CSIRO PUBLISHING

Historical Records of Australian Science, 2014, **25**, 28–42
http://dx.doi.org/10.1071/HR14007

J. T. Jutson: A Master of Synthesis

C. Rowland Twidale[A,C] *and Erland J. Brock*[B]

[A]School of Earth and Environmental Sciences, Geology and Geophysics, University of Adelaide, Adelaide, SA 5005, Australia.
[B]Academy of the New Church, Bryn Athyn, PA 19009-0717, USA.
[C]Corresponding author. Email: rowl.twidale@adelaide.edu.au

John Thomas Jutson (1874–1959) spent most of his life as a practising solicitor in Melbourne. He studied the Victorian coast as a hobby in his later years, though he became known for his work on the Sydney shoreline and the proposal that different processes have simultaneously generated platforms at various levels. Between 1911 and 1918, however, Jutson had been employed as a field geologist by the Geological Survey of Western Australia. Drawing on the work of colleagues as well as his own brief field experiences, he produced an explanatory account of the Western Australian landscape that was published in 1914 and reprinted in revised form in 1934 and 1950. In his synthesis he discussed hitherto neglected arid zone landforms and processes. He presented evidence and argument pointing to the plateau and high plain that occupies so much of the interior of the State being a two-stage development. He attributed it to what would later be called etching, resulting in double planation at a regional scale. His innovative interpretations brought Jutson international recognition.

Introduction

J. T. Jutson was, in the estimation of Rhodes W. Fairbridge, 'truly one of the great geomorphologists of the world'.[1] Such a flattering assessment carries considerable weight, for Fairbridge was himself a scientist of international standing.[2] Born and raised in rural Western Australia and having served on the staff of the University of Western Australia, he was familiar with the State, its landforms and the challenges they offered. He was thus well placed to assess Jutson's contributions to landform studies, for it is mainly on his analyses of the physical face of Western Australia that Jutson's work was, and is, measured. Jutson's contributions to the earth sciences in Western Australia earned him the Clarke Medal of the Royal Society of New South Wales in 1937 and a Doctor of Science degree from the University of Western Australia in 1947.

Jutson's *magnum opus*, Bulletin 61 of the Geological Survey of Western Australia, was published just a century ago, in 1914.[3] Entitled 'An Outline of the Physiographical Geology (Physiography) of Western Australia', it was a synthesis based partly on Jutson's own field investigations but largely on the work of his colleagues at the Geological Survey, namely, Andrew Gibb Maitland, Torrington Blatchford, Robert A. Farquharson, Henry W. B. Talbot, Edward de Courcy Clarke, Francis R. Feldtmann and C. Sidney Honman. Though concerned to provide an explanatory account of the landforms and landscapes of Western Australia, Jutson of necessity also provided a review of the State's geology and physical geography (that is, its climate and vegetation) as well as its landform assemblages. He felt it necessary to justify such a report's being mainly concerned with landscape, but it evidently filled a need for it brought him instant recognition: in Western Australia it was for many years the only available text for students of geology and geography of the State. It included hitherto unrecorded observations and interpretations of arid-zone landforms and processes and became well known both nationally and internationally. Such was its value that in 1934 a revised and expanded version appeared as Bulletin 95, 'The Physiography (Geomorphology) of Western Australia'. This was reprinted in 1950.[4]

Biographical Outline

John Thomas Jutson was born in Melbourne in 1874 and died there in 1959.[5] He was educated at Victorian state primary and secondary schools, and he may have worked as a pupil

Figure 1. Lilian and John Jutson, *c*. 1900.

teacher during the last decade of the nineteenth century. In 1900, he joined the legal firm of Fink, Best, and Hall as a law clerk. In the same year, having become interested in the subject through reading, he enrolled at the Working Men's College (later RMIT) to study geology under George B. Pritchard.[6] In 1908 he was awarded a Government Research Scholarship that enabled him to study under the guidance of Professor Ernest W. Skeats at the University of Melbourne. He investigated and eventually published papers on local geological and physiographic problems.[7] In 1911, he joined the Geological Survey of Western Australia, based in Perth, as a Field Geologist. As a state employee he enjoyed several productive years, including writing the seminal Bulletin 61. Nevertheless, in 1918 he was made redundant as a result of enforced Government economies.[8] Undaunted, he enrolled at the University of Western Australia and in 1920 emerged as a mature age student aged 46 years with a Bachelor of Science degree. He attempted to pursue a career in geology and successfully applied for a senior post in the West African (now Ghanaian) Colonial Survey but he was compelled to decline the offer of appointment because his increasingly troublesome congenital deafness would have been exacerbated by the quinine then routinely taken daily in tropical lands to guard against malaria.

Jutson and his wife Lilian (Fig. 1), whom he had married in 1905, and who was to provide Jutson with sustained and devoted support, returned to Melbourne, where he joined the law firm of Wilcox and Hall. He studied for the bar and obtained a degree in law (LlB. Melbourne 1925). He was made a partner in 1928 and continued to work as a solicitor (for his deafness made court work difficult) until retirement in 1952.

Jutson did not allow the setbacks he had experienced in Perth to dampen his passion for landform studies. He continued to publish. Initially he produced papers which, though based in his experiences in Western Australia, appeared in the *Proceedings* of the Royal Society of Victoria, his new home base, or in overseas journals. In addition, and though the law fully occupied his working days, he devoted his weekends and holidays to the study of Victorian coasts and particularly shore platforms. Such excursions were not readily undertaken. As he stated in a letter to Alan Coulson, with whom he was arranging field investigations, 'I suffer from deafness which in the field causes inconvenience both to anyone accompanying me and myself'.[9] With the assistance of his wife, he worked mostly around Port Phillip Bay but also investigated the coast near Sydney, New South Wales. Between 1931 and 1953 he produced eight papers on shore platforms.

Sources

In addition to his two Bulletins, Jutson left behind almost thirty peer-reviewed papers, most of them single-authored and published in the *Proceedings* of the Royal Society of Victoria. In addition, his surviving correspondence, incomplete as it is, is enlightening not only professionally but also personally and socially.[10] For instance, in a letter dated 24 February 1920, William Morris Davis, the eminent American geomorphologist, commenting on his intention to spend the summer months either in the field or on vacation in the country, stated:

> The habit of going out of town for a time in the summer is increasing; and I am glad to say that it is extending to the working classes, at least to the tradesmen, tho not yet to the laborers. The latter class are becoming very tyrannous, with their unions and their strikes; they seem to prefer a labor autocracy to a general democracy.[11]

Jutson exchanged reprints and ideas with many overseas luminaries besides Davis, including Kirk Bryan of the USA Geological Survey, Eliot Blackwelder, a desert specialist from Stanford University, Douglas Johnson of Columbia University, Johannes Walther, also known for his work on desert landscapes, and John A. Bartrum, the well known New Zealand coastal worker, as well as Australian colleagues such as Ernest C. Andrews and T. W. Edgeworth David.

Methods

Like the character in Molière's *Le Bourgeois Gentilhomme*[12] who spoke prose though he did not know it, Jutson applied the method of multiple working hypotheses in all his investigations without recognizing it as a formal system.[13] He first considered previous ideas concerning the problem at hand. He weighed the various possibilities and tested each against the conventional wisdom of the day and the perceived evidence. He must have been gratified to receive a report from Edward de Courcy Clarke on how Douglas Johnson, during a brief visit to Western Australia during 1929, had discussed the problem posed by the Darling escarpment that is such a prominent feature of the Perth landscape.[14] Apparently he nominated four possible explanations and discussed the deducible consequences of each in terms of the evidence, which was the approach adopted by Jutson in his 1914 Bulletin when discussing, for example, the origin of dry or salt lakes and the origin of the Great Plateau.

The Bulletins best display Jutson's interests and methods and in particular the changes in his thinking. Compared with the 1914 publication, prepared at the request of the then Director of the Survey, Gibb Maitland, primarily for educational purposes,[15] the 1934 Bulletin was expanded by almost 50% and, though reorganized, covered much the same ground as the original, with regional accounts followed by discussions of specific features.[16] Jutson still felt it necessary to justify an explanation of landscape as of wider interest and experience, but retained his scholarly approach. Thus, in view of the explanation and interpretation that are intrinsic to Jutson's approach, the word 'Geomorphology' included in the 1934 title was justifiably preferred to 'Physiography', which implies a mere recording of data and which did less than justice to the 1914 synthesis.

The Glossary of definitions attached to each Bulletin—several of them of questionable accuracy—also changed, in some instances critically. Some, like 'pediment', were introduced but others were retained including the annoying, because tautological, 'gnamma hole'. The meanings of others have changed since Jutson's day. For example, 'travertine' was then widely applied to all surficial calcareous accumulations[17] but later became restricted to channel or spring precipitates as opposed to pedogenic calcrete (caliche, kunkar).

Landscapes and Landforms of Special Interest

Jutson's background and experience in geomorphology were limited but he compensated for this by thorough reviews of the literature, both local and general, germane to the problem, and by astute speculation and testing of possible explanations for the forms. Overall he was a disciple of William Morris Davis, whose influence was then at its peak (though even then not without his having adverse critics). Jutson adopted the peneplain model of land surface lowering with its anthropogenic metaphor of sequential youthful, mature, and old-age stages of landscape development.[18] He was also influenced by Davis' paper on landscape evolution in an arid climate,[19] which in turn introduced Passarge's thesis of aeolian planation at the regional scale and with it the concept of levelling without reference to sea level, the ultimate baselevel.[20] Jutson also accepted many of the tenets of the day. For instance, like many writers of geological textbooks of the time,[21] and others before and since, he accepted without question the impacts of insolation weathering,[22] for he attributed what is undoubtedly an A-tent (evocatively known in the USA as a pop-up), to its power,[23] whereas earlier investigators had associated such forms with crustal compression.[24] They are now thought to be caused primarily by compressive stress, some instantaneously during earthquakes, others gradually over decades.[25]

Similarly, Jutson attributed the rounding of small pebbles he had seen in the field located on slopes and distant from river channels to the impact of raindrops on coherent rocks, including greenstone (dolerite, gabbro, etc.), shale, and grit, but also and significantly, weathered quartz porphyry.[26] This last example suggests that the pebbles may be miniature corestones formed by differential fracture-controlled subsurface weathering.[27] They commonly carry a laminated skin that, unlike cohesive rock, could conceivably be removed by falling drops of rain.[28] He also attributed to the wind features that are more plausibly explained as associated with surface wash.[29]

Nevertheless, Jutson was a keen and questioning observer. He was interested in almost every landform that came to his notice. For example, he published short notes on wind whirls (dust devils or willi-willis) and on the dimpling of rocks as a result of the formation of gnammas or rock basins.[30] But three features engaged his particular attention: the Great Plateau of Western Australia, the dry lakes or salinas that are so notable a feature of the Western Australian interior, and, later in his life, shore platforms.

The Great Plateau

The Great Plateau of Western Australia occupies much of the arid interior of Western Australia and includes Jutson's Salt Lake division or Salinaland, or what is now referred to as the Yilgarn Shield or Craton. Its possible origin and age fascinated him and it is from his studies of this feature that his most important and enduring interpretations emerged.

Erosional Nature

He noted that the plateau or inland high plain is of low relief and transects various structures and rock types, though granite, granitic gneiss and 'greenstone' or basalt are prominent. For this reason, he concluded that the plain is erosional and not structural.

Evidence from Salinas

Some aspects of Jutson's interpretation of the dry lakes or salinas of the Salt Lake Division bear on his understanding of the evolution of the Great Plateau of which they are part. Following Henry P. Woodward,[31] Jutson accepted that the 'lakes' were wind-planed flats. Moreover, he accepted that the cliffs bordering the lake depressions on their western flanks had been undermined by wind erosion (sand blasting) causing them to collapse and effectively be worn back in parallel.[32] In this way the salinas migrated downwind.[33] He also noted that the floors of the salinas consist of either exposed country rock or rock overlain by only a thin cover of transported detritus.

Scarp Retreat

Jutson noted that two 'cycles' or phases of erosion are represented within the Great Plateau. Remnants of the highest and oldest are preserved in plateaux: landforms mostly capped by a ferruginous duricrust (or laterite), or a siliceous carapace (silcrete). This is the Old Plateau. It has been dissected by rivers and streams. Just as the scarps bordering salinas were worn back by parallel scarp retreat so the scarps defining this surface have receded and a lower and younger plain, the New Plateau, has been formed and has extended at the expense of the Old

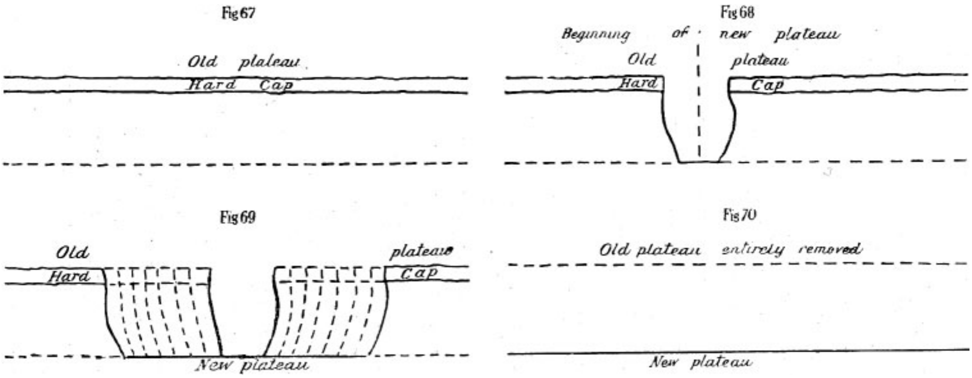

Figure 2. Jutson's sections explaining the relationship between the Old and New plateaux (after Jutson 1914, p. 143, his Figs 67–70).

(Fig. 2). (Given, though, that this feature is not everywhere and is indeed rarely bounded by escarpments, 'high plain' surely would have been preferable to 'plateau'.) Not only is the capping undermined,[34] because water gravitates to lower levels the basal sections of hill slopes are preferentially weathered and gullied, causing collapse and recession.[35] Slopes develop from below,[36] and are steepened to the maximum inclination commensurate with stability. They are worn back so that the steep slope is maintained within small limits: basal attack drives parallel slope retreat.

Jutson's conclusion that scarps are worn back in rough parallelism was no doubt suggested by field observations. The form and inclination of the faceted slopes defining remnants of the Old Plateau are similar regardless of the areal extent of the upland, whether plateau, mesa, or butte. This deduction was not articulated in the Bulletins but is implied in Jutson's diagrams[37] and, as mentioned, the interpretation found support in the perceived behaviour of the dry lakes or salinas.

In this, Jutson inadvertently corroborated the mechanism of scarp retreat postulated on theoretical grounds by Osmond Fisher and later sustained by field observations.[38] Significantly, scarp recession was the critical feature of what became the well known model of landscape evolution proposed by Lester C. King,[39] who acknowledged Jutson's place in his thinking.[40]

Dissection and Regolith Stripping

In the 1914 Bulletin the rock beneath the capping of the Old Plateau is implied to be relatively weak but in 1934 is labelled as soft or decomposed.[41] Though the lower limit of alteration is not indicated it is implied that the regolith is readily stripped away to form the New Plateau (Fig. 3). This exposed surface may have been coincident with a former mean level of a relic water table, and hence a change in the intensity of alteration of the country rock. It is in any event, and as indicated by various investigations of salinas, underlain by coherent rock either exposed at the surface or occurring at shallow depth beneath a thin detrital cover. The weathered rock was friable and readily worn away, whereas the fresh coherent country rock resists stream erosion. Jutson discounted the impacts of floods such as had been envisaged by William J. McGee and instead agreed with Kirk Bryan's conclusion that stream floods or, as he preferred to call them, stream flows, are 'agents of deposition rather than of erosion'.[42] Others were of the same opinion.[43]

Thus, the New Plateau was what later would be called an etch surface, an exposed weathering front or lower limit of significant alteration.[44] It is genetically comparable to corestone boulders, many bornhardts and a host of minor landforms.[45] Jutson suggested that during the planation and weathering (lateritization) of the surface, remnants of which survive as the Old Plateau, subsurface weathering produced a fairly regular weathering front that anticipated the Old; for as the regolith eventually was stripped, the New Plateau emerged. Jutson thus advocated what was later termed 'double planation'.[46] He appears to have been the first to advocate such an etch origin for extensive plains such as dominate

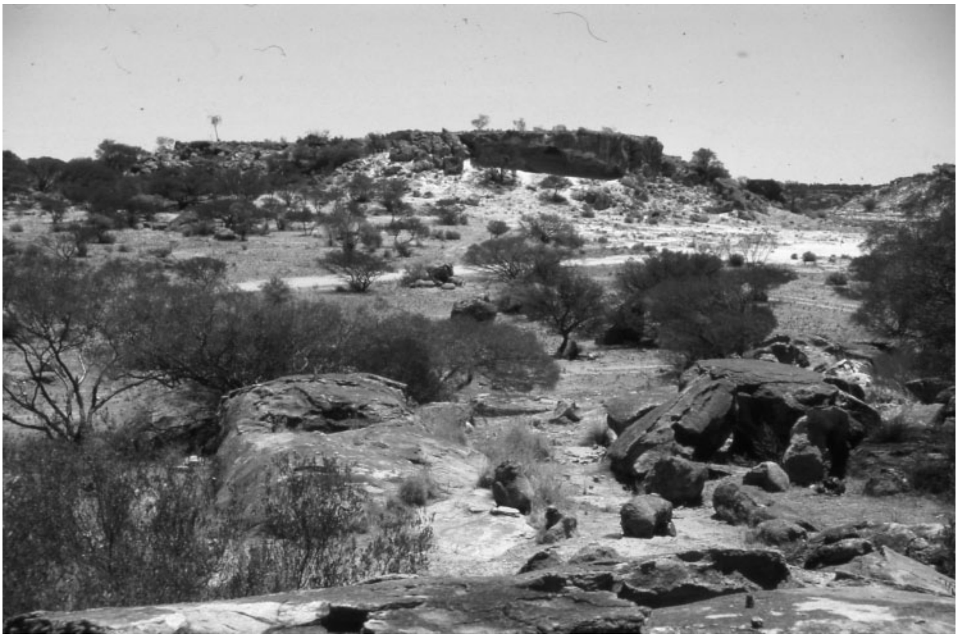

Figure 3. Elements of the Great Plateau exposed at The Granites near Mt. Magnet, Western Australia. As the scarps bounding the laterite-capped Old Plateau have been worn back, more and more of the New Plateau (or high plain), here represented by blocks and boulders of granite, has been revealed.

the Yilgarn Craton of Western Australia. He was not the last.[47]

The recognition of the Old and New plateaux as distinct landscape elements was critical not only to an appreciation of scenery, but also in the search for the ore deposits for which the Yilgarn Craton is well known. In the Old Plateau, there are mineral concentrations (notably bauxite) in the associated duricrust, whereas basement rocks are exposed or occur at shallow depth in the New, and they and the alluvial fills (the Deep Leads of past times) that are part of the younger surface offer different economic possibilities and challenges.[48]

As suggested earlier, Jutson's interpretation may have been influenced by the recognition that in the salinas, so well represented as an integral feature of the New Plateau, fresh rock is either exposed or occurs at shallow depth beneath a thin detrital cover. In addition, studies of coastal landforms and particularly the 'Old Hat' type of shore platform described from New Zealand are relevant to this problem. The platforms were construed as coincident with the level of saturation of the rocks exposed in the coastal sector, with those in the vadose zone being more altered than those in the lower phreatic zone of saturated rock. This idea, later developed by John A. Bartrum, was proposed by James M. Bell and Edward de Courcy Clarke,[49] At the time the shore platform paper was published, the last-named was a member of the New Zealand Survey but later became a colleague of Jutson's in Western Australia. That contrasted susceptibility to erosion was related to the water table may particularly have impressed Jutson, particularly because the notion originated in part with a respected scientist and close friend. On leaving the Government Survey, de Courcy Clarke became Professor of Geology in the University of Western Australia, and when Jutson returned to Melbourne, Clarke was, even on the incomplete evidence, his most frequent correspondent, with lengthy discussions concerning various aspects of Western Australian geology and geomorphology, ranging over scientific research methods and the origin and age of the Darling escarpment to Clarke's forthcoming school text.[50]

Climatic Factor

Jutson noted the occurrence of laterite as a capping to Old Plateau remnants but did not relate that to the strongly held belief that it is a weathering product developed in humid tropical areas (though with some argument as to whether seasonal variations in heat and precipitation are necessary for its evolution).[51] It is almost beyond belief that Jutson could define laterite as a rock that usually forms in dry climates, though he later described it merely as predominantly ferruginous, aluminous or siliceous and implicitly associated the lateritized surface with an earlier humid climate.[52]

Processes at Work

In his earlier report,[53] Jutson stated that the Old Plateau, the components of which are duricrusted remnants of a peneplain shaped under a climate more humid than what now obtains, was dissected by streams, but considered that as the resultant valleys were widened the streams spread out and lost their erosive power. This allowed wind planation to assume dominance. Although influenced by the findings of William Morris Davis and Siegfried Passarge, Jutson's own observations and reasoning, and especially the arid aspect of the interior landscapes with numerous salinas and dunefields such as those of the Gibson Desert, led him to explain the landscapes of the interior of Western Australia in terms of wind erosion.

Initially he entertained no doubts about the erosive capacity of the wind. He asserted that debris fallen from the undermined scarps was removed by the wind so that 'at most cliffs there is practically no talus':[54] a claim denied by the photograph that appeared on the opposite page of a laterite-capped mesa near Cue with large blocks and other debris of sundry sizes scattered round the base. He claimed that deflation, defined as the 'denuding and transporting action of the wind',[55] is the essential erosion process.[56] He made reference to 'the tremendous power exercised by the wind in these arid regions'.[57] He regarded the extensive plain known as the New Plateau as wind planed, as 'shaped mainly by the wind'[58] and without reference to sea level, as an example of levelling without baselevelling.[59]

In this, Jutson was in agreement with authorities both local and overseas. Not only had Passarge, the great German scientist-explorer, ascribed certain African landscapes to aeolian planation[60] but Charles R. Keyes similarly attributed many features of the American Southwest to wind erosion.[61] In Australia, John W. Gregory, a noted geologist of the time, attributed the Great Plateau to arid erosion and Mawson considered that many features of the landscape around Broken Hill were shaped by the wind.[62]

Certainly *dreikanter*, or wind-faceted cobbles, attest the effectiveness of sand-blasting close to the ground.[63] Also, funnelled winds armed with sand grains can cause fluting in crystalline rocks and cut through wooden telegraph posts.[64] Unconsolidated fine sediments are susceptible to differential erosion generating yardangs and deflation produces major salinas as well as small deflation hollows that have subsequently been alluviated.[65] Furthermore, huge volumes of fines are exported in dust storms, implying a lowering of the surface in source areas; but though the wind is effective over the entire surface (as opposed to the relatively limited channels scoured by rivers and streams), the erosional capacity of the wind is limited.[66]

However, no desert is rainless, and floods wreak havoc[67] on surfaces rendered initially impermeable by a baking sun (*croûtes desertiques*), and unprotected by vegetation. Not only do the roots of plants bind the soil,[68] but foliage reduces raindrop impact, the so-called umbrella effect.[69] Floods also take an human toll, for in some years more people are drowned in the Sahara Desert of North Africa than die of thirst there.[70] Even in the deserts, weathering caused by subsurface moisture attack is effective[71] and accounts for the many minor forms such as mushroom rocks popularly associated with sandblasting and the wind. Thus, though at first consideration the idea seems absurd, it is for good reason that some workers have concluded that most erosional desert forms are due to water.[72] Jutson allowed that streams and rivers had dissected the duricrusted surface but argued that, as wash dispersed, the ensuing planation of the New Plateau was achieved by scarp recession and then arid planation, that is, wind erosion.[73]

This proved to be an untenable hypothesis for, as later acknowledged by Jutson,[74] extensive plains, even in arid lands, are shaped by groundwaters and rivers. Those found in arid areas are either inherited from more humid phases of the past or are shaped by streams and rivers associated with the contemporary climatic regime. Jutson perforce revised his earlier opinion, partly as a result of a re-consideration of the evidence both local and global but also no doubt in light of the views expressed by certain of his correspondents. An Australian colleague, Ernest C. Andrews, in a letter commenting on Jutson's 1917 paper on erosional forces active in Western Australia, disagreed with the prominence Jutson accorded the wind and suggested that it achieved no more than a slight modification of the surface.[75] Similarly, writing from the USA, Kirk Bryan, having earlier described pedestal (mushroom) rocks resulting from the combined work of rain and weathering exploited by the wind,[76] later stated, 'I am still unconvinced of the general efficacy of the wind as an erosive agent, but… I have no doubt of its transporting power'.[77]

Thus, Jutson was persuaded that the New Plateau was the result of river planation, though with aeolian retouching in some areas and most obviously with the deposition of fields of desert sand dunes. Surprisingly, however, Jutson appeared to persist with the idea that wind erosion[78] had been active in the deep interior of the Great Plateau, stating that 'arid erosion has been the dominant factor' in shaping the landscape 'for a considerable period'.[79] One can only surmise that this was an oversight, bearing in mind that Jutson revised the 1914 text while working full-time in his legal practice.

According to Jutson, the stream incision that initiated the destruction of the Old Plateau and the formation of the New was triggered by tectonic uplift, such as is evidenced in the southwest of Western Australia, and that continues.[80] As a result its drainage system either disappeared (areic) or became endoreic, by contrast with the exoreic streams of the coastal areas. He made no mention of possible isostatic response to the erosion of the New landscape.

Age of the Great Plateau

Whatever agency is responsible, the friable regolith comprising the altered, usually kaolinized regolith has been stripped to expose a lower plain cut in bedrock but with a veneer of weathered or transported detritus. Two phases of development are implied.

Some earlier workers such as Henry P. Woodward[81] thought the Old Plateau was of Mesozoic age. Augustus C. Gregory[82] also considered the landscape to be of considerable antiquity. But Jutson, bearing in mind the evidence pointed out by T. W. Edgeworth David[83] and others, of Early Tertiary marine fossils in the Deep Leads (valley fills) of the Norseman area, opted for an Early Tertiary origin with a change to aridity in the later Tertiary (Pliocene). Later work has shown that stream incision commenced in the Eocene and gradually extended inland so that the valley fill in the Kellerberrin area, for instance, is of Miocene age.[84] This is consistent with a regressive valley system and suggested that the Old lateritized surface predates the Eocene and the New Plateau (or plain) surface is of Eocene to Recent age and is still extending.

In neither of the *Bulletins* did Jutson refer to the Darling scarp save as being the result of recent uplift and relatively undissected. In his correspondence with de Courcy Clarke, however, the discovery is discussed of later Mesozoic marine sediments in valleys cut into the escarpment at Bullsbrook, near Perth, [85] and later dated as Neocomian or Early Cretaceous,[86]. These marine strata are weathered and are described as lateritized but without pisolitic or other iron-rich horizon. Given its topographic position, intense alteration is not unexpected. Thus, the occurrence can be taken to suggest that as the lateritic surface of the adjacent Old Plateau, of which the Darling Plateau or high plain is part, stands higher in the local topography, it predates the deposition of the marine strata.[87] In these terms it dates from the earliest Cretaceous or Jurassic.[88]

Coastal Studies—Shore Platforms

Jutson noted various coastal forms as part of his regional accounts of Western Australia as part of his 1914 and 1934 *Bulletins* but dedicated only a few pages to specific coastal forms and then primarily to coastal plains. With a Survey colleague he published a paper on the geology and landforms of the coastal Albany district, south of Perth.[89] On his return to Victoria, however, the coast became the favoured holiday destination for the Jutsons. This resulted in a detailed account, notable for its close observation and argument, of the Port Campbell coast in the west of the State.[90] Jutson also collaborated with

Alan Coulson on the geology and landforms area on the western side of Port Phillip Bay.[91] He accepted haloclasty as a prime weathering process at work on the coast.

Jutson's attention became focused on the problems presented by shore platforms, or what were then and by some still are misleadingly referred to as wave-cut platforms—misleadingly because more than wave abrasion is involved in their development. Shore platforms commanded considerable attention throughout the twentieth century.[92] This interest arose partly from debate concerning the processes responsible for shaping the forms. In addition, though platforms are found well developed in the intertidal zone, some occur above and below this range. The question arose whether such flights of platforms form at different levels as a result of the various processes at work, or whether they imply changes in the relative positions of land and sea. Several noted Victorian geologists such as Edwin Sherbon Hills, Austin B. Edwards and George Baker, as well as Jutson in retirement, energetically pursued the problem, particularly as it concerned the coastline of Port Phillip Bay and adjacent areas. As a result, but ironically, despite his signal contributions to the unravelling of Western Australian scenery, Jutson was for many years best known for his paper on the shore platforms of the Sydney area, partly for its contents but also because it appeared in the prestigious *Journal of Geomorphology*.[93]

The choice of the Sydney shoreline was in some ways unfortunate for in it are exposed sequences of flat-lying sediments of varied resistance to weathering and erosion. Structural benches, ledges, or shelves are characteristic of surfaces concident with bedding or another bedrock feature, whether on the coast or inland. Distinguishing structural from erosional features was difficult and in places uncertain. Nevertheless, Jutson was able to show that platforms are being shaped at different heights at the present time under the influence of different processes. In his first 'coastal' paper he expressed surprise that 'in some way that is not yet fully understood, the sea can cut two platforms at different levels at the same time under certain conditions'.[94] This observation went to the heart of what was then a vexing problem, namely, whether what he called wave-cut platforms form at different levels as a result of the processes at work, or whether they imply changes in the relative positions of land and sea. Contrary to those who considered that every platform or coastal flat represents a distinct sea level, Jutson concluded that erosional platforms develop simultaneously in a range of elevations relative to sea level.

As to the processes at work, in his 1931 and 1940 papers Jutson referred to wave-cut platforms and was puzzled that waves apparently continued to abrade even after crossing broad flats covered by shallow water.[95] But their power is diminished because of friction with the sea floor[96] and the continued undermining of the backing cliffs is due as much to biota and biochemical action as wave abrasion and evacuation of weathered debris. Like Edwin Sherbon Hills, Jutson realized that the fact that bay-head platforms are wider than those preserved on promontories implies the action of processes other than wave abrasion.[97] The disparity may, however, be attributed to quarrying by waves in deep water adjacent to headlands, limiting the development of intertidal platforms at such sites.

Like several of his precursors, Jutson came to appreciate that platforms are formed above high tide level in the zone of storm waves and of spray and as a result of water level or water layer weathering.[98] Also 'the wave quarrying action of waves' is responsible for the formation of ramps and platforms, the ultimate platform well below low tide level.[99] Jutson recognized 'fossil' [*sic*] platforms that had been buried by talus and then re-exposed.[100] In addition, however, some shore platforms are etch forms shaped by biochemical weathering beneath a regolithic—sand, gravel or shingle—cover.[101] Indeed, and harking back to the paper by Bell and Clarke of 1909, Edwin Sherbon Hills stated that, 'Broadly speaking, a shore platform is developed by the stripping of soft weathered rock from the hard rock of the permanently saturated zone'.[102]

Hills described geological evidence pointing to recent tectonism and the displacement of shoreline features at various sites on Port Phillip Bay, and warned of the dangers of using shore platforms as the sole criterion: 'Unless we understand the ways in which shore platforms are formed it is obviously fruitless to draw conclusions from them about relative movements of land and sea'.[103] Jutson's investigations along the Victorian coast served mainly to sustain this view. Only at Lorne did he entertain the possibility of a change of sea level leaving its imprint on the coast.[104] He remained convinced that most platforms have formed at multiple levels in relation to one—the present—sea level. As André Guilcher noted, many of Jutson's concepts concerning shore platforms found support and, in turn, corroborated the work of his Victorian colleagues.[105]

Conclusions

Jutson's most enduring legacies are the two Western Australian Survey Bulletins.[106] That they were written is a tribute to Jutson's industry for Bulletin 61 was produced after he had been with the Survey only three years, during which time he also had fulfilled his duties as Field Geologist. Bulletin 95 was completed as a part-time project while he was working as a partner in a Melbourne law firm. In his many short papers concerned with detailed aspects of landform evolution in the arid interior of Western Australia he depended largely on his own observations and deductions, but in producing his Bulletins he leaned heavily on the work of his predecessors, and particularly his colleagues in the Geological Survey of Western Australia. He maintained a life-long friendship with de Courcy Clarke to mutual benefit.

Like a review, a synthesis calls for scholarship, judgement, and imaginative but disciplined innovation. Jutson brought to the task an enquiring mind allied with thoroughness and rigour in his interpretation of data and ideas viewed through the prism of his own field experience. Jutson's is a remarkable story of determination overcoming adversity in its various forms. His beginnings were humble and he was initially self educated, but eventually and relatively late in life he earned qualifications that fitted him for work in both geology and the law (though he practised both professions before he gained formal qualifications to do so). One cannot but admire his tenacity—and his wife's devotion and forebearance.

Jutson made mistakes, some arising from his limited background and experience, but he also offered reasoned explanations that influenced later workers and that indeed find their echoes in modern geomorphology. He identified the New Plateau which dominates the Great Plateau in area, as of etch origin, but, just as Arthur Holmes did not identify the lateral migrations of the continental lithosphere by an evocative name like Harry H. Hess's subsequent 'seafloor spreading' and so lost his justifiable priority,[107] so Jutson, like Edward J. Wayland, is not accorded due credit for the etch concept as applied to planate landscapes partly for want of an apt name or label. Use of the word 'etch' awaited a discussion between Wayland and Bailey Willis some thirteen years later, and the idea of the simultaneous formation and initiation of separate planation surfaces, though implicit in Falconer's exposition concerning the origin of granitic inselbergs,[108] was not specifically articulated until the publication of Julius Büdel's classic paper in 1957, more than twenty years after Jutson's exposition.[109]

In retrospect, Fairbridge's evaluation of Jutson's contributions to geomorphology appears a trifle generous but ideas are judged not in retrospect but in the context of their time. Jutson's methodology was exemplary, as illustrated by his almost but not quite abandoning the cherished but untenable thesis of wind erosion as a significant process in the shaping of landscape. For some years Jutson was best known for his Sydney shore platforms paper but later, championed by Hills and others, his interpretation of the complexity of the Great Plateau came into its own. His interpretation of the New Plateau as the product of etching and scarp recession, as an etch plain of regional significance, was innovative and enduring. He recognized that multiple platforms are simultaneously shaped both inland and on the coast. He implied that running water readily removes regolithic materials but that only major waterways are capable of incising fresh coherent rock. These achievements at once explain and justify the status of John Thomas Jutson as a major figure in Australian geomorphology in the first half of the twentieth century.

Acknowledgements

The authors thank Dr Steve Hill and an anonymous referee for their balanced and constructive suggestions and Dr Jennie Bourne for her usual perceptive comments on the manuscript in draft form and particularly for managing the exacting task of formatting the final paper.

References

1. Rhodes W. Fairbridge 1977, pers. comm. to Brock, who noted the accolade in his thesis: Erland J. Brock, 'The Contributions of John Thomas Jutson to Geomorphology', unpublished Ph.D. dissertation, University of Adelaide, 1977, vol. 1, p. 4 footnote.
2. For example, Phillip E. Playford, 'Rhodes Whitmore Fairbridge 1914–2006: World-renowned Australian geologist', *PESA News*, 86 (2007), 1–3.
3. John Thomas Jutson, 'An outline of the physiographical geology (physiography) of Western Australia', *Geological Survey of Western Australia Bulletin*, 61 (1914).
4. J. T. Jutson, 'The physiography (geomorphology) of Western Australia', *Geological Survey of Western Australia Bulletin*, 95 (1934, reprinted 1950).
5. Brock, op. cit. (n. 1); Erland J. Brock and C. Rowland Twidale, 'J. T. Jutson's contributions to geomorphological thought', *Australian Journal of Earth Sciences*, 31 (1984), 107–121.
6. George B. Pritchard, *The Geology of Melbourne as told by a Few Rambles in and around the City* (Melbourne, 1910).
7. J. T. Jutson, 'A contribution to the physical history of the Plenty River; and of Anderson's Creek, Warrandyte, Victoria', *Proceedings of the Royal Society of Victoria*, 22 (1910), 153–171; J. T. Jutson, 'A contribution to the physiography of the Yarra River and Dandenong Creek basins, Victoria', *Proceedings of the Royal Society of Victoria*, 23 (1911), 469–515.
8. See J. J. E. Glover and J. C. Bowen, *The Forgotten Explorers and Pioneer Geologists of Western Australia, 1826–1926* (Carlisle, W.A, 2010), 104–108.
9. Jutson to Coulson, 6 April 1934; 'Letters to and from J. T. Jutson', in Erland J. Brock, ed., *Papers on Geomorphology* (Special Collections, Barr Smith Library, University of Adelaide), p. 150.
10. Brock, op. cit. (n. 9).
11. Davis to Jutson, 24 February 1920; ibid., p. 79.
12. Molière, *Le Bourgeois Gentilhomme* (1670), act II, scene iv.
13. Thomas C. Chamberlin, 'The method of multiple working hypotheses', *Science*, 15 (1890), 92–96; also Douglas Johnson, 'Studies in Scientific Method. V. The analytical method of presentation', *Journal of Geomorphology*, 3(2) (1940), 156–162.
14. Clarke to Jutson, 25 November 1930' in Brock, op. cit. (n. 9), p. 27.
15. Glover and Bowen, op. cit. (n. 8), p. 105.
16. Jutson, op. cit. (n. 3); Jutson, op. cit. (n. 4).
17. For example, Edward John Eyre, *Journals of Expeditions of Discovery into Central Australia and Overland from Adelaide to King George's Sound, in the years 1840–41* (London, 1845); R. Lockhart Jack, 'The geology of portions of the counties of Le Hunte, Robinson, and Dufferin, with special reference to underground water supplies', *Geological Survey of South Australia Bulletin*, 1 (1912).
18. William Morris Davis, The geographical cycle', *Geographical Journal*, 14 (1899), 481–504; W. M. Davis, *Geographical Essays*, ed. D.W. Johnson (Boston, 1909).
19. W. M. Davis, 'The geographical cycle in an arid climate', *Journal of Geology*, 13 (1905), 381–407.
20. Siegfried Passarge, 'Rumpfläche und Inselberge', *Zeitschrift Deutsche Geologische Gesellschaft*, 56 (1904), 195–203.
21. William B. Scott, *An Introduction to Geology* (London, 1897); Louis V. Pirsson and Charles Schuchert, *A Text-book of Geology* (New York, 1915).
22. J. T. Jutson, 'A striking example of rock expansion by temperature variation in sub-arid Western Australia', *Proceedings of the Royal Society of Victoria*, 32 (1919a), 22–23; Jutson, op.cit. (n. 4), pp. 253–254; but see also Donald C. Barton, 'Notes on the disintegration of granite in Egypt', *Journal of Geology*, 24 (1916), 382–393 and, later, David T. Griggs, 'The factor of fatigue in rock exfoliation', *Journal of Geology*, 44 (1936), 783–796.
23. Jutson, op. cit. (n. 4), p. 254.
24. Henry P. Cushing, Herman L. Fairchild, Rudolf Ruedemann, Charles H. Smyth, 'Geology of the Thousand Islands region', *New York State Museum and Science Service Bulletin*, 145 (1910).
25. For example, Joseph N. Jennings and C. R. Twidale, 'Origin and implications of the A-tent, a minor granite landform', *Australian Geographical Studies*, 9(1) (1971), 41–53; Marc L. Sbar and Lynn R. Sykes, 'Contemporary compressive stress and seismicity in eastern North America: an example of intraplate tectonics', *Geological Society of America Bulletin*, 84 (1973), 1861–1881; C. R. Twidale, 'A recently formed A-tent on Mt Wudinna, northwestern Eyre Peninsula, South Australia', *Revue de Géomorphologie Dynamique*, 35 (1986), 21–24; C. R. Twidale and Jennifer A. Bourne, 'Rock bursts and associated neotectonic forms at Minnipa Hill, northwestern Eyre Peninsula, South Australia', *Environmental and Engineering Geosciences*, 6 (2000), 129–140; C. R. Twidale and J. A. Bourne, 'Active dislocations in granitic

terrains of the Gawler and Yilgarn cratons, Australia, and some implications', *South African Journal of Geology*, 106 (2003), 71–84.

26. J. T. Jutson, 'Note on an unusual method of rounding of pebbles in sub-arid Western Australia', *American Journal of Science*, 48 (1919b), 429–434.
27. Jean-Henri Hassenfratz, 'Sur l'arrangement de plusieurs gros blocs de différentes pierres que l'on observe dans les montagnes', *Annales de Chimie*, 11 (1791), 95–107; John MacCulloch, 'On the granite tors of Cornwall', *Transactions of the Geological Society*, 2 (1814), 66–78; John B. Scrivenor, 'Geology of Malaya', *Quarterly Journal of the Geological Society of London*, 69 (1913), 343–369.
28. Compare with Walter D. Ellison, 'Erosion by raindrop', *Scientific American*, (November 1948), 817–823.
29. J. T. Jutson, 'On the 'clawing' action of rain in sub-arid Western Australia', *Proceedings of the Royal Society of Victoria*, 32 (1919), 20–21; J. T. Jutson, 'Summary of the contributions to the study of the physiography of Western Australia', *Australasian Association for the Advancement of Science Report*, 15 (1921), 326–334.
30. J. T. Jutson, 'Notes on dust whirls in sub-arid Western Australia', *Proceedings of the Royal Society of Victoria*, 32 (1919), 314–322; J. T. Jutson, 'Notes of the 'dimpling' of granite hills in sub-arid Western Australia', *Proceedings of the Royal Society of Victoria*, 33 (1920), 108–110.
31. Henry P. Woodward, 'The dry lakes of Western Australia', *Geological Magazine*, 34 (1897), 363–366.
32. Jutson, op. cit. (n. 3), p. 156; Jutson, op. cit. (n. 4), p. 241.
33. Jutson, op. cit. (n. 3), p. 155.
34. Jutson, op. cit. (n. 4), pp. 236, 242.
35. For example, Jutson, op. cit. (n. 3), pp. 143, 144; Jutson, op. cit. (n. 4), pp. 97, 236.
36. For example, Walther Penck, *Die Morphologische Analyse* (Stuttgart, 1924); C. R. Twidale and Anthony R. Milnes, 'Slope processes active late in arid scarp retreat', *Zeitschrift für Geomorphologie*, 27(3) (1983), 343–361; Hanna Bremer, 'Etchplanation, review and comments of Büdel's model', *Zeitschrift für Geomorphologie, Supplementband*, 92 (1993), 189–200.
37. Jutson, op. cit. (n. 3), p. 143; Jutson, op. cit. (n. 4), pp. 97, 236.
38. Osmond Fisher, 'On the disintegration of a chalk cliff', *Geological Magazine*, 3 (1866), 354–356; Albert Demangeon, 'Le relief du Limousin', *Annales de Geographie*, 19 (1910), 120–149; R. Lockhart Jack, 'The geology and prospects of the region to the south of the Musgrave Ranges and the geology of the western portion of the Great Artesian Basin', *Geological Survey of South Australia Bulletin*, 5 (1915), p. 12; Arthur Holmes, 'The Pre-Cambrian and associated rocks of the district of Mozambique', *Quarterly Journal of the Geological Society of London*, 74 (1918), p. 93.
39. Lester C. King, *South African Scenery* (Edinburgh, 1942); L. C. King, 'Canons of landscape evolution', *Geological Society of America Bulletin*, 64 (1953), 721–752; see also Thomas J. D. Fair, 'Slope form and development in the interior of Natal, South Africa', *Transactions of the Geological Society of South Africa*, 50 (1947), 105–118; and T. J. D. Fair, 'Slope form and development in the coastal hinterland of Natal, South Africa', *Transactions of the Geological Society of South Africa*, 51 (1948), 33–47.
40. Brock, op. cit. (n. 9), p. 13, item 142.
41. Jutson, op. cit. (n. 3), p. 143; Jutson, op. cit. (n. 4), pp. 236, 239, 242.
42. William J. McGee, 'Sheetflood erosion', *Geological Society of America Bulletin*, 8 (1897), 87–112; Jutson, op. cit. (n. 4), pp. 257–258; Jutson, op. cit. (n. 4), p. 258; Kirk Bryan to Jutson, 4 March 1924, in Brock, op. cit. (n. 9), pp. 10–11.
43. For example, Edwin Sherbon Hills, 1962, pers. comm.; also Albert J. Noldhart and John D. Wyatt, 'The geology of portion of the Pilbara Goldfield', *Geological Survey of Western Australia Bulletin*, 115 (1962).
44. Edward J. Wayland, 'Peneplains and some erosional landforms', *Geological Survey of Uganda Annual Report (for year ending 31st March 1934) and Bulletin*, 1 (1934), 77–79; Jack A. Mabbutt, '"Basal surface" or "weathering front"', *Proceedings of the Geologists' Association of London*, 72 (1961), 357–358.
45. John D. Falconer, *The Geology and Geography of Northern Nigeria* (London, 1911); C. R. Twidale, 'The two-stage concept of landform and landscape development involving etching: origin, development and implications of an idea', *Earth-Science Reviews*, 57(1–2) (2002) 37–74.
46. Julius Büdel, 'Die "doppelten Einebnungsflächen" in den feuchten Tropen', *Zeitschrift für Geomorphologie*, 1 (1957), 201–208.
47. For example, see Jack A. Mabbutt, 'A stripped land surface in Western Australia', *Transactions of the Institute of British Geographers*, 29 (1961), 101–114; Charles W. Finkl and Hugh M. Churchward, 'The etched land surfaces of southwestern Australia', *Journal of the Geological Society of Australia*, 20(3) (1973), 295–307; Charles W. Finkl, 'Stripped (etched) land surfaces in southern Western Australia',

Australian Geographical Studies, 17(1) (1979), 33–52.
48. Ravi R. Anand and Mark Paine, 'Regolith geology of the Yilgarn Craton, Western Australia: Implications for exploration', *Australian Journal of Earth Sciences*, 49(1) (2002), 3–162.
49. James M. Bell and E. de C. Clarke, 'The geology of the Whangaroa subdivision, Hokianga Division', *New Zealand Geological Survey Bulletin*, 8 (1909); John A. Bartrum, 'High water rock platforms: a phase of shoreline erosion', *Transactions of the New Zealand Institute*, 48 (1916), 132–134.
50. Correspondence between J. T. Jutson and E. de Courcy Clarke for the period 1929–1947 recorded in Brock, op. cit. (n. 9), pp. 25–54.
51. Francis Buchanan, *A Journey from Malabar through the countries of Mysore, Canara and Malabar* (London, 1807), vol. 1, pp. 436–460; Benjamin Babington, 'Remarks on the geology of the country between Tellicherry and Madras', *Transactions of the Geological Society of London*, 5 (1821), 328–339; Thomas J. Newbold, 'Summary of the geology of S. India, VI. Laterite', *Royal Asiatic Society*, 8 (1846), 227–240; John B. Scrivenor, 'The term laterite', *Geological Magazine*, 47 (1910), 335; Johannes Walther, 'Laterit in West-Australien', *Zeitschrift der Deutsche Geologische Gesellschaft*, 67B (1915), 113–140.
52. Jutson, op. cit. (n. 3), p. 223: defined laterite as a rock formed in dry conditions; Jutson, op. cit. (n. 6), p. 350: re mineralogical composition; but also specified an earlier humid climate: see Jutson, op. cit. (n. 3), e.g. p. 95; Jutson, op. cit. (n. 4), e.g. p. 211.
53. Jutson, op. cit. (n. 3), pp. 144–145.
54. Ibid., p. 147.
55. Ibid., p. 218.
56. Ibid., p. 147.
57. Ibid., pp. 147–148.
58. Ibid., p. 55.
59. Davis, op. cit. (n. 19).
60. Passarge, op. cit. (n. 20).
61. Charles R. Keyes, 'Deflative systems of the geographical cycle in an arid climate', *Geological Society of America Bulletin*, 23 (1912), 537–562.
62. John W. Gregory, *Geography. Structural, Physical, and Comparative* (London, 1908); Douglas Mawson, 'Geological investigations in the Broken Hill area', *Memoirs of the Royal Society of South Australia*, 2 (1912), 211–319.
63. For example, William F. Hume, *Geology of Egypt* (Cairo, 1925), vol. 1; Rushdi Said, *The Geology of Egypt* (Amsterdam, 1962).
64. Richard J. Russell, 'Landforms of San Gorgiono Pass, southern California', *University of California (Berkeley) Publications in Geography*, 6 (1932), 37–44.
65. Eliot Blackwelder, 'Yardangs', *Geological Society of America Bulletin*, 24 (1934) 159–166; Hans Bobek, 'Zur Kenntnis der Sudlichen Lut. Ergebnisse einer Luftbildanalyse', *Mitteilungen der Österreichischen Geographischen Gesellschahft*, 111 (1969), 155–192; Carol S. Breed, John F. McCauley and Marion I. Whitney, 'Wind erosion forms', in *Arid Zone Geomorphology*, ed. D. S. G. Thomas (London, 1989), pp. 284–307.
66. Erland J. Brock and C. Rowland Twidale, 'J. T. Jutson and the work of wind in shaping the landscape', *Geographical Research*, 49(1) (2011), 47–58.
67. For example, Thomas O. Bosworth, *The Geology and Palaeontology of North-west Peru* (London, 1922).
68. For example, Timothy Egan, *The Worst Hard Time: The Untold Story of Those who Survived the Great American Dust Bowl* (Boston, 2006).
69. For example, Ellison, op. cit. (n. 28).
70. Georg Gerster, *Sahara*, transl. S. Thomson (London, 1960).
71. Barton, op. cit. (n. 22); Kirk Bryan, 'Pedestal rocks formed by differential erosion', *United States Geological Survey Bulletin*, 790 (1927), 1–15.
72. For example, Ronald F. Peel, 'Denudation landforms of the central Libyan Desert', *Journal of Geomorphology*, 4 (1941), 3–23.
73. Jutson, op. cit. (n. 3), p. 95.
74. Jutson, op. cit. (n. 4); Brock and Twidale, op. cit. (n. 66).
75. Ernest C. Andrews to Jutson, 29 May 1918, in Brock, op. cit. (n. 9), p. 2, concerning Jutson's paper: 'Erosion and resulting landforms in subarid Western Australia, including the origin and growth of the dry lakes', *Geographical Journal*, 50 (1917), 418–437.
76. K. Bryan to Jutson, 8 March 1923, in Brock, op. cit. (n. 9), p. 10.
77. Bryan to Jutson, 4 March 1924, in Brock, op. cit. (n. 9), pp. 10, 11.
78. Jutson, op. cit. (n. 4), p. 342.
79. Ibid, p. 207.
80. Phillip E. Playford, Anthony E. Cockbain and George H. Low, 'Geology of the Perth Basin, Western Australia', *Geological Survey of Western Australia Bulletin*, 124 (1976); Jonathan D. A. Clarke, 'Evolution of the Lefroy and Cowan palaeodrainage channels, Western Australia', *Australian Journal of Earth Sciences*, 41 (1994), 55–68; Peter Wellman and Raymond

Tracey, 'Southwest seismic zone of Western Australia: a measurement of vertical ground movements by repeat levelling and gravity surveys', *Bureau of Mineral Resources Journal of Australian Geology and Geophysics*, 10 (1987), 225–232; also Kevin C. Burke, 'The African Plate', *South African Journal of Geology*, 99 (1990), 341–409; Timothy C. Partridge, 'Of diamonds, dinosaurs and diastrophism: 150 million years of landscape evolution in southern Africa', *South African Journal of Geology*, 101 (1998), 167–184; Twidale and Bourne, op. cit. (n. 25).

81. Woodward, op. cit. (n. 79); Woodward, op. cit. (n. 31).
82. Augustus C. Gregory, 'The geographical history of the Australian continent during its successive phases of geological development', Presidential Address, *Australasian Association for the Advancement of Science*, VI (1895), 1–12.
83. T. W. Edgeworth David, 'The tectonic lines of Australia', *Journal of the Royal Society of New South Wales*, 55 (1911), 1–60.
84. W. J. Eric Van de Graaff, Rupert W. A. Crowe, John A. Bunting and Michael J. Jackson, 'Relict Early Cainozoic drainages in arid Western Australia', *Zeitschrift für Geomorphologie*, 21 (1977), 379–400; David P. Commander (compiler), *Hydrogeological Map of Western Australia*. Scale 1:2,500,000 (Perth, 1989); Jonathan D. A. Clarke, 'Lake Lefroy, a palaeodrainage playa in Western Australia', *Australian Journal of Earth Sciences*, 41 (1994), 5, 417–427; J. D. A. Clarke, 'Geomorphology of the Kambalda region, Western Australia', *Australian Journal of Earth Sciences*, 41(3) (1994), 229–239; Ramsis B. Salama, 'Geomorphology, geology and palaeohydrology of the broad alluvial valleys of the Salt River System, Western Australia', *Australian Journal of Earth Sciences*, 44 (1997), 751–765.
85. Jutson and De Courcy Clarke letters dated 25 November1930 and 16 September 1931, in Brock, op. cit. (n. 9), pp. 28, 32.
86. Phillip E. Playford, Anthony E. Cockbain and George H. Low, op. cit. (n. 80); Karl-Heinz Wyrwoll and Joseph E. Glover, 'The geological and geomorphological framework of Western Australia', in *Western Australian Yearbook* (Canberra, 1988), pp. 8–33.
87. C. Rowland Twidale and Jennifer A. Bourne, 'Origin and age of bornhardts, southwest of Western Australia', *Australian Journal of Earth Sciences*, 45 (1998), 903–914.
88. See also, Edwin Sherbon Hills, 'Die Landoberfläche Australiens', *Die Erde*, 3–4 (1955), 195–205; E. S. Hills, 'Physiography and Geology', in G. W. Leeper, ed., *Introducing Victoria* (Melbourne, 1955), pp. 25–39; also Elizabeth M. Campbell and C. Rowland Twidale, 'The evolution of bornhardts in silicic volcanic rocks in the Gawler Ranges, South Australia', *Australian Journal of Earth Sciences*, 38 (1991), 79–93.
89. John T. Jutson and Edward S. Simpson, 'Notes on the geology and physiography of Albany', *Journal of the Royal Society of Western Australia*, 2 (1916), 45–58.
90. John T. Jutson, 'Notes on the coastal physiography of Port Campbell, Victoria', *Proceedings of the Royal Society of Victoria*, 40 (1927), 45–57.
91. John T. Jutson and Alan Coulson, 'On the age of certain marine deposits at Portarlington, Victoria, with a proposed subdivision of the post-Tertiary rocks of the Port Phillip Bay district', *Proceedings of the Royal Society of Victoria*, 49 (1937), 314–326; J. T. Jutson and A. Coulson, 'Further notes on certain marine deposits at Portarlington, Victoria', *Proceedings of the Royal Society of Victoria*, 52 (1940), 342–344.
92. André Guilcher, *Coastal and Submarine Morphology*, trans. B. W. Sparks and R. H. W. Kneese (London, 1958); Alan S. Trenhaile, *The Geomorphology of Rocky Coasts* (Oxford, 1987).
93. John T. Jutson, 'Shore platforms near Sydney, New South Wales', *Journal of Geomorphology*, 2 (1939), 237–250. The *Journal of Geomorphology*, briefly (1938–1942) published in the USA, was an unfortunate casualty of the Second World War.
94. J. T. Jutson, 'Erosion and sedimentation in Port Phillip Bay, Victoria, and their bearing on the theory of a recent relative uplift of the sea floor', *Proceedings of the Royal Society of Victoria*, 43 (1931), 130–153, p. 148.
95. Ibid; J. T. Jutson, 'The shore platforms at Mt Martha, Port Phillip Bay, Victoria, Australia', *Proceedings of the Royal Society of Victoria*, 52 (1940), 164–175.
96. Cuchlaine A. M. King, 'Some problems concerning marine planation and the formation of erosion surfaces', *Transactions and Papers of the Institute of British Geographers*, 33 (1963), 29–43.
97. Edwin Sherbon Hills, 'Shore platforms', *Geological Magazine*, 86 (1949), 137–152; J. T. Jutson, 'The shore platforms of Flinders, Victoria', *Proceedings of the Royal Society of Victoria*, 60 (1948), 57–73.
98. Chester K. Wentworth, 'Marine bench-forming processes. I. Water-level weathering', *Journal of Geomorphology*, 1 (1938), 5–32; C. K. Wentworth, 'Marine bench-forming processes. II. Solution benching', *Journal of Geomorphology*, 2 (1939), 3–25; C. K. Wentworth,

'Shore platforms near Sydney; a discussion', *Journal of Geomorphology*, 3 (1940), 154–155; Hills, op. cit. (n. 95); J. T. Jutson, 'The shore platforms of Lorne, Victoria, and the processes of erosion operating thereon', *Proceedings of the Royal Society of Victoria*, 65 (1953), 125–134.

99. J. T. Jutson, 'The shore platforms of Flinders, Victoria', *Proceedings of the Royal Society of Victoria*, 60 (1948), 57–73; see also Austin B. Edwards, 'Storm-wave platforms', *Journal of Geomorphology*, 4 (1941), 223–236; Robert S. Dietz, 'Wave-base marine profile of equilibrium, and wave-built terraces: a critical appraisal', *Geological Society of America Bulletin*, 74 (1963), 971–990.
100. Jutson, op. cit. (n. 99).
101. John A. Bartrum, 'High water rock platforms: a phase of shoreline erosion', *Transactions of the New Zealand Institute*, 48 (1916), 132–134; C. Rowland Twidale, 'The origin and implications of some erosional landforms', *Journal of Geology*, 98(3) (1990), 343–364; Eloy Molina Ballesteros, Elizabeth M. Campbell, Jennifer A. Bourne and C. Rowland Twidale, 'Character and interpretation of the regolith exposed at Point Drummond, west coast of Eyre Peninsula, South Australia', *Transactions of the Royal Society of South Australia*, 119 (1995), 83–88; also C. Rowland Twidale, Jennifer A. Bourne and Juan R. Vidal Romani, 'Beach etching and shore platforms', *Geomorphology*, 67(1–2), 47–61.
102. Edwin Sherbon Hills, 'Underground water as a factor in geological processes', in *Proceedings, Ankara Symposium on Arid Zone Hydrology, Arid Zone Programme II, UNESCO* (Paris, 1953), pp. 262–264, at p. 264.
103. E. S. Hills, 'The question of Recent emergence of the shores of Port Phillip Bay', *Proceedings of the Royal Society of Victoria*, 52 (1940), 84–105; E. S. Hills, 'Morphotectonics and the geomorphological sciences with special reference to Australia', *Quarterly Journal of the Geological Society of London*, 117 (1961), 77–89, at p. 78; see also E. S. Hills, 'A study of cliffy coastal profiles based on examples in Victoria, Australia', *Zeitschrift für Geomorphologie*, 15 (1971), 137–180, at p. 178.
104. J. T. Jutson, 'The shore platforms of Lorne, Victoria', *Proceedings of the Royal Society of Victoria*, 61 (1949), 43–59.
105. André Guilcher, 'Shore platforms in Australia and elsewhere', in *Pathways in Geology. Essays in Honour of Edwin Sherbon Hills*, ed. R. W. LeMaitre (Melbourne, 1989), pp. 103–110, at p. 103.
106. Jutson, op. cit. (n. 3); Jutson, op. cit. (n. 4).
107. Arthur Holmes, 'Radioactivity and earth movements', *Transactions of the Geological Society of Glasgow*, 18 (1931), 559–606; Harry H. Hess, 'History of ocean basins', in *Petrologic Studies: A Volume to Honor A.F. Buddington*, eds E. A. J. Engel, H. L. James and B. F. Leonard (New York, 1962), pp. 599–602; Arthur A. Meyerhoff, 'Arthur Holmes: originator of spreading ocean floor hypothesis', *Journal of Geophysical Research*, 73 (1968), 6563–6565.
108. Falconer, op. cit., (n. 45).
109. Edward J. Wayland, 'Report on the geology of part of Karamoja, by the Government Geologist', *Geological Survey of the Protectorate of Uganda Annual Report for 1920*, (1921), 35–40; Wayland, op. cit., (n. 44); Bailey Willis, *Studies in Comparative Seismology: East African Plateaus and Rift Valleys* (Carnegie Institution of Washington Publication 470) (1936); Büdel, op. cit., (n. 46).