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Sophisticated Stratigraphy – How we got here

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Summary

Stratigraphy is the key to the understanding of Earth history. "Sophisticated stratigraphy" is the science that is now being practiced. It refers to new tools, the application of advanced analytical techniques, and new forms of interpretation. Refinement of the geological time scale is an essential part of this work. and has been joined by new concepts of *cyclostratigraphy* and *astrochronology*. The modern stratigraphic record has been rendered comprehensible by developments in *sedimentology* and *sequence stratigraphy*, and has been fleshed out by the addition of much primary data obtained from the Deep-Sea Drilling Project and its successors. This paper summarizes the history of progress that was accelerated by the needs of petroleum exploration, beginning in the early 20th century.

The history of modern stratigraphic methods

The first stratigrapher was the canal engineer, William Smith, who enunciated the principle of the orderly succession of strata and their contained fossils, and produced the first comprehensive regional geological map, in 1815. It has taken 200 years and a revolution to bring all the necessary modern developments together to create the dynamic science of sophisticated stratigraphy.

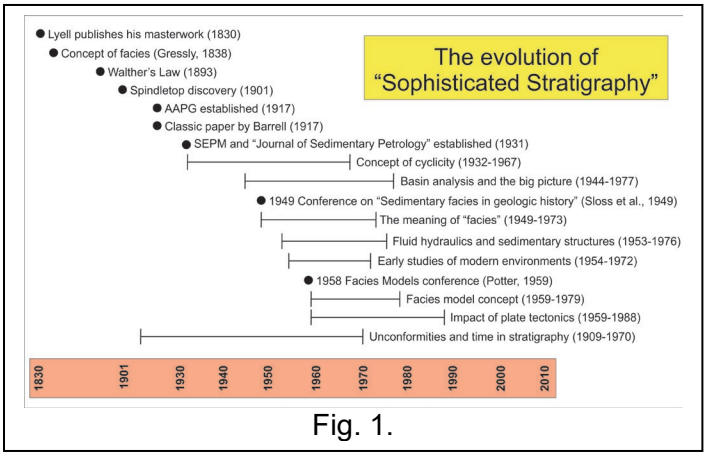

Fig. 1.

Until the 1960s, stratigraphy was largely a descriptive science, concerned primarily with the documentation of the lithologic and biostratigraphic successions of sedimentary basins as a basis for locating and exploiting fossil fuel and mineral deposits. The distinguished petroleum geologist Levorsen (1954) initiated many new ideas. However, over the last fifty years a profound change in approach has taken place, initially under the rubric of *Sedimentology*, which took sedimentary geologists away from description and classification into a focus on processes (Fig. 1). Only in recent years have *Stratigraphy, Sedimentology* and *Basin Analysis* come together to provide a dynamic, unified approach to the study of sedimentary basins (Fig. 2) (Miall, 2013).

The roots of modern, dynamic stratigraphy go back to the recognition of the concept of *facies* in the early nineteenth century, but it is argued here that the modern era began with the increased understanding of *fluid hydraulics* and *cyclic sedimentation* and the evolution of the *facies model* concept in the 1960s. The *plate-tectonics* revolution explained where and why basins form, provided a quantitative basis for their subsidence and uplift behavior, and elucidated the relationships between sedimentation and tectonics. As far as sedimentary geology is concerned, the revolution was not complete until the mid-1970s, when the re-classification of basins in terms of their plate-tectonic setting reached maturity.

The most important step in the maturation of modern stratigraphy was the emergence of sequence stratigraphy. The foundations were laid by Levorsen in the 1940s and Sloss and Wheeler in the 1960s, but it was the work of Peter Vail on the interpretation of modern seismic records (Vail et al., 1977) that eventually made it essential to bring together all the strands of sedimentary geology (lithostratigraphy, sedimentology, chronostratigraphy, the tectonics of basin setting) that until the 1970s had essentially been topics for separate study (Miall, 2016, 2017).

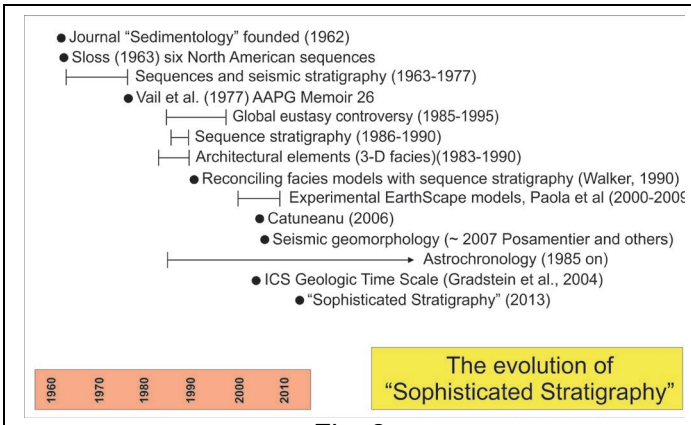

Fig. 2.

The future of Stratigraphy

- Continuous improvements in the accuracy and precision of the Geological Time Scale, with some geological intervals datable to a 10^5-year or even 10^4-year precision.
- Extension of the astrochronological time scale to parts of the Mesozoic
- For petroleum exploration: sub-salt stratigraphy and structure mapped with high-definition seismic. Real-time downhole monitoring and steering. Increasing use of seismic geomorphology to map stratigraphic petroleum plays in three dimensions, based on their depositional architecture.
- Groundwater mapping
- Better reconstructions of ancient climates (e.g., icehouse periods in the Cretaceous; the fluctuations of the Holocene), tightly constrained by time and temperature proxies
- More realistic applications of uniformitarianist principles for the interpretation of the ancient record, in terms of the rates and time scales of geological processes.
- Stratigraphy constitutes the master record of Deep Time.

References

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