



Fig. 2. Showing the relationships between shafts in various stages of development, superimposed on calculated depth and diameter versus time curves

(2) The United States workers propose abrasion by dripping and the effects of trickling water as being responsible for shaft formation. They make no mention of solutional effects. In contrast to this, the caverns described here are considered to be formed mainly by the solutional effect of water of an acid pH. It has been found that carbonic and organic acids are present in the incoming water. Titrations using EDTA reveal an increasing amount of calcium carbonate in solution, with a range of 0–105 p.p.m. (Corresponding pH readings have been given previously: (i), (iii).) No abrasive materials from either the grit or the limestone have been found in the pocket bases, but the abrasion due to friction of dripping water on limestone is yet to be estimated. It is considered that solutional effects, rather than physical ones, predominate.

(3) The transition from the juvenile to the mature stage has been observed to be due to lateral coalescence. This does not appear to have been mentioned in the American literature.

(4) Similar features have been located in other caverns of the same nature within the area (for example, Coeden Prop and Pulpit Hole).

(5) The formation of collapse dolines at senility illuminates the views of Thomas² and is correlated to the distributions which he illustrates, that is, that they are concentrated on the Millstone Grit.

Full results will be published elsewhere.

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¹ Merrill, G. K., *Bull. Nat. Speleol. Soc. Amer.*, 22, 101 (1960).

² Thomas, T. M., *Geomorphology of Breconshire, Brycheiniog*, 5, 121 (1959).

Salt Weathering and Inselbergs

RECENTLY, Wellman and Wilson¹ have directed attention to 'salt weathering', that is, 'the fragmentation of rocks by the crystallization of salts', as a geomorphic process of appreciable efficiency, especially in arid regions and along the sea coasts, but also at other places. They have shown that the formation of 'rock meal' and the development of pitted and cavernous rock surfaces are the most obvious symptoms of this type of rock decay.

During my field work, particularly in the Alps of Central Switzerland, I have here and there come across rock meal linings as described by these authors, for example, under overhanging rock ledges and at cave entrances, and in some cases the presence of 'salts' was obvious, either visible in form of efflorescences or verifiable by the taste of the rock meal. Once, I could even watch a mouse licking eagerly the salty rock meal. Such observations certainly lend support to the authors' findings.

Wellman and Wilson, however, also suggest that salt weathering has been, and is, operative in the formation of "some kinds of tors, and at least some hills that have been described as inselbergs". While I do not intend to question their observations of salt weathering and its influence on such land forms, I feel it should be emphasized in this context that salt weathering cannot—in the overall picture—be considered the principal, or even a major, process leading to the development of inselbergs and related forms. During geomorphic studies made over several

years in West Africa², I have become convinced that these land forms are essentially developing under semi-arid climatic conditions as a late stage in the sequence (or cycle) of pediplanation (scarp retreat and pedimentation)³. An assessment of the late Quaternary progress of pediplanation in Ghana has revealed that the scarp retreat associated with pedimentation is an astonishingly fast process and must—apart from erosive removal of debris—be due principally to vigorous physical breakdown ('exfoliation' in the widest sense, that is to say, the result of release of internal stress in the bedrock at or near its surface, ascribed either solely to removal of load by erosion, or to temperature variations, or differential hydration, or a combination of these and other causes⁴). While rounded exfoliation forms are preponderant on inselbergs consisting of granite or similar massive bedrock, sharply sculptured surfaces usually occur on the inselbergs of less massive bedrock. I do not remember having seen the symptoms of salt weathering on West African inselbergs and am inclined, therefore, to assume that this agent can only have very minor, if any, significance in that region.

It is now well established that the Quaternary climatic changes have left their traces not only in the higher but also in the lower latitudes of the Earth, and that, in the latter regions, they consisted essentially in variations of rainfall, or humidity. Thus it is understandable that inselberg landscapes, although developing typically in areas of moderate rainfall, are frequently found outside the present-day semi-arid zones in both humid and arid climatic regions. While with increased humidity they undergo modifications chiefly by chemical weathering under soil and vegetation cover (see, for example, the special cases described by Twidale⁵), an arid environment would obviously favour modifications by salt weathering as described by Wellman and Wilson.

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¹ Wellman, H. W., and Wilson, A. T., *Nature*, 205, 1097 (1965).

² Brückner, W. D., and Anderson, M. M., *Quaternaria*, 5, 95 (1962).

³ King, L. C., *The Morphology of the Earth* (Oliver and Boyd, 1962).

⁴ See, for example, Holmes, A., *Principles of Physical Geology* (Nelson, 1965); Louis, H., *Allgemeine Geomorphologie* (Walter de Gruyter and Co., Berlin, 1961); Longwell, C. R., Knopf, A., and Flint, R. F., *Physical Geology* (John Wiley and Sons, 1948); and other authors discussing this controversial topic of physical weathering.

⁵ Twidale, C. R., *Zeitschr. f. Geomorphologie*, N. F., 6, 51 (1962).