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Editorial

The Incompleteness Fallacy: The Stratigraphic Record Is an ~~Imperfect~~ Archive of Earth's History

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The stratigraphic record cannot speak for itself, but human descriptions make it sound hopelessly scratched: incomplete, imperfect, shredded, full of holes, and even unfaithful.

To see nature as imperfect, we must have an expectation for how nature should behave, and we are disappointed. Objectively, though, nature cannot be flawed. Stratigraphy is not missing anything. It simply exists as the collective product of earth processes across time and geography. What *is* imperfect is our expectation for a perfect stratigraphic record, and whatever we mean by that.

When we say the geologic record is lacking, we set up a false dilemma around how we would like the record to be. For example, *stratigraphic incompleteness* requires the expectation of *completeness*. But what exactly does completeness look like?

> *Definitions belong to the definers, not to the defined.*—T. Morrison, *Beloved*

Stratigraphic completeness was defined by Sadler and Strauss (1990) as "the fraction of time intervals of some specified length (t) that have left a record." We often use the opposing term (incompleteness) in a subjective way, to highlight the 'inability' of rocks to provide a continuous physical record of the passing of time. This wish we have for linear depositional continuity may have roots in reductionist Newtonian dreams but is ungrounded in nearly everything that has ever happened on Earth.

We are correctly taught that the stratigraphic record is the result of at least eight competing processes, of which deposition is only one. Among the sciences, geologists have unique skills in managing this kind of complexity through time and space. However, by defining stratigraphy in terms of completeness–incompleteness, we flatten its complexity into something tangible, binary, and false. We set *deposition* as the goal, or the outcome we want, despite knowing that in any place at any point in time, deposition—just one of several possible outcomes—is unlikely.

Ironically, humans create false dichotomies to push back our old enemy, uncertainty. The binary choice between completeness and incompleteness gives us a sense of control because our analytical framework is reduced to what we can most easily measure (deposits).

Control has been a driving force behind western scientific observations since Copernicus suspected we were not at the center of the universe (Capra, 1987). It is a distinct possibility that the disorienting revolutions regarding humankind's place in space and time (Fildani, 2022) were a catalyst for seeking evidence of mathematical certainty in nature. By the 17th century, western scientists' desire to control for nature's unknowns had shifted to an aspiration to *control nature*. Francis Bacon led the way, advertising his empirical approach as the way to ensure Nature would be "hounded in her wanderings" and "put in constraint," and, as with the alleged witches of his day, that scientists should resolve to "torture nature's secrets from her" (Merchant, 1980). Though not so violent, even four hundred years later our descriptions of stratigraphy reflect the Baconian view of nature as something of a mess that needs fixing.

If as natural scientists we set a goal to filter the *good* from the *mess*, not only do we engage in a weirdly patronizing relationship with nature, but we also engineer a false sense of certainty. Geology's 'messes' get sidelined in favor of easier observations (see Dickinson, 2003), and we end up with a collection of precise measures adding to an inaccurate sum. We see experiments and models as more rigorous than observations from 'incomplete' sections. We present a neat, controlled view of the world that is not true.

We also undermine the best part of ourselves. Geology, as a historical field science, has expanded the scientific method in an underappreciated but essential and realistic way, by allowing for multiple competing hypotheses and the gathering of evidence outside the limits of experimentation (Cleland, 2001; Frodeman, 2003). Still, it is exactly because of its historical field methods that geology has a reputation for being, in the words of an editor at *Nature* (Gee, 1999), not a science at all. In this way, our descriptions of the stratigraphic record are not only inaccurate but also play into the bias that geology is less effective than the experimental sciences. Our withering language about geologic evidence could be a projection of our insecurities about the historical approach, and about our place in this made-up scientific hierarchy.

> *Perfection belongs to narrated events, not to those we live.*—P. Levi, *The Periodic Table*

All in all, making headway in stratigraphy depends on being able to stand in front of an outcrop and see not what is wrong, but what is possible. Our skill as geologists is seeing nature at its most real, and by focusing less on *certainty–uncertainty* (control) and more on the *range of possibilities* (context). With any single measurement or observation, in any science, the challenge is to make that datum relevant beyond itself. In stratigraphy, no measurement can be replicable in time or space, but each reflects—more than any datum from a controlled experiment—a real possibility within the context of natural complexity over time.

The key to collecting useful field data is to put a cloud of reasonable boundaries around each measurement, giving the datum relevance to other measurements within that greater context. For instance, *sedimentation rate* and *sediment flux* are not useful calculations by themselves. A value like *signal strength* only has meaning within the parameters of signal source and transfer medium. Adding boundary context like sediment composition, time frames, bed geometry, depositional environment, and basin structure opens the door to effective comparisons with other measured rates, strengths, and fluxes, and also to establish their natural range. Importantly, context provides a framework in which a less tangible factor like erosion or stasis is no longer an impedance to some kind of insight but rather accepted as an intrinsically probable component within those natural boundaries. With enough data and context, these boundaries around the stratigraphic record connect to tell its full story.

The stratigraphic record is not flawed, but it is important to remember that our experiments and theories mostly are, in that they are inherently unrealistic attempts to wrap our heads around the roughness of our chosen field. The answers to how Earth works will come from our acceptance of that truth, and from greater confidence in our abilities as geologists to measure nature beyond the limits of equations and experiments. The latter can be useful aids as we navigate the range of earth-surface processes, but we should resist being led by idealistic models when making real observations. We only get closer to some kind of accuracy by looking at the stratigraphic record for what it is, not what we want it to be.

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References

Capra, F. (1987). *The Turning Point: Science, Society, and the Rising Culture*. Bantam Books.

Cleland, C. E. (2001). Historical science, experimental science, and the scientific method. *Geology*, *29*(11), 987–990. https://doi.org/10.1130/0091-7613(2001)029

Dickinson, W. R. (2003). The place and power of myth in geoscience: an associate editor's perspective. *American Journal of Science*, *303*(9), 856–864. https://doi.org/10.2475/ajs.303.9.856

Fildani, A. (2022). The revolutionary impact of the Deep Time concept: Geology's modernity and societal implications. *The Sedimentary Record*, *20*(1). https://doi.org/10.2110/sedred.2022.1.1

Frodeman, R. (2003). *Geo-logic: Breaking Ground between Philosophy and the Earth Sciences*. State University of New York Press.

Gee, H. (1999). *In search of deep time*. The Free Press.

Merchant, C. (1980). *The Death of Nature: Women, Ecology, and the Scientific Revolution: A Feminist Reappraisal of the Scientific Revolution*. HarperSanFrancisco.

Sadler, P. M., & Strauss, D. J. (1990). Estimation of completeness of stratigraphical sections using empirical data and theoretical models. *Journal of the Geological Society*, *147*(3), 471–485. https://doi.org/10.1144/gsjgs.147.3.0471