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SIMPSON DESERT DUNES - DATES AND PROBLEMS

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Abstract. Stratigraphical evidence shows that the Simpson Desert dunefield is of latest Pleistocene-Holocene age. The dunes are still active. TL dating of dunes around Birsdsville however gave Late Pleistocene ages (c. 78,000 and c. 34,000 years). To test this apparent anomaly a site east of Birsdsville was sampled. It is exposed to the dune base and beyond. Internal structures are readily discernible. OSLanalysis gave dates of 8800 years at the crest and 10,000 years at the base. The underlying alluvium is some 36,000 years old. The upper zones of dunes west of Birdsville gave ages of 1000 years or less. Samples from a source-bordering dune were dated at 1000-1300 years. Dunes formed in the lee of such transverse forms are obviously younger, for they developed because of the obstacle. The implications of these dates are discussed as are questions of dune colour and size.

Key words: longitudinal dune, age, development, colour, size, origin of sand.

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1. Introduction

The sand ridges of the Simpson Desert have given rise to several problems and debates. They are related first to the age of the forms, second to the origin of the sand of which the dunes are built, and third to whether the colour of the sand and dune size provide an indication of age.

2. Age of dunes

The Simpson Desert *sensu lato* (Fig. 1) has traditionally been regarded as the most active of the Australian dunefields. The others - the Gibson, Great Victoria, Great Sandy, Tanami, and so on - are regarded as essentially relic, and comparable to the extensive areas of stabilised dunes found in southern South Australia and western Victoria. Perhaps it is for this reason that the Simpson is the earliest, and most intensively, studied of the Australian dunefields (e.g. Madigan, 1936, 1946).

The dunes are of longitudinal, linear or sand ridge type (Fig. 2) though reticulate and parabolic forms are developed locally. They trend SSE-NNW except in the south where they run SSW-NNE. They range in height between about 10 m and almost 40 m above the interdune corridors. They are built of quartz sand, though clay particles are trapped between the sand grains and may constitute as much as 5% by volume. In many instances the clays have been illuviated and concentrated in clay-rich dune cores. Occasionally, buried remnants of thin discontinuous A-horizons are found high in some dune exposures, and calcrete nodules occur in some crests, but apart from these developments the siliceous sands are unweathered. Where the interdune corridors are floored by sand calcrete nodules are common (e.g. Twidale, 1981; Wright *et al.*, 1990). Wasson (1983) uses pedogenic lime - not the material of choice bearing in mind the open dune system and the ready translocation of the carbonate - to date Simpson Desert dunes (as latest Pleistocene) but the presence of lime does not of necessity indicate any great antiquity. Lime rapidly accumulates in soils at the present time, as is indicated, for instance, by the widespread replacement decayed plant roots by carbonate.

The sand ridges have been regarded as essentially Holocene, and active, for various reasons.

a) In the eastern and southern sectors of the dune field, the sand ridges rest on a substrate of alluvia and lacustrine sediments (Figs. 2b and c) which contain mammalian remains as well as mollusca and other organic remains (Wopfner & Twidale, 1967, 1988; Mabbutt & Sullivan, 1968). Palaeontological and physical dating (14C, ESR) show that the substrate is of Late Pleistocene-earliest Holocene age with the latter probably «too young» because of carbon contamination. The sand dunes stand on and are younger than the Late Pleistocene alluvial substrate and must there-

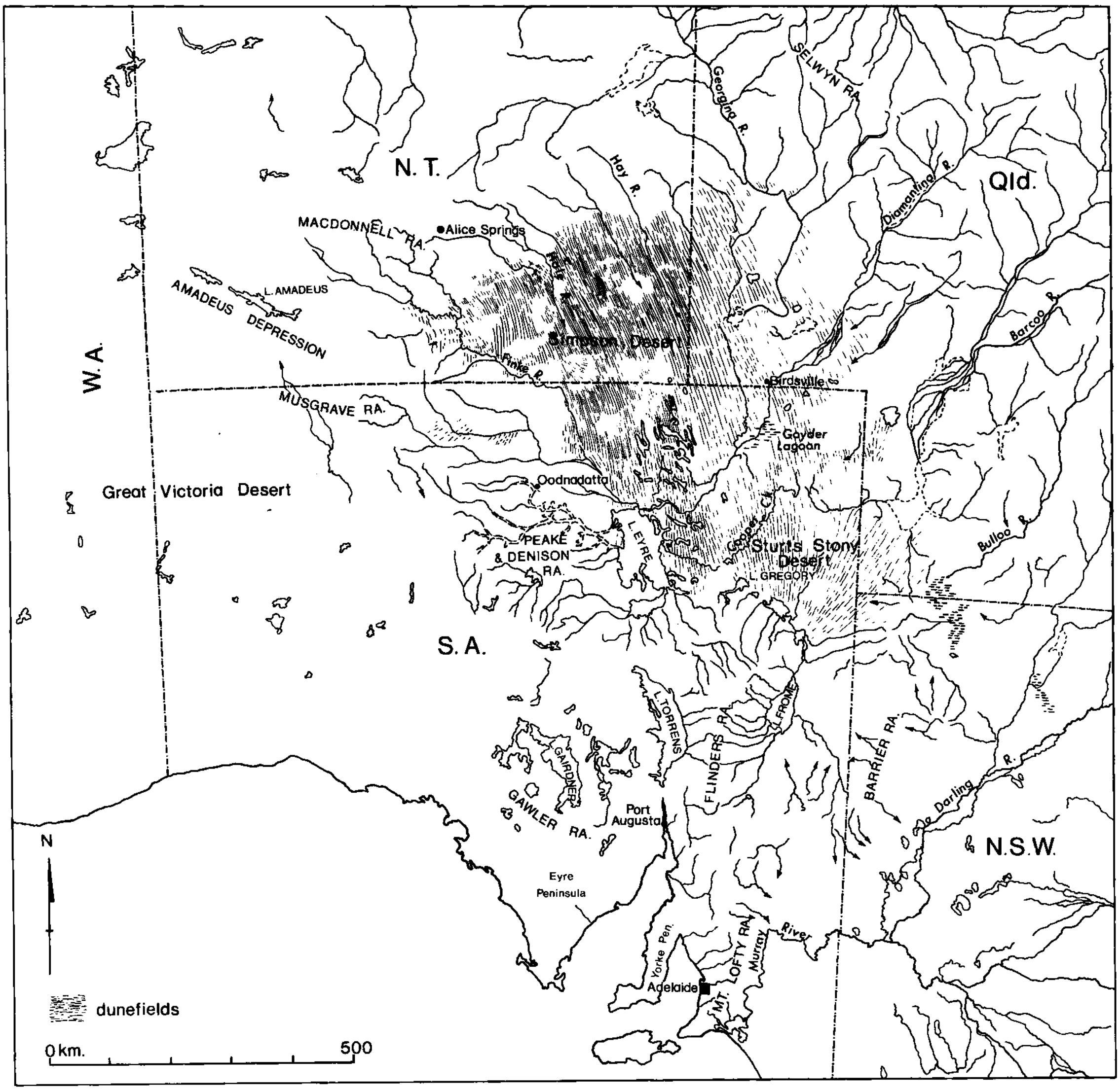

Figure 1. The Simpson Desert in its regional setting

Figure 2. Longitudinal dunes of the Simpson Desert (a) high oblique view, (b) and (c) low oblique shots showing dunes on a substrate of alluvium

fore be no older than the very latest Pleistocene and can be regarded as essentially Holocene forms.

b) Historical evidence, including repeat photography, shows that the dunes are advancing to the NNW, albeit spasmodically and at temporally varied rates (e.g. Ratcliffe, 1936, 1937; Wopfner & Twidale, 1967, 1988).

In 1992, however, Nanson *et al.* reported dunes from the Diamantina flood plain south of Birdsville and from the region west of the town (Fig. 3) which gave thermoluminescence (TL) dates (processed in the Wollongong laboratory) of some 78,000 years and almost 34,000 years respectively, and clearly of Late Pleistocene age. This is at variance with the stratigraphically determined age of the dunefield and suggests either

(a) that the Nanson *et al.* (1992) dates are flawed; or
(b) that the stratigraphic ages, though reinforced by physical datings, are somehow incorrect; or
(c) that though the present dunefield is overwhelmingly a Holocene development, remnants of older dunes which predate the Late Pleistocene flood plain alluvia are preserved in places.

3. Sampling and dating

In an attempt to clarify this anomaly, and with the support of a grant (#5906-97) from the National Geographic Society, Washington D.C., several dunes from the Birdsville area were located (Fig. 3), sampled and dated using the Optically Stimulated Luminescence (OSL) method in J.R. Prescott's Adelaide Physical Archaeometry Laboratory (Twidale *et al.,* 2000). One located some 16 km ENE of Birdsville (SD1) is exposed from crest to below the sand base (Figs. 3 and 4). It evidently extended over a gibber plain in which the (silcrete and quartzite) stone layer is underlain by alluvium. Sampling included alluvium below the gibber horizon as well as down the dune profile. The sand is of latest Pleistocene age (about 9,000-10,000 years old) and the alluvium Late Pleistocene (about 36,000 years old). Though ideal for dating in that it is exposed from crest to base, this particular dune is anomalously small, for other dunes in the area consisting of younger sand, at least in their higher sectors, are 4-5 times as high.

In another dune, located 14 km WSW of Birdsville and labelled Big White from its size and colour, the sand is up to 1000 years old. Sand was obtained from the basal slope of the dune and it was the oldest sampled, but it may be sand draped down the slope. It was probably not from the base of the core of the sand ridge and does not indicate the age of initiation of the dune: it is a minimum age. Similarly the sand from a large dune labelled Big Red (29 km west of Birdsville) is only a few hundreds of years old. Many desert dunes develop in the lee of mounds, source-bordering dunes or lunettes (e.g. Twidale, 1972) and the sand in one such mound from near Alton Downs, and 57.5 km SSW of Birdsville, is only 1000-1300 years old so that the dunes genetically related to it must be younger than that.

Thus the dunes of this area are, on this TL evidence, Holocene or latest Pleistocene in age. Dates from near surface sand show that they are still accumulating, and the SD1 dune shows that some sand ridges began accumulating about 10,000 years ago. But some dunes may be older than others. On the other hand, Nanson *et al.* (1992) older dunes appear to be inconsistent with the Late Pleistocene age of the alluvial substrate for there is no evidence that the dunes dated are inliers protruding through the alluvial cover.

What, then, of the Nanson *et al.* (1992) old dune dates? Could they be remnants of an older dune sequence? This would imply that they are inliers projecting through the later Pleistocene flood plain alluvia, and no evidence of such a relationship has yet been reported; on the contrary the

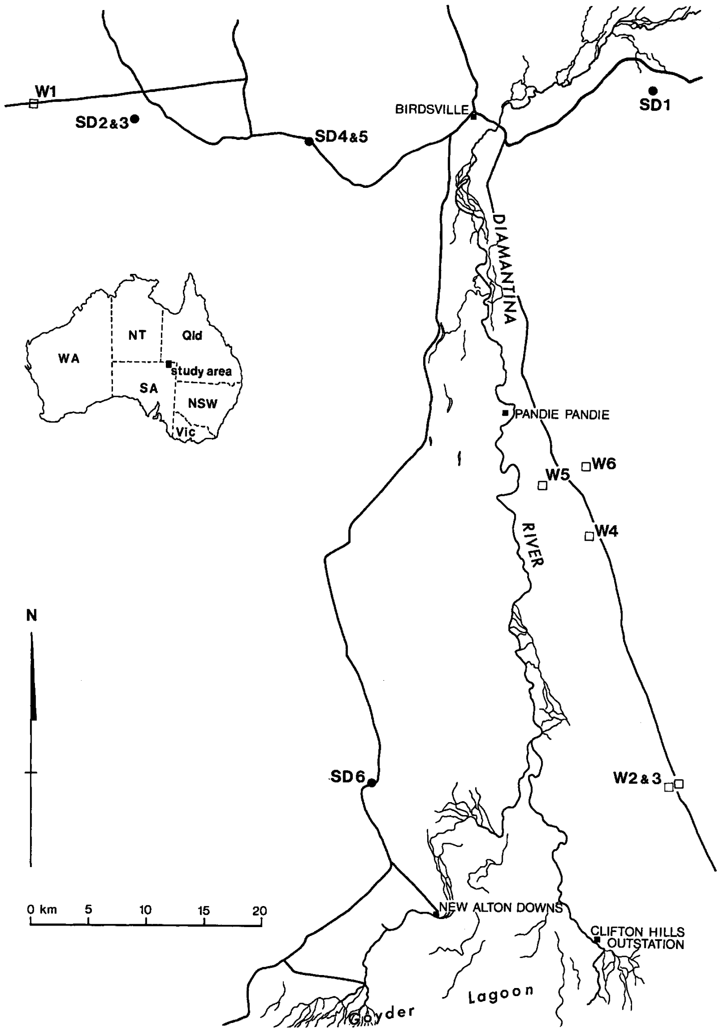

Figure 3. The Birdsville area, showing sampling sites: W1-W6, white squares, Nanson et al. (1992) Wollongong sites; SD1-SD6, black dots, Adelaide sites

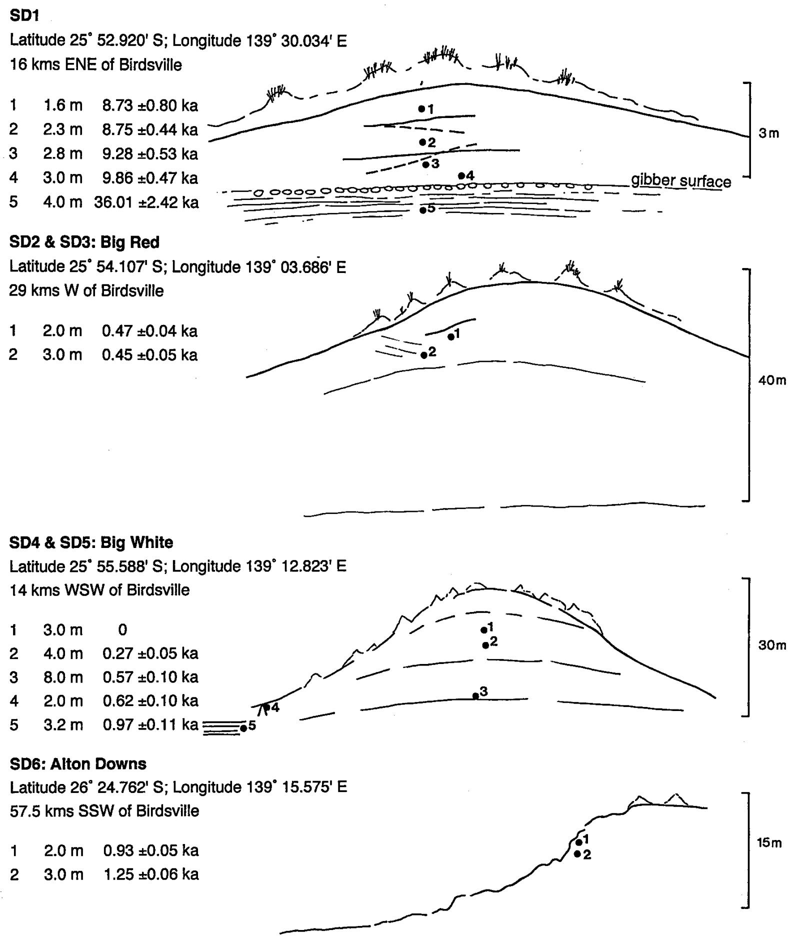

Figure 4. SD1 and other dune sections with TLdates

dunes of the eastern, central and southern Simpson Desert consistently have been shown to rest on the alluvial substrate.

Nanson *et al.* (1992) did not provide GPS data for their sites and despite a careful search using the information given in their account it has not been possible to relocate and resample their site W4. But examination of the Nanson *et al.* (1992) data suggests that they are suspect in at least two respects. The sampling was by vertical augering and it was not possible to see the sampled sites in their overall context, for instance in terms of sets of cross-bedded laminae, or of surficial draping of sand. One of the samples of old sand (at site W1, Nanson *et al.'s* 1992 Figure 3) was obtained from a metre depth low on the flank of a dune, the other (site W4, Figure 3) from a low remnant on the adjacent interdune plain: in neither instance was it possible to relate the sand sampled to the structure of the dune. For instance, it is not clear whether the old sand sample, that from the interdune corridor, represented the base of the dune. It is suggested that the SD1 dune, where the relationships of the samples taken are obvious, and where the location of the oldest sand, representing the age of dune advance, are clear, provides a more reliable chronology of local events.

4. Origin of dune sand

Two settings for dune development have been suggested for the sand ridges of the Simpson and other Australian deserts. Many sand ridges in the southern and eastern sectors of the Simpson Desert undoubtedly originate in the lee of source-bordering dunes which are in turn deposited in the lee of playa beaches or other sand accumulations deposited in river valleys and channels. Both mounds and channels are obstacles which interfere with the airflow and induce deflection and ephemeral turbulence. Ribbons of sand are deposited in the low velocity zones between turbulent eddies and these grow and coalesce downwind, so that numerous small sand ridges are transformed into fewer large ones; dune height is related to density or spacing and is, arguably, a function of time. This mechanism can be demonstrated in the wind tunnel, and is consistent with various aspects of the field evidence (Wopfner & Twidale, 1967, 1988; Twidale, 1972, 1981, 1994).

One implication of this mechanism is that the immediate sources of the sand from which the dunes are constructed by the wind are playas (mostly salinas) and river channels. These are fed by rivers which drain immense areas of central and northeastern Australia in a catchment of 1.3 million square kilometres (Fig. 1), which includes rocks of many types and ages. The dune sands of the Simpson Desert are ultimately derived from the rocks of the Australian Craton to the west and the various orogenic belts to the east and northeast (Pell *et al.*, 2000), but have been weathered, transported, eroded, and deposited several times, and in some instances by various agencies at different periods. Thus the mineralogical characteristics of the sand grains are not necessarily diagnostic of their transportive history.

On the other hand Folk (1971), working in the northwestern Simpson Desert, where the dunefield extends on to the Australian Craton, presented evidence to suggest that the sand of the dunes is locally derived from weathered country rock. A similar conclusion has been reached for the relic dunes of the Great Victoria Desert (Pell *et al*., 1999) and the same workers (Pell et al., 2000), using heavy minerals, quartz oxygen-isotope composition and zircon U-Pb age characteristics, have established the provenance of the materials from which the dunes are derived in various sectors of the Simpson Desert. From these data they argue first, that the sediment was carried to the Lake Eyre depocentre by rivers (cf. Wopfner & Twidale 1967, 1988), but second, that aeolian transport in the Quaternary was minimal. Dunes were formed by «vertical corrasion of underlying sedimentary rocks or residual deposits of local basement weathering.» (Pell *et al.*, 2000. p. 107).

According to this interpretation the sand of which the dunes are constructed is locally derived. Sand was scoured by evenly-spaced horizontal vortices and deposited in linear zones between turbulent eddies. Hence, in theory, the dunes ought to consist either of a core of substrate over which aeolian sand is draped by the wind and gravity, or of an elongate plinth or low elongate platform eroded in substrate on which wind-blown sand has been deposited. Also, Tseo (1990, 1993) cites theory and observational evidence supportive of helical flow development in desert environments (see also Tsoar, 1989).

It is fair to comment that only a very few - two - dunes of the cored or windrift type have been demonstrated in the Simpson Desert (King, 1956). Several general and specific arguments can be levelled at the argument presented by Pell *et al.* (1999) concerning the Great Victoria Desert (Wopfner & Twidale, 2000). If the plinth argument were correct, and bearing in mind the volumes of sand included in the dune ridges, there ought to be a substantial difference in level between the dune base and that of the adjacent corridors, yet no dunes of obvious plinth type have been located, despite the exposure of scores of dunes during the bulldozing of seismic lines during the 1960s. As is shown in the SD1 dune, the base of the dune sand, the unconformity between it and the substrate is essentially at the same level as that of the adjacent interdune corridors (Fig. 4), and any slight lowering is best attributed to wash during floods or the winnowing of material from playa floors during wind storms (see also measured sections in Mabbutt & Sullivan, 1968). Furthermore, an origin involving scouring of local sand is difficult to accept in view of the convergence of ridges in Y-junctions and ‘witch’s broom’ forms. Quite apart from the difficulty of reconciling an internal dune structure consisting of alternating cross-beds with the theoretical motions developed within contrasted pairs of vortices (upwards in one notional dune, down in those adjacent: see Tseo, 1993) how could ridges converge as they manifestly do?

All this is not to suggest that there are no contributions of dune-building materials from local sources. On the contrary, local sand deposits whether accumulated in old flood plains or basins of interior drainage or derived from weathered bedrock are tapped by the wind and contributed to the dunes. Of course much depends on what is meant by «minimal» wind work or «long-distance» transport, but overwhelmingly, longitudinal dunes are constructional forms built of sand that has been transported scores of kilometres. This is demonstrated for example by the 'witch's broom' plan form of many dunes (Fig. 5), and consistent downwind changes of dune colour from white through salmon pink to brilliant red (though with local exceptions - see below) are compatible with long distance sand movement. The occurrence of dunes distant from any possible sand source on the floors of dry swamps and lagoons such as those which occur on Goyder Lagoon (Fig. 6) also shows that dune sand is basically far-travelled. Some are located adjacent to sandy channels others have migrated many scores of kilometres downwind; so far indeed that the source area cannot with confidence be identified. Also the bed of the lagoon is silty and scouring would not produce sand.

5. Sand colour and dune size as indicators of age

5.1 Colour

There is no doubt that in the southern and eastern sectors of the Simpson Desert, where the dune sand is derived from alluvium, the sand is initially an off-white or pale cream colour, and that with downwind transport a reddish hue is gradually acquired. Clay particles coagulate to form pellets on playa shores and in river channels and, saltated with the quartz grains, are commonly trapped between sand grains. The change in colour of dunes downwind from source areas is attributed to the gradual alteration of such clays, resulting in the release of iron which is then oxidised (Wopfner & Twidale, 1967; also e.g. Walker, 1979). A very small amount of such iron oxides (haematite, goethite) adhering to quartz grains imposes a deep reddish hue on the whole deposit.

The transport of sand from the source area takes time, and distance from source is a function of time so that colour is also an indicator of age. Thus, the sand of the dunefield known as the Cobbler Sand Hills originated in the playas known as lakes

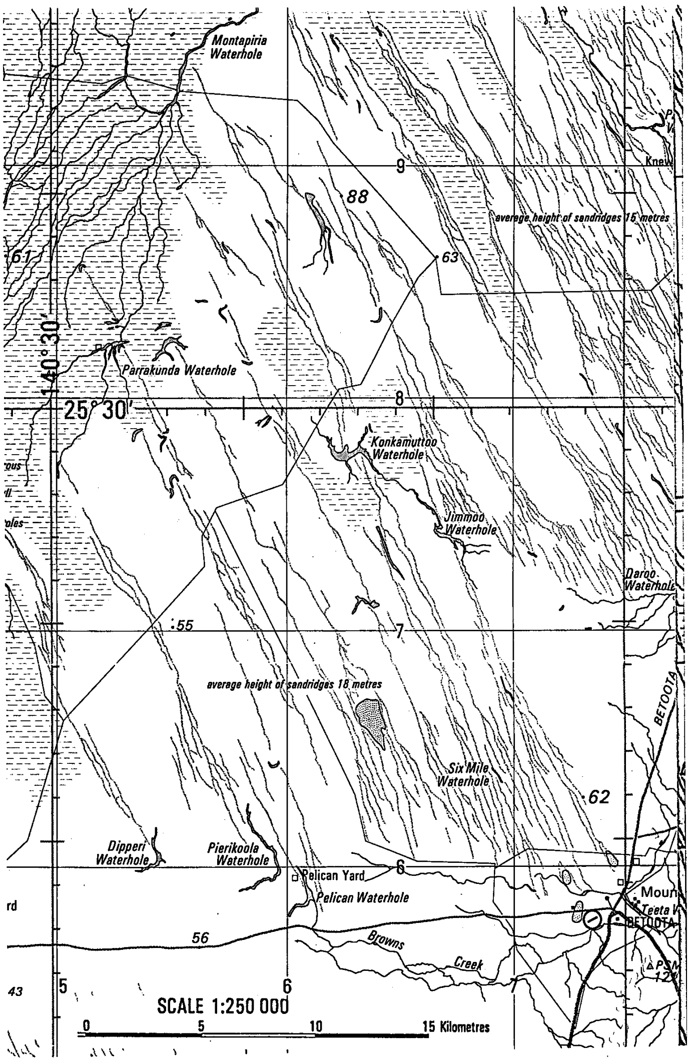

Figure 5. Extract from topographic map (SG54-6 *Betoota*. Australia 1:250,000 Topographic Series) showing 'witch's broom'pattern of dunes north of Betoota, southwest Queensland

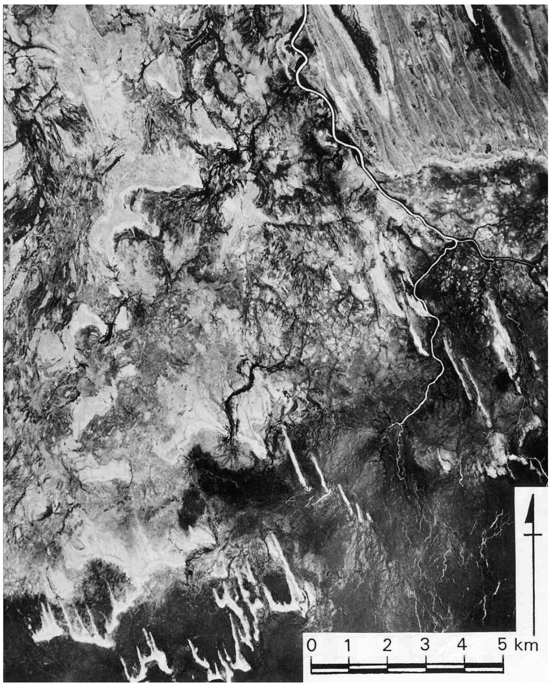

Figure 6. Vertical air photograph showing (in south) white dunes on the bed of Goyder Lagoon, and at the northern edge of the latter a lee-side mound with dunes generated to the north. The river is the Diamantina (Department of Environment and Natural Resources, South Australia)

Callabonna and Blanche. Immediately to the north of these source areas the sand is a dirty white colour but it becomes pale pink and then pink to the north until in the vicinity of Moomba the sand is red.

On the other hand, any sand that is occasionally washed by water, as for example during floods, remains whitish, presumably because fines (clay, silt) and any ferruginous coatings that have developed are rinsed away. Thus the sand ridges originating in dry billabongs on the exposed bed of Goyder Lagoon, for instance, remain white (see Fig. 6; also Figure 8 in Twidale & Wopfner, 1989) regardless of how far they have migrated downwind from their source, and presumably because the occasional inundations to which the lagoon is subject wash the quartz grains of any patina they may have acquired.

Yet adjacent dunes are of contrasted colours. Big Red is, as its name suggests, a brilliant red colour. The ridge labelled Big White is really pale pink or dun, depending on whether it is in sunlight or not, but its colour contrasts sharply with that of Big Red, only 15 km away. Provenance provides part of the answer. Big Red originates far to the south and is, as it were, merely passing through the Birdsville area, whereas Big White was initiated a short distance to the south, on the Diamantina flood plain.

Thus though in general a deep red dune is older than a white one, several factors influence the relationship between colour and age both locally and regionally within the dunefield. Nanson et al. (1992) pointed to similar local discrepancies.

5.2 Size

Evidence from many sites shows that numerous, small sand ridges form in the lee of topographic obstacles such as mounds and channels and coalesce downwind to form fewer, larger dunes. The ‘witch’s broom’ pattern of dunes (Fig. 5) reflects this tendency for small dunes to coalesce downwind into larger sand ridges, and similar tendencies have been noted in the lee of source-bordering dunes (e.g. Twidale, 1972, 1981, Plate 1 at p. 237). Thus size has been taken as an indicator of age, for downwind location is a function of time. But of the dunes dated, the oldest (SD1), is apparently much smaller than Big Red and Big White. Even allowing for the oldest core sand not being sampled from these two sites, the near surface material from SD1 is much older than that from other sites. Size as an infallible general indicator of age must be questioned.

The sand in SD1 consists of quartz grains but contains about twice the average amount of clay, trapped between sand grains, found in the Simpson Desert dunes (Wopfner & Twidale, 1967; Twidale *et al.*, 2000). SD1 is probably a dune core from which the superfiicial unconsolidated sand has been eroded. That is why it is low and also why it consists entirely of older, deep red sand. Only the crests of Big Red and Big White are exposed: their cores were not sampled because their internal structures could not be observed.

Thus the high concentration of fines in the lower levels of SD1 suggests that it is the core of a dune in which the sand is partly cemented by fines, and from which much of the loose surface sand has been eroded and transported downwind.

6. Discussion

Though limited to the area around Birdsville, the TL dating of dunes confirms that the sand ridges are essentially Holocene forms. If SD1 is a dune core, then recent and contemporary erosion, transport and, by implication, deposition of sand is indicated; a conclusion confirmed by the age of sand and dunes at other sampled sites. Some of the very large dunes of equivalent ages are a brilliant red, others white. Thus colour may not be a simple indicator at the local scale, for source area and proximity to waterways are significant variables. But at the regional scale colour is a reliable indicator, though superimposed on regional tendencies are lighter coloured dunes derived from local sources.

Nor is dune size an invariable indicator of age, for some dunes are degraded so that in the study area the oldest dune sand sampled is from a core remnant of a once larger form. Again, however, regional tendencies provide a good guide to age for dunes certainly coalesce downwind to form larger individuals.

Some dunes evidently pass through a sequence of stages: (a) deposition and shaping of sand into a sand ridge, white where derived directly from a playa or channel, red where transported by the wind from a dry source; (b) simultaneous alteration and illuviation of clay particles to produce red colour and clay core; (c) erosion of upper part of dune which consists of loose sand leaving a clay core plus a veneer of loose sand in a much reduced sand ridge. In these terms, some older dunes may be quite low yet widely spaced, and some youthful forms relatively high.

Previously enunciated explanations of various aspects of the Simpson Desert dunefield have not been rendered untenable by the new data reported here. The overall age of the field is confirmed and the mechanism of dune development remains intact. It also has to be borne in mind that the dated dunes are few within a myriad of forms. Clearly, however, though regional patterns provide an overall impression, local variations are many, and the evolution of the Simpson Desert dunefield may well be more complex than was previously appreciated. In particular, Pell *et al.*'s (2000) identification of the provenance of dune sands within the Lake Eyre depocentre is a valuable contribution, and the argument linking source materials with local dune building is compelling, though varied and overlapping distributional areas (and wind transport?) may have confused matters. Equally, however, dune patterns, structure and other characteristics suggest that most of the dunes of the Simpson Desert are constructional and that long distance sand movement has been involved.

Several sites suitable for dating (with the unconformity between dune sand and substrate exposed) have been located to the south of the Birdsville area, in the Strzelecki dunefield. Sampling and analysis of these sites ought further to clarify the dune and implied climatic chronologies of the area. On the other hand, more data may serve to confuse the problem. As is frequently the case, data can spoil the attractive simplicity of elegant theories!

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