

THE DARLING PENEPLAIN OF WESTERN AUSTRALIA.

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With Plate XXX.

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THE foundations of the study of the physiography of Western Australia have been laid deep and strong by Jutson in his masterly survey of the question in Bulletin No. 61 of the Geological Survey of that State, published in 1914. The author desires to express his admiration for the work done by this investigator, a work remarkable quite as much for its sobriety of hypothesis as for its scope of reading, care in investigation and profundity of deduction. As Jutson himself has pointed out, little detailed investigation of physiographic problems has been carried out in Western Australia, and the results of a preliminary statement of physiographic structure cannot be considered as final or complete. From time to time the author hopes to add contributions to the subject. The present note in some ways elaborates, and in others differs from the views of the previous author.

With Jutson's main premise, that the "Great Western Australian Plateau" is a vast uplifted peneplain, the author is entirely in agreement. Peneplain is here used in the sense of an almost level, or, at most, a gently undulating surface, carved out at an altitude very near base-level of erosion (usually sea-level), by the ordinary forces of sub-aerial erosion under humid conditions. As a result of many years of teaching experience, it has been found extremely

difficult to get beginners to remember the fact, that a peneplain is not a mathematical plane; and the same difficulty seems to exist in the minds of some geologists. Criticisms are frequently levelled at descriptions of peneplains because differences of level, amounting sometimes to a couple of hundred feet, are noted.

The evolution of a perfect peneplain, while rapid in its earlier stages, is undoubtedly almost inconceivably slow as completion is approached; and it is for this reason that, in most of the peneplains of Australia, various types of "residuals" of the older land surface, from which the peneplain has been carved, are left standing above the general level. Mechanical transportation of detritus is almost non-existent during the later stages of erosion, by reason of the extremely sluggish nature of the streams. On the other hand, chemical weathering, and the action of solutions are strongly predominant. In another paper (in the press) the author has endeavoured to show that these phenomena, combined with the action of a copious, but markedly seasonal rainfall, have been necessary and sufficient conditions for the production of the laterite capping which is so ubiquitous a feature throughout the length and breadth of Western Australia. The latter part of the thesis has been put forward by Simpson¹ and others, but, so far as the author is aware, the formation of the material

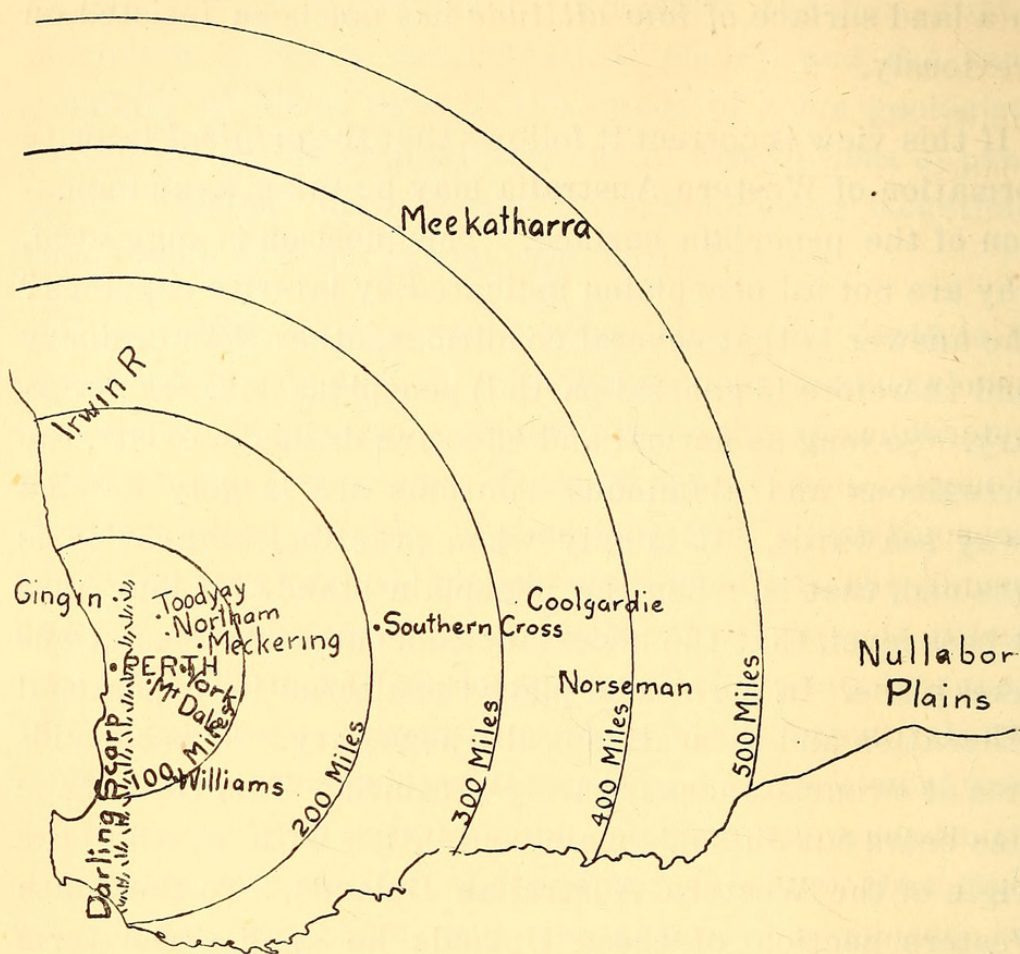
¹ Simpson, E. S., Laterite in Western Australia, *Geol. Mag.*, Decade v, Vol. ix, pp. 399 - 406, 1912.

Burton (*Rec. Geol. Surv. India*, XLVIII, pp. 204 - 218, 1917) believes that the laterites of the Central Provinces of India are lacustrine in origin, and in this he follows Middlemiss, Wetherell, and Fermor, (references in paper quoted). That such cannot be the case with the laterites of Western Australia is clearly shown by the occurrence of fine quartz and aplite veins *in situ* in the leached "pipe clay," which always forms the foundation of the laterite of the Darling Range. It seems probable that two essentially different but superficially similar substances are being called "laterite" in India and Western Australia respectively.

on a land surface of *low altitude* has not been insisted on previously.

If this view is correct it follows that the *original* laterite formation of Western Australia may be taken as an indication of the peneplain surface. The question is suggested, why are not all peneplains indicated by laterite cappings? The answer is that several conditions, other than ordinary (and therefore in general partial) peneplanation, are necessary. So long as normal and effective drainage exists, the ferruginous and aluminous solutions are largely carried away seawards. It is only when practical stagnation is attained, that is, when the peneplain stands for long ages at base level, that the necessary concentration of solutions takes place. In the second place the alternation of seasonal desiccation and saturation is also necessary. This coincidence of circumstances is rarely attained. This view of the case bears out Jutson's main contention with regard to the origin of the Western Australian Uplands. To the South Western section of these Uplands he applies the term Darling Peneplain, and it is to this portion of the area that the author wishes to draw attention chiefly. The altitude of the laterite "level" rises gradually from about 800 feet above sea level at the Darling Scarp overlooking the coastal plains, to 1,400 feet at Coolgardie, and 1,700 feet at Meekatharra.

The surface of the Darling Range is remarkably level (neglecting the obviously recently-denuded valleys of the existing streams) and the skyline is very even. When examined in closer detail, however, quite considerable differences in altitude of different parts of the laterite cap are noticeable. These are, in part, and probably principally, due to the sagging of the outer edges of "Mesa" cappings through the removal of the very decomposed granitic material on which the laterite universally rests.



In part, however, there is a real and fundamental difference of level. So far as the observations of the author extend (and the Darling Range area has been fairly thoroughly traversed) these residual differences amount to less than 200 feet in most cases, and this difference does not appear excessive when the proviso that a peneplain is not a mathematical plane is remembered. The present height of the laterite surface is due to epeirogenic uplift of the whole area under discussion to the extent of the difference in altitude between the laterite-level and sea-level. A tilt as well as an uplift is at first suggested. When, however, it is considered that the difference in altitude between Coolgardie and the Darling Scarp is only 600 feet, and the distance is about 300 miles, it is apparent that the gradient of the surface must have been negligible

even if the same difference existed prior to uplift. There is then no necessity to postulate a tilt as well as bodily uplift, though it is possible that such a tilt may have taken place.

Up to this point the author's observations are merely a corroboration and amplification of the principles laid down by Jutson. Here, however, the author desires to diverge somewhat. Jutson has made no mention of residuals of an older landscape standing above the surface of the Darling Peneplain, and such residuals are by no means abundant or conspicuous. One's outlook from one of the laterite scarps usually so circumscribed, owing to the heavy jarrah forests and to the youthfulness of erosion of the stream valleys, that an extensive prospect is rarely obtained. The author was fortunate enough to visit the estate of Mr. A. R. Gorrie near Chidlow's Well, and to obtain thence a magnificent panorama of part of the Darling Peneplain (Plate XXX, fig. 1). From this point of view the existence of monadnocks of considerable dimensions was at once recognised. The chief of these is Mount Dale, associated with which are a number of other out-standing peaks including Eagle Hill, Mount Randell and others. On two recent motor journeys between Perth and Albany, near views of Mount Randell (about 45 miles south of Perth) were obtained, and the general contour of the mountain strongly bears out the views stated as to its mode of origin. The same group of hills also forms a conspicuous landmark from the higher ground near Williams (100 miles south of Perth) and from this aspect also their residual character becomes apparent. There is therefore evidence of the existence of a higher, and therefore older, level of erosion for which the name of the "Mount Dale Level" is proposed.

Jutson has noted the highly mature character of many of the valleys on the surface of the Darling Peneplain, of which the Avon River at York and Northam is a striking

example. It appears to the author, however, that Jutson has not fully appreciated the significance of these valleys, which are extremely widely developed in the Darling Range area. They form a series of sub-parallel troughs, roughly meridional in direction, and parallel with the general "grain" of the country. They are very wide in proportion to their depth, that is, are highly mature, and are of the utmost economic importance, since they constitute the arable portion of the "Wheat Belt" of Western Australia. They *are carved out of the laterite covered plateau*, and their bottoms lie at least 200 feet below its level. The floors and sides are clear of laterite coating, and the basement granites and "greenstones" of the country are exposed.

The author regards these great longitudinal valleys as evidence of a slight uplift which occurred *after* the formation of the Darling Peneplain, and *before* its elevation to its present altitude. This uplift was of small amount, but sufficed to rejuvenate the drainage, and to reinstate the normal processes of corrosion; and the land surface remained in a stable condition long enough for advanced maturity of erosion to be attained, without production of a complete peneplain. For this reason the author suggests the name "Mature Valley Level" for the partial peneplain which was produced under the circumstances described. If a local name is preferred instead of that suggested, (and such is probably better, since there are other mature valley levels in Australia and elsewhere) the name "Meckering Level" may be substituted, since the prosperous agricultural town of Meckering occupies one of these valleys. Meckering is preferred to Beverley, York or Northam, as being more distinctively Western Australian, though the mature valley topography is even more marked at the towns mentioned.

At the time of the principal Darling Range uplift, these mature valleys were occupied by long, gently-flowing

"subsequent" streams, some of which probably fell southwards while others flowed to the north. As a result of the production of the Darling Scarp, new, active, consequent rivers came into existence. In the area under review these streams flowed from east to west, and, rapidly extending their valleys headwards, they gradually dismembered the older streams and produced the present arrangement of the drainage. While this latter part of the question is treated by Jutson, the author differs from him in some of his conclusions as to matters of detail, and intends to deal with the matter of river development in a subsequent paper.

At Northam and York (Figs. 59 and 60, Jutson *loc. cit.*) the Avon River has not yet been affected by the piracy carried out by the Swan. The stream occupies its ancient mature valley. A little further north, at Toodyay, however, the Swan is actively incising its valley and is in a comparatively youthful stage of development. Its bed lies far below the original valley bottom, but the positions of both the Darling Peneplain and of the Meckering Level can be traced quite readily; the former in the level-topped laterite covered hills of the 1,000 foot level, and the latter in the broad, gently sweeping, curved shoulders of these hills (Plate XXX, fig. 2).

In many parts of the Darling Range there is a strong suggestion of two mature-valley levels, but much more investigation will be necessary before such a fact can be substantiated. Passing eastward across the mature valleys of the Avon, Logan and other streams, the clearness of definition of the Meckering Level is lost, though, all the way, to Southern Cross at all events, the existence of mature valleys is noticeable. This is only what would be expected on the theory of a slight uplift after perfect peneplanation. The roughening of the land surface would be most pronounced near the coast, and would become less

marked inland. While it is really beyond the scope suggested by the title of the present paper, the author wishes to suggest the possible bearing of the theory, above outlined, upon the problem of the topographic development in the great interior Salt Lake Region. Jutson has implicitly stated that the summits of the higher levels in this region are the remnants of the Great Plateau. The author desires to make this statement explicitly, and to claim the laterite residuals like the Red Hill at Coolgardie (Plate XXX, fig. 3) as the remnants of a peneplain contemporaneous and co-extensive with the Darling Peneplain. During the great rest-period, when laterization was going on, this surface was at a much lower level than at present, quite low enough to account for the submergence below sea-level which has been noted at Lake Cowan (Norseman).

While it is by no means so certain as the fact of the existence of a western coast not far from the present one, there is strong probability that a coast line existed away to the south-east of the Coolgardie area. The comparatively recent date of the limestones of the Nullarbor Plains (Eucla Limestone Plateau of Jutson) suggests former extension of the Southern Ocean as a veritable Mediterranean Sea far into the south-eastern portion of the State.

The uplift which produced the Meckering Level on the western side rejuvenated the drainage on the eastern side as well. As Jutson has pointed out, there is every reason to believe that the climate of the interior of Australia was formerly much moister than it is now. Under such conditions a development of mature valleys analogous to those of the Meckering level may be postulated. As these would be base-levelled, their lower courses would undoubtedly enter salt water, and Lake Cowan may have been a bay or estuary.

About the time of the main Darling Uplift, which may also have caused the Bunda Scarp, the progressive desicca-

tion of the climate prevented the development of young consequent streams on the eastern side of the peneplain, and the previous normal erosion gave place to the cycle of arid erosion through which the region is passing at present. The author is of opinion that such a mode of development reconciles the somewhat divergent views which have sought to explain the great salt lake systems by arid erosion, by river erosion or by wave action.¹

The author has not travelled sufficiently extensively in the salt lake region to be able to speak with the same certainty as with respect to the Darling Range area, but wishes to suggest that some of the higher hills in that area such as Mount Burgess, north of Coolgardie, may possibly be residuals of the Mount Dale level. It is possible also that the recognition of a mature valley cycle of erosion may assist in explaining some of the difficulties which exist in connection with the origin of the deep leads of Norseman and elsewhere. Jutson has explicitly assumed such a cycle, subsequent to the main planation of the area (*loc.cit.*, p.98).

Age of the Different Levels.

The author agrees in every point with Jutson as to the evidences of date of peneplanation afforded by the Irwin River sections and those from that point southward to Gingin. The author has had an opportunity recently of re-examining the Irwin River area, and is convinced not only that: "the Jurassic rocks in the Irwin River district were uplifted with the granite," (Jutson, p. 94), but that the laterite level marking the Darling peneplain is continuous across the old fault plane which marks their junc-

¹ Gregory, J. W., "The central lakes of Westralia and the Westralian peneplain," *Geog. Journ.* 1916, pp. 326-331. Jutson, J. T., "Erosion and the resulting land forms in sub-arid Western Australia, including the origin and growth of the dry lakes," *Geog. Journ.*, 1917, pp. 418-437. Montgomery, A., "The significance of some physiographic characteristics of Western Australia," *Journ. Roy. Soc. W.A.*, vol. II, 1915-6, pp. 59-96.

tion. The evidence with regard to the Cretaceous rocks at Gingin is almost, if not quite as conclusive, except that the topmost member of the Cretaceous series, being a porous sandstone, is not a suitable rock to produce laterite. It is, however, so strongly ferruginous as to suggest that it was a superficial formation when laterization was in progress. Its position with regard to the laterite to the Darling Range is not identical with that on the Jurassic formation (fifty miles further north). It is certain, however, that it has been displaced to some extent by the formation of the main Darling fault. There is no doubt, then, that the peneplanation is post-Jurassic, and there is extremely strong presumption that it is post-Cretaceous.

With regard to its upper limit of age, the author is much more doubtful, and is inclined to place it much further back than does Jutson. The latter argues from the immaturity of development of existing valleys in the Darling Range, but, as the author has shown, these valleys do not date from the termination of what may be termed the "great laterite cycle," but from the close of the "Meckering Level" cycle. Assuming the latter to have been contemporaneous with the formation of the Norseman Beds, it is to the Meckering Level cycle that Jutson's reasoning applies with full force. This being so, the age of the Darling Peneplain must be notably older, since a considerable period must have been necessary, not only to excavate the valleys of the Meckering Level, but to bring them into such marked adjustment with geological structure as seems to be the case. The author would therefore place the date of the close of the main peneplanation at least at the lower limit (older Pliocene) assigned by Jutson, with a strong probability that it may even be somewhat older still.¹ Reasons

¹ The author feels strongly, that in view of the uncertainty which exists with respect to the correlation of the Australian Tertiaries, the use of such terms as Miocene, Pliocene, etc., is of doubtful advantage, and would prefer the use of a term such as Norseman or Eucla to indicate the ages of the formations developed respectively at these two places.

have been given for believing that the duration of the great laterite cycle was almost inconceivably protracted. *The beginning* of this period must therefore have been much earlier in Tertiary time, and the date of the Mount Dale peneplanation may have been quite early in that era.

Summary.

The author agrees with Jutson in describing the uplands of South-Western Eastern Australia as an uplifted peneplain but goes further, and claims that not one but several periods of uplift, with intervening periods of crustal stability, can be recognized. For the oldest peneplain, represented by a few scattered residuals only, the name "Mount Dale Level" is suggested.

The name "Darling Peneplain" should be confined to the laterite covered surface so widely developed in Western Australia, and reasons are advanced for believing that an enormously protracted period of crustal stability is demanded for the production of this peneplain.

A subsequent small elevation caused the development of an extensive series of mature valleys, for whose base level the name "Meckering Level" is suggested. It is probable that, during this cycle of erosion, mature valleys were carved on the eastern as well as the western side of the land surface, and that these valleys subsequently decided the development of the great salt lakes of the goldfields areas. Probably the marine beds of Norseman were developed during this period, and possibly also some of the deep leads.

A sharp uplift of the highlands, with an isostatic depression of the coastal area, brought about the existing conditions of topography. Dissection of the uplifted Darling Peneplain, now at an average altitude of about 1,000 feet above sea-level, caused dismemberment of the mature valleys of the Meckering level.

The author differs somewhat from Jutson in the ages assigned to these earth movements, and believes that the early or late Pliocene date assigned by that author to the Darling Peneplain should refer to the Meckering Level. The formation of the Darling Peneplain was older, while that of the Mount Dale Level may be as ancient as early Tertiary.

EXPERIMENTS ON THE BEHAVIOUR OF IRON IN CONTACT WITH SULPHURIC ACID.

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Two papers on this subject have already appeared.¹ Comparatively little research on this subject has been carried out, yet the matter is of great importance; the researches already published (*loc. cit.*) have therefore been continued. There are many peculiarities about the action of sulphuric acid on iron that have still to be cleared up, but we have confined our present experiments to two questions only.

Part I.—*A comparison of Iron in concentrated Sulphuric Acid with Passive Iron.*

Although iron is attacked very noticeably when first inserted into concentrated sulphuric acid, the action is much less vigorous after a few hours, and suggestions have been made by some chemists to us that in this case we may have to do with something resembling a “passive” state of iron. We have therefore performed some experi-

¹ Fawsitt and Powell, *Journ. Soc. Chem. Ind.*, xxxiii, 234, 1914; and Powell, *Proc. Roy. Soc. N.S.W.*, xlvii, 59, 1913.



Woolnough, Walter George. 1918. "The Darling peneplain of Western Australia." *Journal and proceedings of the Royal Society of New South Wales* 52, 385–396. <https://doi.org/10.5962/p.359732>.

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