must, like the Watch Hill Grits, point to the existence of ancient crystalline rocks near by.

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8th November, 1947.

QUERY AS TO THE TEMPO OF AUSTRALIAN DENUDATION

SIR,—The conclusions of various workers in eastern Australian States indicate the survival there of extensive relics of very ancient land surfaces which have been continuously subject to denudation throughout several geological periods.

Andrews,[1] who has found very extensive residuals of peneplains forming a high plateau and a somewhat lower benchland in the New England district of New South Wales, has attributed the highest well-preserved peneplain (itself surmounted by some monadnocks) to a cycle interrupted in the Cretaceous period.

Basaltic lava flows of Oligocene or early Miocene age survive extensively in the New England district, and Voisey [2] has found that they bury a land surface of rather strong relief. The high altitude at which the residuals of the lava now stand is, therefore, in part original : they have been high enough above base-level to be subject to erosion for several geological periods, and yet they have escaped destruction.

Craft [3] recognizes a Triassic surface of almost perfect peneplanation (never since buried) in the Blue Mountains, and this, with flanking benchlands, makes a composite surface in southern New South Wales which was, he claims, in existence with a configuration very much like that of the present day (though then somewhat lower as a whole) prior to the outpouring over parts of it of Middle Tertiary basalts.

In Victoria according to Hills [4] the most ancient land surface survives in some plateau residuals on areas of particularly resistant rocks that have been at a fairly high altitude ever since the interruption by upheaval of a Cretaceous cycle of erosion. A later and lower-standing peneplain, extensively but imperfectly developed at the expense of the dwindling Cretaceous surface, was buried, together with monadnocks rising above it, under Oligocene basalts, and the compound mass has

[1] E. C. Andrews, The Geology of the New England Plateau, Part I : Physiography. *Rec. Geol. Surv. N.S.W.*, 7 (4), pp. 281–300, 1904.

[2] A. H. Voisey, The Tertiary Land Surface in Southern New England, *Jour. and Proc. Roy. Soc. N.S.W.*, 76, pp. 82–5, 1942.

[3] F. A. Craft, The Surface History of Monaro, N.S.W., and The Coastal Tablelands and Streams of N.S.W., *Proc. Linn. Soc. N.S.W.*, 58, pp. 229-244 and 437–460, 1933.

[4] E. S. Hills, Some Fundamental Concepts in Victorian Physiography, *Proc. Roy. Soc. Vic.*, 47, pp. 158–174, 1934.

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been subject to erosion ever since. Subsequently to this (in the Pliocene period) the differential upheavals took place which gave the more prominent mountain masses of Victoria, such as the Eastern and Central Highlands, their present relief and their initial form. Though subject since that date to continuous erosion, they have suffered only a moderate reduction in bulk.

So in New South Wales and Victoria the earth movements that initiated erosion over much of the region are to be regarded as ancient, and the tempo of denudation has been rather slow. This is borne out by the calcareous nature of the exiguous Tertiary marine sediments. Such a state of affairs may be contrasted with some of Teichert's recent findings in Western Australia.[1] In the North-west Basin of Western Australia this author finds anticlines and domes " in various parts of the basin ". Besides younger formations a very thick succession of Permian marine strata is extensively bevelled by erosion, and the terrain is also intensely faulted (p. 135). All the deformation took place in the Pliocene period, however. " The young age of the deformation is evident," he writes. " There is at present no clear evidence for more than one tectonic phase, and this is not older than Pliocene, since Miocene limestones, possibly even Pliocene, have been folded. The youthfulness of the structures is a factor that must be regarded as favourable to the accumulation and preservation of oil " (p. 136).

Yet the surface has since undergone an " almost perfect planation " (p. 135), and it had, indeed, been already planed even before the end of the Pliocene period, for the " almost continuous laterite layer " over the peneplain of Western Australia is regarded by Teichert as most likely a Pliocene formation (p. 119). From such findings one must conclude that the tempo of denudation in Western Australia has been unbelievably rapid. Judging from figures given by the author, if the geological history of the larger Desert Basin, where folded Permian strata are reported, can be assumed to be similar to that of the North-west Basin, the bulk of clastic sediments that resulted from this vast postulated Pliocene denudation might it seems, as a guess, approach 100,000 cubic miles, all of which must, of course, be now below sea-level in the Indian Ocean. This is obviously possible, but it is a large order : it would raise the level of the ocean by nearly four feet.

In the account Teichert gives of the late geological history of Western Australia under the head " Summary of Tertiary Palaeogeography " there is no hint of the occurrence of a Pliocene orogeny, or, indeed, of any differential movements whatever of that date. In writing this section the author has obviously overlooked the implications of the

[1] C. Teichert, Stratigraphy of Western Australia, *Jour. and Proc. Roy. Soc. N.S.W.*, 80, pp. 81–142, 1947.

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presence of the folded Miocene and Pliocene strata mentioned on p. 136. It seems necessary to assume also that the Pliocene date assigned (admittedly on negative evidence) to the folding of the thick mass of Permian strata is a still more serious error, the vast implications of which the author has failed to see.

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10th November, 1947.

TECTONIC HISTORY OF THE MALVERNS

SIR,—Dr. F. M. Trotter, in a private communication, has taken me to task for omitting any reference to the Forest of Dean or Mayhill in my recent note on the tectonics of the Malverns (*Geol. Mag.*, lxxxiv, 1947, p. 233). While this was partly intentional, I was certainly unaware at that time of the 1942 Survey Memoir on the Forest of Dean, apparently owing to an erroneous assumption that a revised 1 inch to the mile map usually precedes, or at any rate accompanies, a memoir. I should therefore like to remedy the omission.

Dr. Trotter points out that strong intra-Carboniferous movements during the post-Lower Carboniferous/pre-Upper Coal Measure time interval are proved by the attitude of the Crease Limestone (the basal member of the old Upper Limestone division of the Lower Carboniferous). This limestone, the chief repository of the haematite ores, has been worked to a depth of 800 to 1,000 feet for a distance of 5 to 6 miles on the eastern side of the coalfield, and its dip to this depth over the whole zone of working is within 20 degrees on either side of the vertical. The limestone is overlapped with great unconformity by the Upper Coal Measures.

Dr. Trotter also refers to the fact that between the south end of Mayhill and the Mitcheldean area the whole thickness of the Old Red Sandstone, together with the Carboniferous Limestone, dips westwards between 60 degrees and the vertical. It seems difficult to avoid the conclusion that the Mayhill structure, and the several N.S. structures in Lower Carboniferous rocks which protrude from beneath the Upper Coal Measures of the Forest of Dean coal basin, were formed by the same pre-Upper Coal Measure movements which produced the overturning in the Malverns.

Although these movements appear to have started in Lower Carboniferous times, and to have continued in places during post-Upper Coal Measure times (as shown by the westerly dip of between 20 and 40 degrees on the eastern side of the Forest of Dean), the evidence seems to suggest that the most violent episode, followed by great

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