

a21 Two fundamental geological principles due to Hutton < granite >

To the geologist a rock is a page of the Earth's autobiography with a story to unfold. —Holmes.¹

Principle of crosscutting relationships: Whatever cuts off or cuts thorough something else, is younger than that which it cuts.

Hutton enunciated this principle after studying the field relationship of 1) granite and the country rock of “schist and limestone” in which it occurs at Sandyhills Bay (“... here we found the granite interjected among the strata, in descending among them like a mineral vein, and terminating in a thread where it could penetrate no farther. Mr Clerk's drawing, and a specimen which I took of the schistus thus penetrated, will convince the most sceptical with regard to this doctrine of the transfusion of granite”)¹ and at Glen Tilt, Scotland, and 2) of “trap” (*Brit. dolerite or Amer. diabase*) and the country rock of sedimentary strata of sandstone & limestone in which it occurs at Frederick Street, Scotland. This principle has wide application to establishing the relative age of things: An igneous intrusion is younger than the country rock that it intrudes. A fault is younger than the rocks offset by it. An impact crater that obliterates part of another crater is the younger one.

Steno in his *Forerunner*, 1669, stated the same (“If a body or discontinuity cuts across a stratum, it must have formed after that stratum.”)¹ but for field geology his priority can be denied as he gave no worked examples of its use. (*Note: Steno illustrates basin-fill strata (recall Topic a20) that cut off against older inclined strata.*)

Principle of inclusions (also known as the *principle of components*): Whatever encloses something else, is younger than that which it encloses.

Pebbles within a conglomerate are sometimes themselves fragments of a still earlier conglomerate—evidence of more than one cycle of erosion and uplift. Hutton clearly grasped this point: “The strata of the globe are also found composed of bodies which are fragments of former strata, which had already been consolidated, and afterwards were broken and worn by attrition, so as to be made gravel.

—McIntyre & McKirdy, *James Hutton (and to the memory of John Clerk of Eldin)*, 2001.¹

The origin of granite batholiths must address the room problem: How did the granite make room for itself?

If the granite stopped (a mining term for breaking away rock to make an opening) its way into the country rock, engulfed disoriented fragments of the country rock may be found in it. Then the contact is judged to be intrusive. Alternatively, if the country rock was changed into granite (granitized), country rock may be enclosed in it as oriented recognizable extensions of the country rock. Then the contact is judged to be metasomatic. In both cases, the granite is younger than the country rock.

If country rock in contact with granite encloses the granite as clasts (pebbles and boulders), then the contact is a nonconformity. The granite is older than the country rock.

Note: Steno's three and Hutton's own two principles were used by Hutton in *Theory of the Earth* to infer that land is restored from time to time by uplift of sediments that accumulate in ocean basins: “THE strata of the globe are actually found in every possible position: For from horizontal, they are frequently found vertical; from continuous, they are broken and separated in every possible direction; and, from a plane, they are bent and doubled. It is impossible that they could have originally been formed, by the known laws of nature, in their present state and position; and the power that has been necessarily required for their change, has not been inferior to that which might have been required for their elevation from the place in which they had been formed. ... WE are now to conclude, that the land on which we dwell had been elevated from a lower situation by the same agent [he thinks lithification requires partial melting] which had been employed in consolidating the strata, in giving them stability, and preparing them for the purpose of the living world. This agent is matter actuated by extreme heat, and expanded with amazing force. IF this has been the case, it will reasonable to expect, that some of the expanded matter might be found condensed in the bodies which have been heated by that igneous vapour; and that matter, foreign to the strata, may have been thus introduced into the fractures and separations of those indurated masses. WE have but to open our eyes to be convinced of this truth.” □