

GEOLOGICAL PRINCIPLES

Preamble

... no individual wants to regard their life before last night as pure illusion.¹

Geological principles are statements of ordinary truth that help us understand Earth's makeup and workings. The following geological principles are used to read the rock record.

a19 Three fundamental stratigraphical principles due to Steno < strata >

Niels Stensen (1638-1686) (**Figure a19.1**) under the patronage of and physician to Ferdinand II, was able to ponder the nature of the strata (stratified formations) that are exposed in Tuscany, Italy. In 1669, he published *De Solido intra Solidum naturaliter Contento Dissertationis Prodrromus* (Forerunner dissertation on solid bodies [fossils such as shells and sharks teeth] naturally embedded in other solids [such as limestone and shale]). As this was written in Latin, he published using the name Nicolai Stenonis, a Latinized version of his Danish vernacular name. In this book (reprinted in Latin and in French during the 1700s and widely circulated) he clarified for others that strata originate sequentially and record a readable Earth history.² An English version of *De Solido*, 1968, with an introduction and explanatory notes by John Garrett Winter is available.³ Steno's principles (the truths of what he had seen of precipitations in bowls produced in alchemy experiments at the Lutheran Vor Frue (Our Lady) school, Copenhagen, Denmark, by his Latin teacher Ole Borch) are applicable to all Earth materials that have successively settled into place, had time to consolidate between settlings, and so are stratified.⁴

Principle of superposition Steno's first principle is to assume that young strata overlap older strata and, in any pile of them, the youngest stratum is at the top and the oldest stratum is at the bottom. This principle derives from an understanding of the true origin of sediments as accumulations of transported materials. In his words: "... at the time when any given stratum was being formed, all the matter resting upon it was fluid, and, therefore, at the time when the lower stratum was being formed, none of the upper strata existed."³

Application of the principle of superposition requires that the strata considered are correctly identified as sedimentary, or volcanic, and are not, say, gneissic layering, or multiply intruded plutonic igneous bodies.

This principle allows spatial relations between layers of rock to be translated into temporal relations. The layers contain information, such as: the physical depositional environment (erg, floodplain, lake, shore, marine, and so on) that existed, and the life (as sampled by the fossil content) that populated the past when each layer came to be. The multitude of events and their durations that have become known, now defy shoehorning to fit beloved myth and induce an appreciation of deep time.

Principle of original horizontality Steno's second principle is to assume that when sedimentary strata come into being they are horizontal. This principle derives from the observation of how solutes precipitated by a reagent settle in a basin to accumulate with a horizontal upper surface. By analogy, in water a dump of sediments that remains unconsolidated can become spread out by gravitational settling and current redistribution, and a horizontal stratum results. Internally a stratum can be cross-bedded.) When deposition is episodic, each stratum, can consolidate (become firm) before the next accumulates. Thus, boundary contacts between strata can be sharp.

Steno realized that mountains do not grow like trees, which take in material to expand, but are the inorganic result of the deformation of fixed volumes of preexisting rock. The core strata of the Apennines, in most exposures, are steeply inclined. So if they were originally horizontal they now record evidence of deformation by collapse, faulting, or folding. In his words: “Strata either perpendicular to the horizon or inclined to the horizon were at one time parallel to the horizon.”

Principle of lateral continuity Steno’s third principle is to assume that a stratum cannot end abruptly within a basin of deposition, but must feather out, or extend across the width of the basin and terminate against older rocks. In his words: “Material forming any stratum were continuous over the surface of the earth unless some other solid bodies stood in the way.” The principle of lateral continuity has application to the correlation of strata. Where the lateral continuity of the strata is missing, erosion or faulting can be inferred. In his words: “If a body or discontinuity cuts across a stratum, it must have formed after that stratum.” This statement anticipates the principle of cross-cutting relationships usually ascribed to Hutton for his illustrative use of it (*see* Topic a22)

Steno’s principles have wide application. In the case of volcanic rocks: 1) The principle of superposition can establish the relative age of lava and ash where these are piled upon each other. 2) The principle of original horizontality is not strictly applicable but it can be modified to refer to the original slope witnessed for lava outpourings. 3) The principle of lateral continuity applies to the distance that lava flows can travel before congealing as rock, which is to the perimeter of the volcano. Ash can be distributed as far as the wind may carry it. □

Figure a19.1 Niels Stensen [Nocolaus Steno] (1638-1686)

“Those who proclaim the large Glossopterae [literally: tongues of serpents] to be sharks’ teeth do not seem to me to be very far from the truth.”

And further study convinced him (even though he conceived of a world no older than that of historical time) that they are truly fossil shark teeth although superstition had it that the abundant Glossopterae in the source strata of Malta had become stone there to remind of Paul’s survival from the serpent that had bitten his hand and which he had shaken off back into the fire from which kindling it had crawled—a fire that he had built to warm himself having just survived the sinking offshore of the ship on which he had been traveling (*The Acts of the Apostles, Chapter 28*).⁵

On mountain heights, shells can be found that are perfect in their organic form and not irregular in their perceived growth as geometrical inorganic crystal masses commonly are. The shells he noted can be found broken or eroded but are never distorted as are vegetable roots grown in hard soil. In his view, shells are not “sports of nature” or in situ inorganic growths but are the remains of once living shellfish that had burrowed or were buried in place when, during a high stand of the sea, the enclosing sediments had accumulated.

Steno enunciated his stratigraphical principles from his alchemist’s knowledge of the way that showers of precipitants can accumulate in a bowl and from what he (later) perceived of stratified formations that are sedimentary.

