Comments and Communications

Geology in the Grade Schools

MOST large universities have courses in geology, but they reach only a small segment of the population. An early foundation in geology is desirable for the many who never get to college. Why not start in the grade schools? Childhood is the age of wonder, of fresh impressions, of deep curiosity, and of great imagination—just the period of life in which geology should most appeal to young minds and can be best presented.

Children are eager to know the why of things, and simple, intelligent explanations of the objects around them would furnish a sound basis for understanding natural phenomena. Teach geology as the Mother of Sciences, not as one of the natural sciences. Some religious groups still think that the universe was formed in 4004 B. C. and consider that geology upsets the Bible. Such groups are politically powerful in many places and will, no doubt, oppose the introduction of geology in the grade schools. Their main objections are the fear, first, of upsetting Bishop Upshur's Age of Creation, 4004 B. C., and, second, of giving support to the theory of the evolution of man from lower animal forms. Geologic processes cannot be well taught without the time element, but evolution need not be presented in the grade schools.

It is outrageous that geologic subjects are so much neglected in the grade schools. In physical geography one finds references to metals and minerals and to nonmetallics, but there is insufficient information to supply the pupils with a sound idea of what goes on around them.

A dust storm furnishes a fine example of wind action; a heavy rainstorm, a lesson in erosion. Plaster and stone all come from rocks. The streets are made of concrete; in fact, the construction materials all contain a geologic story. Samples of sand, limestone, sandstone, and other rocks should be shown. It is really pitiable to find grown men and women who cannot recognize even the simplest rocks.

The fuels—natural gas, oil, and coal—can be explained in geologic terms. Agates and marbles and synthetic products should fall into the study, as well as gems and precious metals. Copper, brass, tin, and lead vessels are used daily in every home, as are china and pottery. Trace these products to their origins, and correlate the information by showing samples of ore and other raw materials.

Fossils introduce the subject of ancient life. The knowledge that living forms had ancestors millions of years old will appeal to children. Children should learn early that the sun is a great star, one of many billions, and the earth is perhaps but one of many billions of planets, with all the elements found in the sun.

Groundwork carried through the grade schools would in time give every child a knowledge of geology. In high school some laboratory work could be done on rocks and minerals. Earth processes, and even historical geology, could be discussed in greater detail. Students who do not go to college would at least have a solid foundation in general geology, and a better appreciation of the earth than most college students now possess.

The introduction of geology into the grade schools will demand tact and patience, and require organized educational processes. Simple school texts must be carefully and sympathetically written and skillfully illustrated. The books should be prepared by able geologists, even if they use "ghost" writers to assist them, since many scientific men deplore simplification or scorn it as unscientific. Geologists with the ability of a McGuffey should write such books. In a generation they would do more to make people realize that geology is a vital science than all the college texts and treatises.

All geologists should work together for the teaching of the most fundamental of sciences in grade schools. In time their efforts would result in more open-minded acceptance of the idea from educators and the public.

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Physiologic Limits of Vision

IN THEIR paper entitled "The Physiologic Limits of Vision in Physiographic Observation" (*Science*, 113, 176 [1951]), Olmsted and Olmsted stated that ". . . a cliff 100 ft high, at a distance of 13.06 miles, will subtend an angle of 5′, as does the letter of the Snellen '20-20' line viewed at its standard distance of 20 ft. It will be just perceived as a discontinuity of form by a person with 'normal' vision." The conclusion is then reached that, ". . . the discussion leads to a simple rule for field observation: a 100-ft cliff at 13 miles will be just perceptible under optimum conditions." The calculations seem to be based upon two erroneous concepts of visual acuity:

1. "Just perceptible" is dependent upon the size of detail (1′) rather than the over-all size of the letter (5′). Thus, if the comparison to the Snellen chart were to be made, it is a 20-ft cliff and not a 100-ft cliff that could be just perceived at the 13-mile distance.

2. The situation described is, however, not analogous to the perception of Snellen letters but rather to the recognition of vernier offset or change of contour, a faculty referred to by Duke-Elder (*Textbook of Ophthalmology*. St. Louis: Mosby, Vol. 1, 934 [1940]) as the faculty of the discrimination of contours. The average monocular threshold for this faculty is approximately 10″, and hence a cliff only 3.3 ft in height could be perceived at the distance of 13

miles. Binocular thresholds as low as 2″ were found by one of the undersigned (Anderson and Weymouth, *Am. J. Physiol.,* **64**, 561 [1923]) for vernier acuity, which would mean that under optimum conditions a "cliff" less than 1 ft in height could be recognized as a change in contour at a distance of 13 miles.

The conditions of contrast, illumination, absence of haze, and others mentioned by Olmsted and Olmsted would, of course, have to be optimum to obtain thresholds like those mentioned. In addition, since it is vernier acuity that is being considered, each line (ground and cliff level) would have to be of sufficient length.

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OUR paper was not primarily concerned with an exact definition of the resolution limits of the human eye under conditions of laboratory technique. Rather, we are attempting to evaluate the observations it will make in the field as an "instrument" of the reasonably careful observer of terrain.

It is true that the precision of laboratory instruments such as range finders, vernier scales, and the like is attained through observations of linear discontinuity far more subtle than 1′ of arc. Here the field is well illuminated, contrast is enhanced, and, above all, attention is meticulously directed to a single predefined region, line, or point. Under these conditions distinctions of the order of 2″–10″ are observed because the image on the mosaic of cones overlaps.

Again, it is true, as we pointed out below Table 1 of our paper, that the average normal eye will distinguish as unique a visual image subtending 1′ of arc. Indeed, many eyes will better this resolution somewhat. Here, again, good black-and-white contrast and adequate illumination are implied. The Snellen E is made up of three bars, subtending (for the 20/20 line) 1′ each and spaced 1′ apart. This 5′ form is easily observed at 20 ft by a normal eye as a recognizable letter when printed to extreme contrast and well illuminated.

We concluded, then, that under field contrast, haze, thermal distortion, and illumination, a cliff subtending about this angle would be recognizable by a careful observer scanning the horizon for detail. The chart of Fig. 1 was carefully drawn to illustrate this when viewed at 20 ft, to allow the interested reader to form his own "standard" based on this concept. In the construction of the chart other discontinuities of the order of 1′ of arc were purposely included. The knoll to right of center rises above the adjacent background by 1′. The notch half an inch to the left of it is of like dimension but with lower contrast of shading. The former is marginally distinguishable when sought as a known point, but the latter cannot be found. We agree, therefore, that meticulous attention to a minute sector of the horizon might permit the definition of these subtle discontinuities. However, such microscopic examination is not the method of even the most objective observer of topography in the field.

Hirsch and Weymouth have transferred our original subject matter from the field of geomorphology to that of a fine point of physiological optics. They quote our warning about haze, contrast, and illumination and admit that they would have to be "optimum" to reach their stated limits. They would not be satisfied by attainable optima. Rather they would have to be supernatural for 67,000 ft of atmosphere. Simple geometric extrapolations of the type being made by Hirsch and Weymouth are only valid in a vacuum. Thermal currents and minimum dust and haze completely vitiate them in the earth's atmosphere.

You can perhaps obtain from your window a line of sight to a building 1 mile away. Normal architectural cornice work allows discontinuities of the order of 1 in. If you could perceive these on a building 1 mile away, you would begin to approach Weymouth's 1 ft at 13 miles.

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A Choice of Difficulties

IN A recent letter G. W. Leeper (*Science,* **113**, 213 [1951]) states that scientific journals should either suppress bad work or else publish criticism of it. While agreeing with his main contention, I think attention should be called to a third course that is unfortunately followed by many editors. This is the publication of a paper after the removal of its worst features. In this form it may look like a contribution to knowledge and may mislead any reader who does not know the author personally.

If a paper has not been heavily edited, it is often possible to assess the competence of the author from the manner in which he writes or from internal inconsistencies in the paper. But when the style has become that of the editor, and when referees have ironed out the inconsistencies, what is the reader to do? Undoubtedly many papers are only sent to the editor after they have been improved in this way as a result of criticism by colleagues in the laboratory. This criticism, however, generally leads to some experimental revision; editing is a purely literary matter.

I contend that, if any paper has been subjected to significant editorial improvement—that is, to more than is needed to bring it into line with the conventions of the journal—this fact should be noted. An indication of the actual extent of the editing would be even more valuable.

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