Tracing the Past Through Layers of Sediment

Signals in layers of sedimentary rock hint at climates and ecosystems come and gone. Understanding this history can help us forecast the future, but challenges abound.

Source: Journal of Geophysical Research: Earth Surface

Earth's stratigraphic record preserves clues about past climates, ocean conditions, tectonics, and more. The sequence of red bed paleosoils in the Bighorn Basin of Wyoming, for example, records the paleoclimate of a global warming event 56 million years ago. Credit: Brady Foreman

By Aaron Sidder 5 hours ago

The stratigraphic record (https://www.sciencedirect.com/topics/earth-and-planetary-sciences/geological-record)—layers of sediment, some of which are exposed at Earth's surface—traces the planet's history, preserving clues that tell of past climates, ocean conditions, mountain building, and more. As Rachel Carson once wrote (https://www.rachelcarson.org/SeaAroundUs.aspx), "The sediments are a sort of epic poem of the earth."

Yet interpreting how these sedimentary layers document Earth's past is complex and challenging. In a recently published study, *Straub et al.* (https://doi.org/10.1029/2019JF005079) identify three obstacles standing in the way of accurate stratigraphic interpretations and outline the grand challenges facing geologists trying to read the clues.

First, Earth's surface responds dynamically (https://eos.org/features/forgotten-legacies-understanding-human-influences-on-rivers)to the forces shaping it (e.g., climate, tectonics, and land cover change). Yet the environmental signals, or markers, of such change are often buffered and dampened by the movement of sediment (https://eos.org/research-spotlights/underwater-robot-tracked-ocean-sediment-during-hurricane-sandy), which diminishes the signals' detectability in sedimentary deposits. Second, surface conditions are recorded only when and where sediment accumulates; environmental conditions that do not coincide with this deposition will be absent in the recorded history of Earth. Last, environmental clues may be missing in rock layers because of the storage and later release of sediments in landforms like river bars and floodplains. This process, called signal shredding, destroys some sediment signals left by external events like storms and earthquakes.

In the review, the authors explore these impediments in depth, examining numerical, experimental, and field findings behind each. For example, when evaluating how signals are buffered as they move through landscapes, the authors dig into the diffusion equation (https://en.wikipedia.org/wiki/Diffusion_equation). The equation describes how a property is conserved in one dimension and flows down a gradient, for instance, how heat disperses through a medium. In a sedimentary context, the equation helps model the formation of alluvial fans and other topographic features.

As discussed in the study, four grand challenges confront geologists today as they try to improve interpretations of the stratigraphic record. These include the following:

1. Defining the causes of landscape stochasticity (https://www.merriam-webster.com/dictionary/stochastic)across environments
2. Increasing collaboration between research communities studying surface processes and stratigraphy
3. Embracing hypothesis testing and quantifying uncertainty in stratigraphic interpretations
4. Teaching both quantitative theory and field applications to the next generation of stratigraphers.

Improving stratigraphic interpretation, the authors argue, is key to unlocking quantitative information about the past that will improve forecasts of the future. Their exhaustive review charts a path forward for using the stratigraphic record to answer basic and applied science questions. (*Journal of Geophysical Research: Earth Surface*, https://doi.org/10.1029/2019JF005079 (https://doi.org/10.1029/2019JF005079), 2020)

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Citation: Sidder, A. (2020), Tracing the past through layers of sediment, *Eos, 101,* https://doi.org/10.1029/2020EO143043. Published on 01 May 2020.