divine intervention is no longer an issue in science". This viewpoint ignores the continuing need of a sound philosophy in geologic research and teaching.

Gould comments that the acceptable view of Hutton's concept "belongs to the definition of science and is not unique to geology". Probably Sir Isaac Newton would have agreed that the law of gravitation belongs to all science and not just to his own field of physics. We recognize, however, that Newton's discovery came logically from researches in his own field. The concept announced by Hutton is a natural product of geologic study, though it is reinforced and shared by other fields of science.

The essence of the Huttonian doctrine is an essential part of geologic science; but the cumbersome term applied to the concept by Whewell is unnecessary and unfortunate. Let us hope that eventually it will be replaced by a more intelligible designation, such as "uniformity of process through time".

REFERENCE

Gould, S. J., 1965, Is uniformitarianism necessary?: Am. Jour. Sci., v. 263, p. 223-228.

REPLY

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The purpose of my original paper was twofold:

1. To demonstrate that the term "uniformitarianism" has been applied to two different concepts:
   a. A testable proposition asserting constancy of rates of change or of material conditions through time—substantive uniformitarianism.
   b. An undemonstrable, though entirely necessary, procedural assumption asserting spatial and temporal invariance of laws describing the operation of nature's processes—methodological uniformitarianism.
2. To assess the status of each of these concepts:
   a. The testable proposition is incorrect in any strict formulation.
   b. The *concept* embodied in the procedural assumption is essential, but the *term* "uniformitarianism" is unnecessary since the invariance assertion is synonymous with the principle of induction.

In this context, I believe that our maxim, "the present is the key to the past", contributes nothing to a resolution of ambiguities inherent in the term "uniformitarianism". We can extrapolate to the past either rates measured from present processes or laws abstracted from their operation. Hence the maxim, too, has both substantive and methodological senses and is thereby rendered as confusing as the term it supposedly explains. I regret that my poor choice of words led to misunderstanding; I did *not* suggest (1965, p. 225) that we abandon the present in our search to understand the operation of past processes.

The only directly observable processes are present processes. Of the operation of processes in past times, we have only fossilized results. Any inference

as to the mode of action of past processes can be made only by comparing ancient results with modern ones formed by processes we can directly observe. In an example cited by Longwell and myself, we find that a distinctive type of modern polished bedrock surface is always produced by glacial action and infer that strictly similar ancient configurations were similarly caused. Our confidence in this induction, and for that matter in the entire inductive process upon which all empirical science depends, is predicated upon the assumption of spatial and temporal invariance of nature's laws (methodological uniformitarianism); for, as Hutton said, (1795, v. 1, p. 297) "if the stone, for example, which fell today were to rise again tomorrow, there would be an end of natural philosophy, our principles would fail, and we would no longer investigate the rules of nature from our observations".

Is inductive inference justified? Shall we assume methodological uniformitarianism? These are two ways of stating the same problem. I therefore suggested that the *term* (methodological) "uniformitarianism" be dropped in favor of "induction" which has had priority at least since the *Posterior analytics* of Aristotle's *Organon*. I did *not* suggest that the *concept* be eliminated. That, after all, would be tantamount to denying the possibility of empirical science. (See my original paper, 1965, p. 226—"Methodological uniformitariansim as a statement of scientific procedure remains vital to geologic inquiry".)

The notion that asserting the "uniformity of nature" (Lyell's designation —Whewell coined "uniformitarianism") is synonymous with affirming the validity of inductive inference is common among philosophers. One of the most popular recent introductory philosophy texts states: "The principle of the uniformity of nature is also known as the principle of induction" (Sprague and Taylor, 1959, p. 100-101). J. S. Mill (1881, p. 183) contended that a statement of "the uniformity of the course of nature is the ultimate major premise in all cases of induction". David Hume, whose classic 18th century critique of induction set the context for most future work on the subject, states (1748, p. 44): "If there be any suspicion that the course of nature may change and that the past may be no rule for the future, all experience becomes useless and can give rise to no inference or conclusion". Nor has this observation passed entirely unnoticed by geologists. The paleontologist, E. D. Cope wrote of "the uniformity of nature's processes, or inductive reasoning" (1887, p. 10-11), and, recently, Scott contended that "a statement of this sort seems crucial to inductive inference (1963, p. 518).

Hutton temporally extended the realm of inductive reasoning to past Earth history just as the students of celestial mechanics had extended it spatially to the planets and stars. These two great synthesizing insights brought past time and extraterrestrial space into harmony with an earthly present that suffered no deviation from an order accessible to scientific inquiry. The alternative, taken by many catastrophists, was to propose divine suspension of natural laws in past times, making induction, and with it the idea of scientific geology, inapplicable to Earth history. In the throes of such a controversy, a special term describing the position of those upholding inductive reasoning throughout time was clearly useful.

The uniformitarians won the Earth for inductive reasoning and empirical science. Their *term*, used today in tilting at the windmills of non-existent opponents, is anachronistic. We so often see statements of the form: "Since all these molluscs live only in marine waters today, we suppose from the principle of uniformitarianism that the sediments enclosing them were most likely deposited in marine conditions". The phrase "from the principle of uniformitarianism" means no more than "using inductive inference", which, after all, is done whenever a scientist generalizes on the basis of particulars. It is naive, and very wasteful of journal space, to write a phrase having no more force than "I am being scientific" when an empirical generalization is made.

As for teaching, I believe that in preference to a complex word too often taken as a unique geological key (at least I took it that way in my freshman course), we should emphasize that the geologist's method of using the present to interpret the past is a particular instance of that inductive mode of reasoning that unites all the empirical sciences. If a student learns to appreciate the power of the scientific enterprise in general by understanding how basic notions are applied to one field in particular, this will have been far more valuable than the memorization of a term which, due to its double meaning, leads to confusion more often than to illumination.

I am glad that the apparent controversy seems to resolve itself into agreement. Professor Longwell and I both emphasize the need for study of present processes in attempts to understand nature's past operations: moreover, we both suggest that "uniformitarianism" be dropped as a term describing assumptions used in extrapolating from present to past.

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