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THE NECESSITY FOR GEOLOGICAL LAWS

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Geology, a sluggish science, with no diastrophic influence to affect it, for many years has made little impression upon the minds of business and professional men. It has meandered along haphazardly for decades until it now has reached a plane which, if it is to continue as a science, must be elevated to a position commensurate with scientific thought and belief.

Hopeful signs, even now, however, are beginning to manifest themselves. Current geological literature reveals an occasional expression of dissatisfaction with geological science as it now exists. There is too much of the quantitative and not enough of the qualitative; too much descriptive and argumentative geology and insufficient expository geology. Observations must be collected and tabulated, hypotheses expressed, and theories published.

But science can not end in supposition. Theories must be enacted into laws. Quantitative experiments give us facts for theorization, and innumerable observations of natural phenomena present us with evidence for hypothecation. First, there is the observation, then the hypothesis, next the theory, and finally the law.

Do we not at present have sufficient hypotheses and theories from which to establish definite geological laws? If geology is to become, or remain, a science, is it not necessary to establish certain fundamental geological truths and to teach these truths as basic facts?

Geology is not pseudo-science. Pseudo-science is unlawful; it has no foundation upon which to stand, no basic laws for support. Is there a Mendelian Law in astrology, or a Boyle's Law in divination? Do phrenology, mesmerism, or telepathy have a single law to authenticate their existence?

All science is based on facts, and these facts invite hypotheses, which evolve into theories, and which in turn demand laws. It is possible to state definitely several laws of geology. If these laws are not published in our textbooks and are not taught to our children, how can the average person distinguish between the science of geology and the pseudo-sciences which do not have and never can have basic laws? Why not substitute numeralogy for mathematics, or faith cure for medical science? True science is supported by unrefutable laws; pseudo-science is based only on hypothesis and superstition.

Laws of geology, though unrecognized as such, have been established through research and through the study and postulations of thousands of geologists. Such might be classified as general geologic laws, stratigraphic laws, paleontologic laws, and so on. For the purpose of "starting something" I am listing below a few geological laws which I believe are basic and which I also believe have passed from theory into fact. I do not attempt to prove these laws at this time. They are merely stated, together with a few comments.

1. *Every geological phenomenon is the result of some natural law.*

Simply because a superficial examination of the evidence does not indicate the cause, we must not say that the phenomenon exists because Providence willed it so. That is the explanation of by-gone ages. If folding or faulting in some areas can not be reduced to order by any mechanical analysis, we must not assume that these folds or fractures follow no law. Torsion, in rigid, elastic rocks, is produced by unequal elevations, subsidences, and lateral pressures with resultant systematic folds and fractures. If peculiar and intricate folds or faults are to be explained only in terms of the miraculous, then miracles must be considered wholly as manifestations of uncharted natural laws.

2. *No geological law can be established through the consideration of a single theory or hypothesis.*

A single fossil found in a particular bed of rock is only an incident. Two or three of the same species and variety may be coincidental and not particularly characteristic of that stratum. But if thousands of these same fossils are discovered similarly situated, with varieties of this species in adjacent lower beds and still other varieties in beds above, the fossils in question may be considered diagnostic of the stratum and are true index fossils.

A specimen of Wilcox Sand from the outcrop is found to be 12 per cent porous. Still other samples show porosities of 14, 16 and 18 per cent, respectively. Cores taken from oil wells show porosity percentages up to 30. When thousands of these tests have been made, it is safe to generalize that the porosity of Wilcox Sand is from 12 to 30 per cent, though the generalization may be delimited to much closer figures when restricted to definite oil fields or to localities within a specific field.

To formulate a geological law, it is essential that all information possible be procured from every available source, from professor and student, from geologist and paleontologist, from chemist and physicist, and from engineer and farmer. Hypotheses may be born in the field or in the laboratory, and then may mature to full-grown theories through surface observations or by a study of detailed sub-surface data.

No single theory is adequate to explain the principles of sedimentation, the mechanics of rock deformation, the origin of oil, or the migration and accumulation of petroleum.

3. *Every observable geological phenomenon has its counterpart in similar greater and lesser phenomena.*

Generally speaking, the microscope reveals nothing new. Mineral crystals, microscopic in size, have identically the same form as large cystals of the same mineral. Weathered rock under the microscope appears exactly as it does to the naked eye on the outcrop. Bleached limestone examined microscopically reveals the same characteristics, even to the extent of exhibiting partially weathered-out fossils, as bleached limestone on a much larger scale on the ground surface. Many macrofossils have their counterpart in fossil organisms less than a millimeter in length.

Nonconformities may be large, or they may be so small as to be determined only microscopically. Faults, occurring along fractures or shearing planes, may be large, or they may be microscopic in size. Identical types or faulting and folding are recognized in regions many miles in extent and in the smallest hand specimen of rock.

Even the Biogenetic Law (ontogeny recapitulates phylogeny) illustrates the principle that the small thing always has its counterpart in the more extensive. These facts are daily coming to be more universally recognized.

4. *In every normal section of stratified rocks, the lowermost beds are the oldest, and the strata above, in ascending order, become successively younger.*

This theoretical statement has been amenable to proof for many years. The fact that it requires abundant proof is conclusive evidence that it is worthy the status of a law. But a law is a guide to future action and endeavor. Is the above statement such a guide? I think it is.

In all practical geologic work, in all our economic labors, the age of the rocks in question is of the utmost importance. In economic geology the relative age of rocks tells more than any other one thing facts concerning their origin, structure, lithology, and economic value.

5. *With the exception of some of those formed chemically, all sedimentary rocks are deposited in a horizontal, or nearly horizontal, position.*

Calcareous tufa, precipitated from springs and waterfalls, is not often deposited in horizontal layers. Stalactites and stalagmites, also formed by chemical precipitation, may be laminitic in nature, but show little, if any, horizontal bedding. On the other hand, beds of gypsum, anhydrite, and salt are distinctly stratified, as are our chemically deposited marine limestones.

Talus, when submerged and covered with other sediments, might properly be called "detritus." Such a zone would consist of a heterogeneous mass of fragmentary rock. Basal conglomerates are often detrital in character. The clastic horizontal Lower Simpson beds in the Oklahoma City field were the cause of much confusion and argument two years ago. Their straitigraphic nature was not readily discernable, and only a paleontological comparison with Lower Simpson in other areas was sufficient to straighten things out.

Wind-blown sand in time becomes cross-bedded sandstone. Gravitational forces clear surface waters of even their finest sediments and deposit them as horizontal strata. Horizontal deposition is so universally recognized that there is little room for argument. Unusually steep initial dips have been observed by Bridge and Dake* in southeast Missouri. Were it not that the dips of undisturbed beds in this area are exceptional and that conditions under which they were deposited are peculiar to the region and relatively infrequent, it might well be supposed that horizontal deposition is substantially theoretical and that highly tilted beds of limestone in any area are *in situ* exactly as precipitated from the clear, warm waters of the sea. Dake and Bridge give a very satisfactory explanation as to the conditions of sedimentation and the manner in which these limestones and dolomites were deposited at such high angles.** They say that the condition most favorable for the development of such dips would be a rather rapid submergence of the rugged pre-Cambrian surface. The lime oozes collecting on the slopes of these submerged porphyry knobs would rest at dips up to the maximum angle of repose of such materials, and the narrow and winding character of the bays between the higher knobs, in such an archipelago as probably existed, would prevent excessive wave action and favor the accumulation on steep slopes.

6. *Every stratum of rock is a lense.*

Proof to corroborate the truth of this stratigraphic law, were such the purpose of this paper, would consist in showing that every stratum of rock is bounded by the sea or by other strata. The question might arise, "How would you classify a faulted lense? Is it still a single lense? Is it one stratum, or is it more than one?"

7. *The presence of plant and animal fossils in original stratified rocks is proof of the former proximity of living organisms to such rocks. The absence of fossils in stratified rocks, however, does not prove that living matter did not previously exist there.*

Planktonic organisms may die, and their remains, which then become subject to factors controlling inorganic sediments, may be entombed by the rapid deposition of sands and muds. Such organisms will be preserved under conditions tending to an extremely rapid rate of deposition of sediments, whereas benthonic, and to a more limited extent nektonic organisms, both inhabiting sea and lake-bottoms, could not even exist under such conditions. The nektons are hardy, and were it not for their natural enemies, the planktons—carnivorous fishes, for instance—much laborious fine-combing of certain rocks for fossils would be eliminated. The benthos, though dependent on ideal conditions for fossil preservation, should command high respect as indicators of the age of the rocks in

*Bridge, Josiah, and Dake, C. L., Mo. Bur. of Geol. and Mines, 55th Biennial Report, Appendix I.

**Op. cit.

which their remains are found. Certainty of preservation is only possible under extremely rapid sedimentation. Alternating slow and rapid deposition, such as results in thin, interbedded shales and limestones, should preserve many reliable, uninjured, benthonic forms.

The word "proximity" is relative in scope, and the value of a law containing such a word, unless delimited, is questionable. The above-mentioned law might properly be made to read: "The presence of benthonic fossils in orginal stratified rocks is proof of the habitat of such living organisms."

The latter part of this law, as first stated—the absence of fossils in stratified rocks does not prove that living matter did not previously exist there—is more explicit and intelligible than the former. A very great percentage of living organisms is destroyed by scavengers. Metamorphism, rock flowage, and other earth movements demolish countless others in the fossil state. A paucity of fossils in a shale bed may be interpreted to mean that few living organisms were present during its deposition, while, as a matter of fact, they may have been extremely abundant. In dolomitized limestones and in sandstones and sandy shales, preservation may have been defeated by chemical solution and by the solvent action of connate waters.

8. *Gradual changes in specific fossils in rocks extending from older to younger strata prove definite differences in the ages of these rocks. Such continuous changes also prove the fact of evolution.*

Such a law as this can easily be demonstrated by the vertebrate paleontologist. The evolution of the horse, the camel, and of certain amphibians is typical. The invertebrate paleontologist has still greater demonstrative opportunities, though not so easily comprehended. A popular and somewhat spectacular exhibition of evolutionary changes in invertebrates can be prepared from any average collection of cephalopods. The simple straight forms show a gradual change upward through the more complex curved shapes and on up into the intricate, completely coiled types. Palentology can be so demonstrative in proving the fact of evolution, yet the evolutionary arguments are left largely to embryologists, physiologists, zoologists, and other biologists.

9. *All rocks within the earth's crust respond in some manner to external forces.*

Recrystallization may be the result of dolomitization, simply the replacement of smaller crystals of one mineral for the larger crystals of some related mineral. Pseudomorphs, usually the same size as their models, are thus formed. Compaction and settling are readily demonstrated in the laboratory and are well known phenomena to the field geologists.

Isostasy is yet a theory in its entirety, but there can be no contradiction to the statement that it plays an important part in mountain-building and in the formation of many other geologic structures. The mechanics of folding is frequently subject to controversy, but the fact of folding due to external forces is universally recognized. Whether or not the continental drift theory ever obtains complete acceptance by the geological profession, the fact remains that if it has any basis for credence, external forces control the drifting.

In conclusion, it must be stated that obviously the geological laws herein considered are merely suggestions. Others may be more important and more worthy of consideration. But the use of geological laws is not impractical. No law is infallible. Many physical laws have been ripped asunder and discarded upon the discovery of new facts and new evidence. Do we expect the laws of gravity to stand forever? Nothing is permanent. Science—civilization—life itself, is based on change. As our political and social laws change from time to time, contemporaneously with our ever-changing ideas, so will scientific laws in the various sciences be modified and readjusted to meet the changing conditions.

It is my earnest desire and one ambition to place geology near the head of the scientific procession, to make of it a *comparative natural science.* For it really is an important economic science, one whose methods are characterized by extensive observations, classifications, and comparison of phenomena as they occur in nature.

If geologists will get together on fundamentals, from a time scale down to basic laws, they can make of geology a natural science comparable with the exact science, mathematics. With such rejuvenation of thought, geology will be firmly entrenched and a new cycle of scientific thinking begun that will make of geology as true a science as botany, zoology, chemistry, or physics.