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Position and developmental history of the central watershed of the Western Shield, Western Australia

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Abstract

Completion of the latest series of topographic maps at scales of 1:100 000 and 1:250 000 by the Commonwealth agency AUSLIG and of the 1:250 000 geological maps by the Geological Survey of WA has provided much new valuable data on the topography and surface features of the Western Shield in Western Australia. It has long been known that the Shield has a longitudinal central watershed or so-called continental divide separating drainages to east and west, and it is now possible to plot this precisely following contours on the new maps. The lateral watersheds bounding the catchments of rivers, still mainly active, which drain to the west coast have also been mapped. The central watershed rises steadily from 400 m asl at its southern end to a maximum of 750 m near its northern end, in conformity with a general tilt of the Shield. The lateral watersheds slope down gradually from the central watershed to $\pm$ 250-300 m at the western edge of the Shield, a height corresponding, it is suggested, to Cretaceous sea level. Metamorphic belts incorporated in the general granite-gneiss ground mass of the Yilgarn Craton have only very local effects on drainage patterns. On the Yilgarn Craton the mapped watersheds tend to be covered by sandplains, varying from complete cover in the south to partial in the north. Whereas the superficial deposits on these sandplains may be of different ages, i e subsequently disturbed, reworked or replaced, the saprolite beneath is suggested to conform to a palaeosurface resulting from planation during the Mesozoic era, when the drainage systems of today also originated.

Introduction

Geological terminology has been undergoing revision in recent years, and while the term Western Shield appears prominently in the Geological Survey's 1975 authoritative account of the geology of the State (Anon 1975), it does not appear at all in the 1990 edition (Anon 1990). None the less it is useful for geomorphological purposes as it defines a practical unit (Fig 1) of Precambrian rocks surrounded by Phanerozoic basins whose history and surface features are different. The Yilgarn Craton forms the southern portion with an area of 657 000 km^2 accounting for over half the Western Shield. It consists of Archaean granite and gneiss with infolded beds of meta-igneous and meta-sedimentary rocks known as "greenstone belts", and forms a plateau surface varying between 200 and 600 m above sea level, known as the Old Plateau (Jutson 1914), Darling Plateau (Cope 1975) or Yilgarn Plateau (Jennings & Mabbutt 1977; Mulcahy & Bettenay 1972). In the north is the Pilbara Craton, divided from the Yilgarn Craton by a complex belt of metamorphic sedimentary and igneous rocks known as the Capricorn Orogen (Anon 1990). Part of the smaller Albany-Fraser Orogen borders the Yilgarn Craton on the south.

A major feature of the Western Shield is a north-south watershed or divide (Fig 1) which separates the valley systems of rivers, some still active, draining to the west coast from those now largely inactive and disorganised which formerly drained east and south-east. This watershed runs north-south approximately central to the Western Shield equidistant from the margins of the sedimentary basins on either side (Fig 1). This watershed orientation could be expected for a tectonically inert continental peninsula twice as long as broad with sedimentary basins on each of the two longer sides (Beard 1973). This was the situation during the Mesozoic when the Shield was a peninsula of Antarctica, suggesting that its present drainage systems originated during that era (Beard 1973). The latter are unrelated to those which developed after uplift of the land in the Canning and Officer Basins in the Early Tertiary, which flowed north-west and south respectively from another principal watershed extending SW to NE between latitudes 22 ° and 25 ° (Beard 1973; van de Graaff *et al.* 1977).

Descriptions of the surface features of the Western Shield have declined in number in the past 20 years after active publication in the 1960s and 1970s, although new topographic and geological information has steadily continued to become available. New data are mainly derived from two sources. First, the latest series of topographic maps at scales of 1:100 000 and 1:250 000 (AUSLIG) have been recently been completed. These maps are contoured at 50 metre intervals and also show abundant spot heights, whereas few heights were previously available. They enable a much better appreciation of the conformation of river catchments and the major features of the Shield. Secondly, the 1:250 000 series of geological maps (Geological Survey of WA) conform to the grid boundaries and sheet names of the topographic series and provide a complementary treatment of surface features.

Jutson (1914) did not indicate the Central Watershed in his map of the drainage divisions of Western Australia

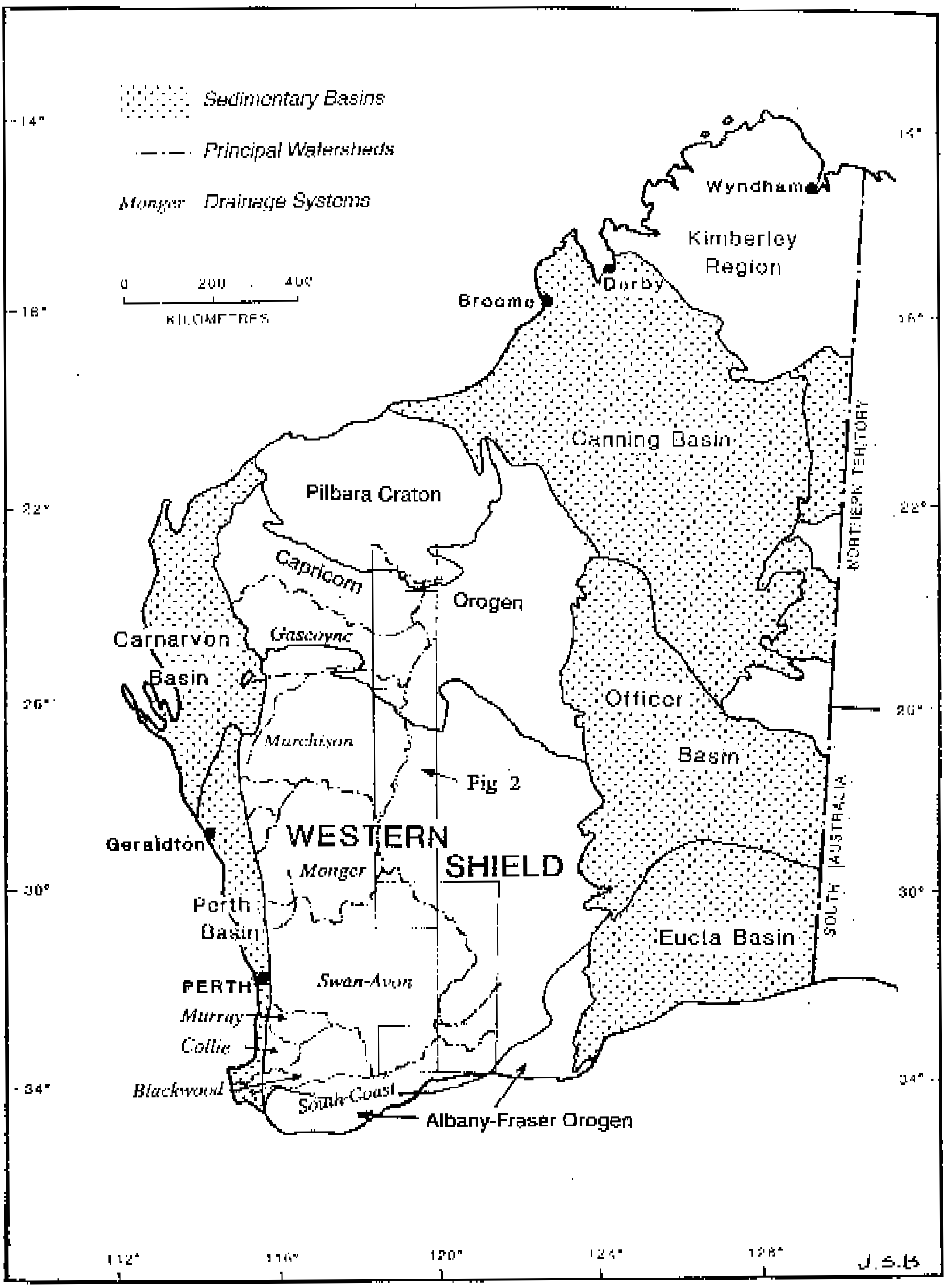

Figure 1. Simplified map of geological structure of Western Australia, based on Figs 3.1 and 4.1 in Anon (1990), to show the Western Shield, its subdivisions and surrounding sedimentary basins. Positions of the central and western lateral watersheds have been added, and drainage systems.

as it was not then recognised that the salt lakes of the interior (Jutson's "Salinaland") occupy the valleys of relict river systems. The southern part of the watershed was figured by Mulcahy & Bettenay (1972) as the "major continental divide", by Beard (1973) as the "principal watershed" and by van de Graaff *et al.* (1977) as the "major drainage divide" on their drainage system maps. The first of these terms has been used by Glassford (1987) and Glassford & Semeniuk (1995) as well as in a number of explanatory notes to geological sheets but seems open to objection as it is not strictly speaking a continental divide. I prefer "watershed" to "divide" and refer to the valley system of a particular river as a "catchment" to avoid confusion with the geological term "basin"

Methods

The surface of the Western Shield is mostly of low relief and so it has been difficult in the past to determine the alignments of watersheds and former drainage lines. This paper provides a precise plot for the position of the Central Watershed using modern topographic data to improve the sketch maps of previous authors. Data from vegetation and geological maps have been incorporated to show the conformation of the watershed and its surface features. The watershed was drawn following the contours shown on the latest series of 1:250 000 topographic maps. As it traverses relatively high ground, numerous spot heights, bench marks and trig points were available to establish precise elevations. On the granitic Yilgarn Craton, the watershed mostly traverses extensive sandplains where it was difficult to establish its exact position, so assistance was obtained from vegetation and geological maps. Within the Capricorn Orogen the watershed traverses mountainous country with ranges striking WNW-ESE to W-E which form transverse ridges across it with flat plains between them. In addition to the Central Watershed, the position and conformation of three main lateral watersheds were plotted and described in the same way, those dividing the Swan-Avon, Moore-Monger, Murchison and Gascoyne systems on the west side.

Results

The alignment of the central and lateral watersheds is shown in Fig 1 at small scale in relation to the Western Shield, and in Fig 2 at larger scale in more detail. All available heights on the alignments have been marked. For easy reference in Fig 2, the diagrams are divided into rectangles of latitude and longitude corresponding to the national 1:250 000 map grid, with the names of the map sheets indicated.

Central Watershed

The Central Watershed extends from an undistinguished eminence 652 m above Australian Height Datum situated 45 km due south of the township of Newman in the Pilbara (map ref QU7769) to an equally undistinguished point at approx 400 m situated near Lilian Stokes Rock, 40 km due east of Lake King (map ref TD3040). It terminates at either end where it meets a transverse watershed delimiting drainage to the north and south coasts respectively. In the south this corresponds in part to the Jarrahwood Axis of Cope (1975). The Central Watershed extends from lat 23 º 46 ' S to 33 º 3' S, a linear distance of 1036 km but a much greater actual length of 1481 km, as the watershed twists and turns considerably.

The heights along the Central Watershed, while undulating, show a steady rise towards the north in conformity with the tilt of the Western Shield already noted by other authors (Lowry *et al.* 1972: Stewart *et al.* 1983). The lowest point on the watershed is at the southern termination; the highest is at the junction with the lateral watershed between the Ashburton and Gascoyne rivers at 750 m. The rise is therefore 350 m in 1000 km equivalent to a slope, slight but significant, of 1.2 '. The highest point anywhere on the Western Shield is at Mt Meharry (1250 m) shown at top left on Fig 2, with a rise of 850 m in 1130 km, equivalent to 2.6 '. This compares with the observations of the above authors, who calculated 1.5 ' and 1.6 ' for smaller portions of the Shield.

Locally, while on the Yilgarn Craton, the watershed is somewhat flat and traverses extensive sandplains, On the Lake Johnston, Boorabbin and Kalgoorlie map sheets in the south, the watershed lies entirely on sandplain for 326 km except for a single minor greenstone outcrop at Hatters Hill and occasional protruding granite rocks. Further north, more topographic diversity appears where greenstone belts cross the line of the watershed and where these contain resistant rocks such as banded ironstones, to form outstanding hills and ridges. Since the general strike of the greenstone belts is NNW-SSE, they tend to intersect the watershed at a low angle. They do not appear to have significantly influenced the location of the watershed and may appear elsewhere in isolated summits and ranges reaching greater heights but only locally affecting the drainage. Thus on the Jackson and Barlee maps a major greenstone belt intersects the watershed, and the summits of the Die Hardy Range coincide with the watershed from Mt Geraldine (642 m) to Deception Hill (516 m; Fig 2).

Other hills formed by greenstone outcrops in the vicinity *e.g.* Mt Manning (646 m) and Mt Jackson (617 m) are unconnected with it. Greenstone belts do not always have such marked topographic expression, and on the Youanmi map the watershed is intersected but shows no apparent change in its general heights. Further north, however, on the Sandstone map the Ballanhoe Peaks and the Montague Range both intersect the watershed whose course is unaffected in the first case but runs along the summit of the range for a short distance in the second. In between these hilly belts the watershed continues its even course, undulating very gently with a slight rise towards the north and situated for the most part on sandplains. On the Barlee and Youanmi maps, lateral watersheds diverge towards the west.

On the Glengarry map there is a low transverse "Unnamed Range" which marks the transition from the mainly granitic Yilgarn Craton to the Proterozoic metamorphics of the Capricorn Orogen. From here, northward, the watershed is underlain by rocks of varied lithology, some more resistant than others, which strike across it at a high angle, The watershed therefore crosses successive transverse ridges with plains between them.

Figure 2. Detail of alignment of the watersheds.

This topography has evidently affected the location of the watershed to some extent since although it maintains its general northerly direction it is sinuous with a pronounced loop east of the Collier Range (Fig 2). The main watershed passes to the east of both the Robinson and Collier Ranges, both of which control lateral watersheds bounding the Gascoyne River catchment.

Height variations along the central watershed are remarkably small and there are no major gaps or irregularities. In a few cases there are minor gaps which may possibly indicate some change in the drainage pattern in the distant past. Beginning in the south, the first of these is a low point of 417 m on the Boorabbin map (ref TE7573). Over a length of 20 km the watershed declines in height from 495 m to this col, and rises again to 489 m in a similar distance. The col is a flat plain with scattered claypans and separates a north-trending palaeotributary of the Swan-Avon system from an east-trending chain of salt lakes leading into the Lefroy palaeodrainage (Clarke 1994). On the Jackson map there is a gap in the watershed with a minimum height of just under 500 m a little west of Mt Dimer (ref QM7838). This lies at the north- eastern end of a “major lineament” trending NE-SW which was identified in the geological survey (Chin & Smith 1983) as responsible for the south-west trending drainage line from the Clarkson Flats to Lakes Deborah and Baladjie, and attributed to crustal fracturing and Proterozoic dyke intrusion. A second similar gap occurs on the Barlee map just west of Deception Hill (ref QM2399). In both cases there is very little drop in level in these gaps where the col is at about 500 m but they do lie at the southern end of north-trending drainages of the Lake Barlee system. Further north there is only one conspicuous gap in the watershed, on the Glengarry map on Killara Station, where the watershed crosses a plain between two east-west ranges of hills at a col (ref QR208O) dividing east and west palaeodrainages. The col is 50-100 m below the general level of the watershed to north and south. Its significance may be no more than that it follows the trend of less resistant rocks within the Proterozoic sedimentary complex (Elias *et al.* 1982).

Lateral Watersheds

The alignments of the lateral watersheds bounding the Swan-Avon, Monger, Murchison and Gascoyne drainage systems to the west of the central watershed have been traced and mapped in the same way, and are shown at small scale in Fig 1. Presentation of the data in detail may more appropriately be reserved for later studies of the evolution of drainage in these individual systems which it is hoped to publish. Briefly, the Swan-Avon/ Monger watershed leaves the central watershed on the Barlee map (Fig 2) at a height of 495 m at first in a south-westerly direction. With minor undulations it descends gradually from 495 m to 250 m at the Darling Fault, and has a total length of 410 km. It forms a continuous ridge without any noticeable low points or gaps, and is situated for its entire length on sand plains.

The Monger/Murchison watershed branches off on the Youanmi map at 552 m in height and is 455 km long to the edge of the Western Shield. This watershed is controlled by a greenstone belt for some 30 km from Mt Charles (639 m) to Dalgaranga Hill (642 m) where the country is hilly and reaches greater heights. Close to the eastern end the watershed has a pronounced gap which may have been associated with former drainage out of Lake Boodanoo. Otherwise the watershed maintains even heights of about 500 m along its eastern half and then descends gradually to 300 m at the edge of the Western Shield. Outside the greenstone belt patches of sandplain occur along its length.

The Murchison/Gascoyne watershed branches off from the central watershed on the Peak Hill map at an undistinguished point on a wide sandplain, altitude 640 m. For the first 100 km it is formed by ridges of the Robinson Ranges at heights of 600-650 m (max 714 m), but further west takes an even course descending to 300 m at the edge of the Western Shield. The total length is 400 km. There are no sandplains except at the start, but portions of the alignment have been mapped geologically (Elias & Williams 1980; Williams *et al.* 1983) as capped with duricrust, which I interpret as former sandplain from which the superficial sand has been removed. Fig 2 also maps part of the south coast watershed delimiting the numerous short streams flowing to the Southern Ocean, and the watershed dividing the Lefroy and Cowan drainages (Clarke 1994) which appears to represent the Jarrahwood Axis of Cope (1975).

Discussion

The descriptions of the central and lateral watersheds with their surface features may throw light on the nature and origin of the landscapes traversed, though landscape evolution on the Western Shield has been long and complex and many details remain unknown. Only the broadest framework of major episodes and phases can be presented here but may provide a first approximation for future testing and refinement.

The watersheds themselves and the drainage systems which they enclose are evidently of considerable antiquity, having been attributed to the Mesozoic by numerous authors *e.g.* Beard (1973), van de Graaff *et al.* (1977), Butt (1981) and Clarke (1994). On the Yilgarn craton the watersheds are mainly situated on sandplains - broad, sand-covered expanses of little topographic relief. Exceptions occur locally only where monadnocks of resistant rocks protrude or where the sandplain has been eroded away. The central watershed slopes up gently towards the north, suggesting a tilt of the Western Shield by epeirogenic movement. The lateral watersheds slope down equally gently from the central watershed to the edge of the Shield. The surfaces on which the watersheds are situated appear strongly to conform to a palaeosurface created by general levelling of the craton during Mesozoic time as suggested by Butt (1981) and completed by the mid-Cretaceous. The rise in sea level in the early Cretaceous would have prevented further down-cutting by the rivers, and the general levelling would have reduced erosion and silt-load. This is supported by the reduced thickness of Cretaceous sediments in the Perth Basin and the appearance of carbonates among them. The levelling would have provided a relatively inert surface beneath which deep weathering could take place as it has done generally on the Craton, and on which erosional material could accumulate without being transported outside the system. It is envisaged that by the mid-Cretaceous a gently undulating plateau had formed on the Yilgarn Craton, broken only by scattered monadnocks. It was covered largely by the products of its own erosion and drained by sluggish rivers in shallow valleys.

It is important to distinguish in this context between the surface as a landform and its superficial deposits. The landform is the surface of the superficial deposits which have accumulated on the saprolite to form a new land surface, the components of which are not necessarily directly related to the upper bounding surface of the buried saprolite. A relatively stable landform surface is clearly a necessity if deep weathering is to take place, in view of the time scale involved. Relative stability results when the products of weathering are removed from the surface at a slower rate than they are formed. Weathering can continue below the saprolite surface but once it is covered by superficial deposits there can be no more removal of weathered material from the saprolite other than by solution, and the buried surface remains stable without further lowering. It is therefore quite possible for surfaces of some antiquity to be preserved, as demonstrated by Nott (1995) in the Northern Territory. On the Yilgarn craton the Mesozoic palaeosurface is preserved beneath later sandsheets. It was formerly thought, following Prescott (1931) and Stephens (1946) that the profile under the sandplain represented a soil developed directly and *in situ* from the pallid zone but this view has been challenged. Glassford (1987) and Glassford & Semeniuk (1995) have shown that the upper portion of a typical profile (at least in areas studied) consists of a sandy clayrock overlying the weathered saprolite; this is turn unconformably overlain by sandy laterite, and capped by sheets and dunes of silicic sand. These deposits were named by the authors as separate geological formations and held to have been laid down as wash, dusts and aeolian sands, thereby burying a former landsurface. The age of these superficial deposits was held to be post-Eocene, in some cases as recent as Quaternary. While obviously reworking of the topmost Gibson Formation could be expected to occur intermittently down to any recent date, the sandy clayrock of the bottom-most Westonia Formation is more likely to have been laid down during the later stages of levelling of the Mesozoic surface. The difficulty is that the sandplains bearing these superficial deposits are not universal. They are limited to high ground capping watersheds, residual hills and mesas, and are not normally found in valleys where the soils are developed directly on saprolite. Such sandsheets as occur on lower ground are demonstrably of a different and later aeolian origin (Beard & Sprenger 1964; Beard 1981). The facts suggest that a universal palaeosurface once existed on which the superficial deposits were emplaced, and that this has later been dissected by valley deepening, and surface erosion.

If the general levelling and formation of the Mesozoic palaeosurface was completed by the mid-Cretaceous the superficial deposits must have been laid down already or soon after and subsequently dissected. Since the superficial deposits are considered by Glassford and Semeniuk (1995) to have been derived from wash, aeolian sands and dusts it is difficult to see how these could have been deposited on high ground only and not in the valleys, A post-Eocene date is too late for removal of valley deposits by fluvial action. By that time valley infill had become the dominant pattern. This difficulty does not arise if one adheres to the Prescott-Stephens view of the development of the sandplain profile since this would go on simultaneously with deep weathering and there is no need to postulate a post-Eocene date.

I suggest a more likely scenario as follows. High sea level prevailed in the early Cretaceous up to the Neocomian. After deposition of the Poison Hill Greensand in the Perth Basin the marine transgression began to recede, exposing a sedimentary surface (Playford *et al.* 1976). The Western Shield was effectively uplifted by an amount at least as great as the depth of the water offshore when the Poison Hill Greensand was being deposited. I am informed that as open marine conditions prevailed, a depth of 200 m should be allowed (A E Cockbain, pers comm). Since rainfall was high in the late Cretaceous and early Tertiary it is likely that the rivers lowered their beds to the new base level at the coast, and that the valleys were adjusted accordingly. A period of 30 million years from the Maastrichtian to the Upper Eocene is available for this process during which the sandplains could have been substantially removed and left capping higher ground as at present.

The landscape in the Capricorn Orogen is entirely different. For the most part it is controlled by a sub-parallel series of ridges of steeply dipping rocks forming north-facing cuestas, with country of more gentle relief between them. A Mesozoic surface may once have existed but it is difficult to find any trace of it now, due to active external drainage and erosion. In some valleys there are small duricrusted mesas formed from early, probably Tertiary, valley-fill. Sand sheets are found mainly along the central watershed and to its east on plains between the ridges and appear to be derived from decomposition of local quartzitic rocks.

Conclusions

1. This investigation more precisely locates the position of a central drainage watershed on the Western Shield.
2. On the granitic Yilgarn Craton the included greenstone belts have had no obvious effect on the general drainage pattern, which generally does not conform to the strike of these rocks. Ridges within greenstone belts may occasionally coincide with a watershed for a short distance but they have only local significance.
3. Within the Capricorn Orogen, where rocks are stratified and strike transversely to the central watershed, the general north-south trend of the watershed is maintained, but lateral watersheds are strongly influenced by the strike.
4. The central watershed rises steadily in altitude towards the north along its length which is consistent with the whole Western Shield having been subjected to a history of regional tilting.
5. Gaps or low points in the watershed, which may relate to prior drainage alignments, are few and appear to be of little significance.

6. The central watershed is of great antiquity and is likely to have been in existence since the Mesozoic. On the Yilgarn Craton it traverses a buried palaeosurface little modified since the Cretaceous. According to Glassford & Semeniuk (1995) this surface has been deep weathered and buried, thereby preserved, by lateritic dust and sandsheet deposits.
7. Lateral watersheds and any high ground within the catchments also tend to preserve portions of the palaeosurface and its superficial deposits, whereas in the valleys it has been eroded away by river action. It is suggested that this erosion took place between the Maastrichtian and the Upper Eocene.

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