LITERATURE REVIEWS

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GEOLOGICAL CHANGES AND TIME

ON THE SURVIVAL OF PALEOFORMS. C. R. Twidale. 1976. American Journal of Science 276:77-95. THE TEMPO OF GEOMORPHIC CHANGE. Maxwell Gage. 1970. Journal of Geology 78:619-625.

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The question of the amount of time required for geological changes is of considerable interest to those concerned about various theories of origins. Evolution needs all the time possible to increase the probability of unlikely events, and proponents of creation propose much shorter periods than those suggested by the standard geological time scale. The two papers considered here address themselves to questions of rates of geological change; hence are of great interest.

The first paper by Twidale entitled "On the Survival of Paleoforms" is the more comprehensive and technical of the two. It considers the question of the survival of some ancient topographical features of the past which according to several standard interpretations should have disappeared. These are referred to as paleoforms. The author discusses especially flat plain-like features that have a low relief; however, more irregular features are not ignored. Ancient plains recently exhumed by erosion do not, in Twidale's opinion, pose a problem, since their overburden protected them in the past from the erosion that might have destroyed them. However, this is not the case with those plains which appear to have been exposed to weathering for long periods of time, yet have survived. He states:

> *Even if it is accepted that estimates of the contemporary rate of degradation of land surfaces are several orders too high (Dole and Stabler, 1909; Judson and Ritter, 1964; see also Gilluly, 1955; Menard, 1961) to provide an accurate yardstick of erosion in the geological past, there has surely been ample time for the very ancient features preserved in the present landscape to have been eradicated several times over. Yet the silcreted land surface of central Australia has survived perhaps 20 m.y. of weathering and erosion under varied climatic conditions, as has the laterite surface of the northern areas of the continent. The laterite surface of the Gulfs region of South Australia is even more remarkable, for it has persisted through some 200 m.y. of epigene attack. The forms*

preserved on the granite residuals of Eyre Peninsula have likewise withstood long periods of exposure and yet remain recognizably the landforms that developed under weathering attack many millions of years ago.

Later he states: "The survival of these paleoforms is in some degree an embarrassment to all of the commonly accepted models of landscape development."

Twidale then proceeds to point out the inadequacies of the commonly held models of landscape development and proposes alternative ideas which may help explain the survival of these paleoforms. He suggests that rivers have a strong local influence on erosion and that paleoforms which happen to be between them are not eroded away as fast as the river beds themselves. This results in a tendency to increase relief with time. This idea is contrary to the generally accepted view that landscapes tend to become flatter with time. Other factors which the author feels contribute to the survival of paleoforms are the greater hardness of the rocks, protection from weathering effects in elevated areas compared to low-lying ones and several complex phenomena associated with erosional processes. The paper concludes by proposing a model "characterized by persistent and increasing relief" where the paleoforms are preserved while deeper erosion proceeds between them.

In the reviewer's opinion, Twidale's ideas make the generally accepted model for the formation of peneplains all the more difficult to accept. Peneplains are extensive plains of the past. Usually they are buried in the rocks that form part of the crust of the earth and are supposed to be the results of long-term erosion producing a near-flat surface. They are quite common in some sedimentary deposits, but their mode of origin has been much debated. If, as Twidale suggests, time increases relief patterns, the presence of extensive flat-like peneplains in ancient sediments may well represent features where little or no time for erosion has occurred, having been buried rapidly after deposition. This is a concept which Twidale and most other geomorphologists might vigorously reject.

Twidale's paper is particularly gratifying because he shows an unusual degree of independent thought, being quite free to challenge well-established concepts. His models are based on a thorough knowledge of field relationships; he has published extensively in this area.

The second paper entitled "The Tempo of Geomorphic Change" by Maxwell Gage also challenges some established geological concepts. The author feels that it is dangerous to extrapolate present-day rates to the past. He emphasizes significant variability in rates of change. Like Twidale he mentions very stable geomorphic features in South Australia which have survived since post-Paleozoic time (presumably several hundred million years). In contrast to this, some rivers on the steep western slopes

of the Southern Alps appear to be eroding their watersheds at a rate of 0.1 inch per year. If one extrapolates this figure back in time over a period of 10 million years, one would get 25 kilometers of erosion. Such conclusions would not be compatible with standard geological interpretations. Mention is also made of the Waiho River in New Zealand which during a single high intensity rainstorm elevated its bed from 10 to 80 feet over several miles. During the succeeding few weeks, rapid downcutting produced a flight of 10-foot terraces. Referring to these and other terraces, he states:

> *Colonized rapidly by plants in this moist temperate region, they soon acquire a false aspect of antiquity and in another environment might be mistaken for late Pleistocene degradational terraces.*

The next section in Gage's paper presents a variety of relationships between time and geomorphic change. He rejects the extremes of a rectilinear relationship as well as instantaneous change, characterizing the latter as "absurd." He opts for some kind of incremental pattern. He recognizes the importance of catastrophism, pointing out that the concept "has received perhaps less attention than it deserves"; however, he favors a model that gives greater importance to "smaller, cumulative changes." He concludes by steering a course between classical uniformitarianism and catastrophism, stating:

> *The uniformitarian approach may appear not to measure up to the requirements of quantitative work; yet it would be unjust to consider this doctrine invalidated merely because of difficulties due to our inadequate knowledge of the essential link between present and past.*

Both these papers raise some thought-provoking ideas. The writers exhibit a great deal of confidence in the standard geological time scale; yet if this were not accepted as sacrosanct, the concepts presented could serve as a strong basis for questioning its validity. Why have some paleoforms survived many times longer than expected? If variation in tempo in geomorphic change is so common, is it sound to extrapolate the present into the past? Unfortunately the proposed explanations given are not quantitatively evaluated and are not very useful in answering the time questions raised in this review. The scientific data of both papers indicate that much greater caution is warranted in approaching questions regarding the length of time involved in the past history of the earth.