Figure 1. Sadler's (1981) relationship explained in terms of the range of geological processes that generate the sedimentary record. The numbers in the boxes refer to a proposed “Sedimentation Rate Scale” (Miall, 2015).

as little as 10% of the elapsed time represented by the section is recorded by actual sediment (e.g., see Miall, 2014; Bhattacharya et al. 2019). These processes may be formalized in the concept of a “Stratigraphy Machine”, as illustrated in Figure 2.

This figure represents an attempt to express in tabular form the hierarchy of processes that generate and remove sediments over the full range of geological time scales. For convenience, the time scale is subdivided into four broad and overlapping time ranges. To read the diagram, enter at the red arrow on the left. Sediments are generated by depositional processes, with preservation (downward directed red arrow) or removal (upward directed black arrow) creating the initial succession. With the passage of time, longer-term processes affect the succession (diagonal yellow arrow), with preservation and/or removal acting over the progressively longer time scales. High-frequency processes are episodic or gradual over extended time periods and affected by longer term processes. Thus, as implied by the nested loops at the base of the diagram, a longer allocyclic process or episode will affect the autogenic processes operating at the shorter time scales. Sufficient time ( $\geq 10^7$  years) must elapse for all geological processes to complete at least one full cycle. Numerous sedimentary breaks of various durations are generated at all stages, as indicated by the wavy unconformity symbol crossed by the upward-directed black arrows. The end product is the preserved rock record, and is represented by the lowermost box at the right. This shows the preservation of a basin fill by the long-term accommodation driven by plate-tectonic processes, for example, the slow thermal subsidence at an extensional continental margin. A guide to the use of this diagram and its application to stratigraphic interpretation is in press (Holbrook and Miall, in press).

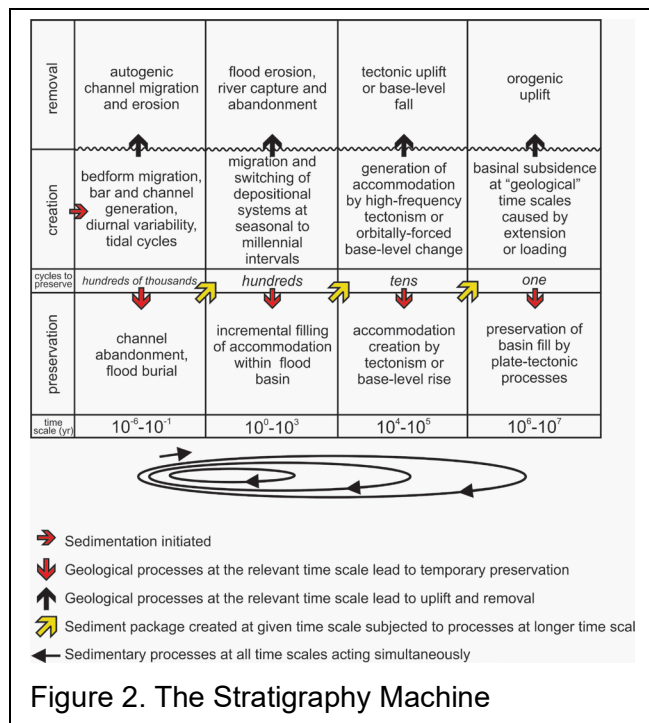


Figure 2. The Stratigraphy Machine

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