REGIONAL LANDFORM PATTERNS IN THE STRZELECKI DESERT DUNEFIELD: DUNE MIGRATION AND MOBILITY AT LARGE SCALES

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INTRODUCTION

The Australian desert dunefields dominate the continent, forming a large anti-clockwise whorl across more than one third of the country (WASSON *et al.* 1988). The majority of these dunes are linear bedforms, forming parallel to the resultant vector of the sand shifting winds prevailing at the time of their formation (KING 1960). Despite being the most extensive landforms on the continent, studies of regional landform patterns relating these linear dunes with other landforms have been scarce. This work aims to make use of a new geomorphic mapping system designed for aeolian environments to identify regional landform patterns in the Strzelecki Desert (Figure 1), potentially shedding further light on dunefield formation at large scales.

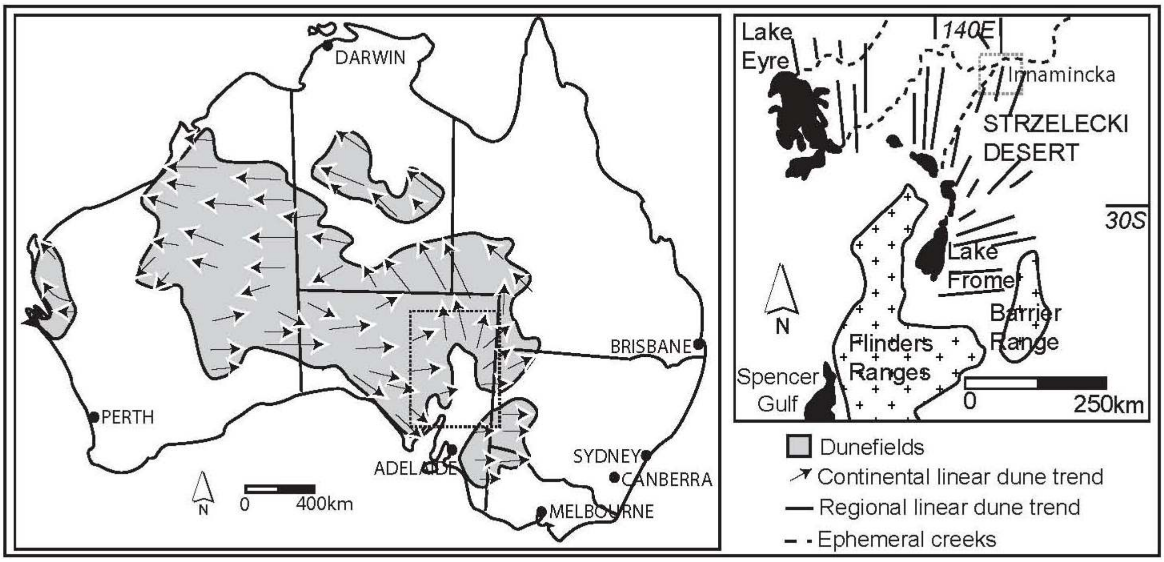

Figure 1: Distribution and orientation of the Australian desert dunefields (adapted from WASSON *et al.* 1988), and the location of the Innamincka region within the Strzelecki Desert, which forms the basis of this study.

DUNEFIELD VARIABILITY AND DYNAMIC EQUILIBRIUM

Extensive desert linear dunefields exhibit significant planimetric variability, which is most visibly manifested in the spacing between dunes, their orientation and level of organisation (BULLARD *et al.* 1995). The spacing between linear dune crests is inversely proportional to the density of the junctions which merge dunes together (LANCASTER 1996), whilst the orientation of linear dunes broadly relates to regional wind regime (BROOKFIELD 1970; MABBUTT & WOODING 1983). The level of organisation of a dunefield and dune spacing is determined by the density of junctions between dunes (WERNER & KOCUREK 1999). Closely spaced dunes are more likely to be disorganised than widely spaced dunes simply due to proximity to their neighbours (THOMAS 1986). Spacing is also thought to be related to substrate type (and hence sediment availability) and dune height, although the latter is considered less important in the development of landform patterns (WASSON *et al.* 1988).

Dunefield equilibrium is the condition whereby planimetric patterns remain consistent, having achieved steady state conditions between dune activity and the local environment (MABBUTT & WOODING 1983). The spacing between dunes reflects the establishment of dynamic equilibrium within the dunefield over time (THOMAS 1986). It is not uncommon for more than one type of dunefield equilibrium, expressed by differences in spacing, to occur within a region (MABBUTT & WOODING 1983). These variations in equilibrium may be caused by local differences in wind regime, sand supply and substrate (MABBUTT & WOODING 1983), and are often separated from one another by a transitional zone (BULLARD *et al.* 1995). Equilibrium is attained over time and space; more highly organised zones may occur at the downwind margins of a dunefield (e.g. BULLARD *et al.* 1995), or are older (at least 50k.y. in age - WERNER & KOCUREK 1999). Geomorphic mapping aids the identification of zones of equilibrium and the transitional areas between them, thereby illustrating regional landform patterns relating to dunefield migration and mobility.

GEOMORPHIC MAPPING

Conventional geomorphic mapping systems typically focus on the morphologic expression of landforms in relation to erosional and depositional processes (e.g. GUSTAVSSON *et al.* 2006). These are well suited to regions with significant variability in geomorphic process and relief. However, in areas such as dunefields, which are dominated by aeolian activity, such schemes do not satisfactorily reflect the planimetric variations developed by limited geomorphic mechanisms. Nor are they able to illustrate the establishment of dynamic equilibrium within a linear dunefield. Aeolian environments, despite their significant global extent, are given limited consideration in the creation of geomorphic units. Early geomorphic studies of desert dunefields quickly established the need to identify different dune types in order to understand principles of regional dune formation and mobility (e.g. GROVE 1969). Subsequent work classified the variations between linear dune types on the bases of criteria such as spacing, length and orientation (BROOKFIELD 1970), and made use of both aerial photographs (e.g. BULLARD *et al.* 1995; MABBUTT & WOODING 1983) and LANDSAT satellite imagery (e.g. BREED & BREED 1979; FRYBERGER & AHLBRANDT 1979). The Australian dunefields were mapped on a continent-wide scale by Jennings (1968) and Wasson et al. (1988), using the broadest of dune classification systems based on width and orientation. At a regional level, Mabbutt and Wooding (1983) created a map of the Simpson Desert on the basis of statistically demonstrated dunefield equilibrium determined by dune spacing, length and junction frequency.

This research uses ASTER satellite imagery to create geomorphic maps of areas of interest in the Strzelecki and Tirari Desert dunefields. Each ASTER scene is 60km by 60km, with high spatial resolution of 15m in bands within the visible region (YAMAGUCHI *et al.* 1998). Geomorphic features such as linear dune crests are clearly visible at this resolution, and the size of each ASTER scene is ideal for identifying regional scale patterns, thereby eliminating the need to create mosaics from sparse and expensive aerial photographs. Photographs are also variable in scale, colour and shade balance, and the time they were taken, which further complicate attempts to map at regional scales.

Considering the three major criteria for planimetric variability as demonstrated in the literature, I created a classification system for the linear dunefields, based upon spacing, substrate and frequency of junctions. The categorisation of spacing and junction density was created using statistical analysis of the variability of each, using values derived from quadrats 5km by 2km in size. Substrate was classed as gibber, alluvial plain and floodplain, and identified based on the spectral signatures of each within the visible bandwidths, combined with ground truthing.

Geomorphic units were divided into aeolian and non-aeolian landforms, the latter including alluvial channels and floodplains, playas and vegetated clay flats. Aeolian units were defined according to the dune classification scheme. The spatial distribution of regional landform patterns yielded considerable information about the patterns of linear dunes at this scale, including the high degree of interaction between dunes and other, non-aeolian, landforms. For this reason, only the geomorphic map of the Innamincka region is discussed here (Figure 2).

REGIONAL LANDFORM PATTERNS AT INNAMINCKA

The region covered by the Innamincka map comprises four major landform types; stony desert, the Cooper Creek system, the floodplain dunefield and main dunefield. The stony desert is characterised by flat to undulating gibber plains and breakaway tablelands, dissected by small ephemeral streams. The Cooper Creek system is an active, well-defined major ephemeral stream flowing southwest through this region. The Strzelecki Creek, a barely defined string of waterholes, diverges from the Cooper Creek to flow southwards at Innamincka township. Downstream of the point of divergence, a large floodplain has developed between the two streams and extends to the north of the Cooper Creek. A small floodplain lies south of the Cooper Creek near the Cullyamurra waterhole, upstream from the point of divergence.

The large floodplain which lies between the Cooper and Strzelecki Creeks consists of a broad plain with intermittent current and palaeochannel traces, including small waterholes. Small patches of organised linear dunes and degraded source bordering dunes have developed upon the floodplain, and are here termed floodplain dunefield. The development of these dunes suggests that, if the sand supply is limited, the floodplain has been inactive for a sufficiently long time for aeolian reworking into dunes to have taken place.

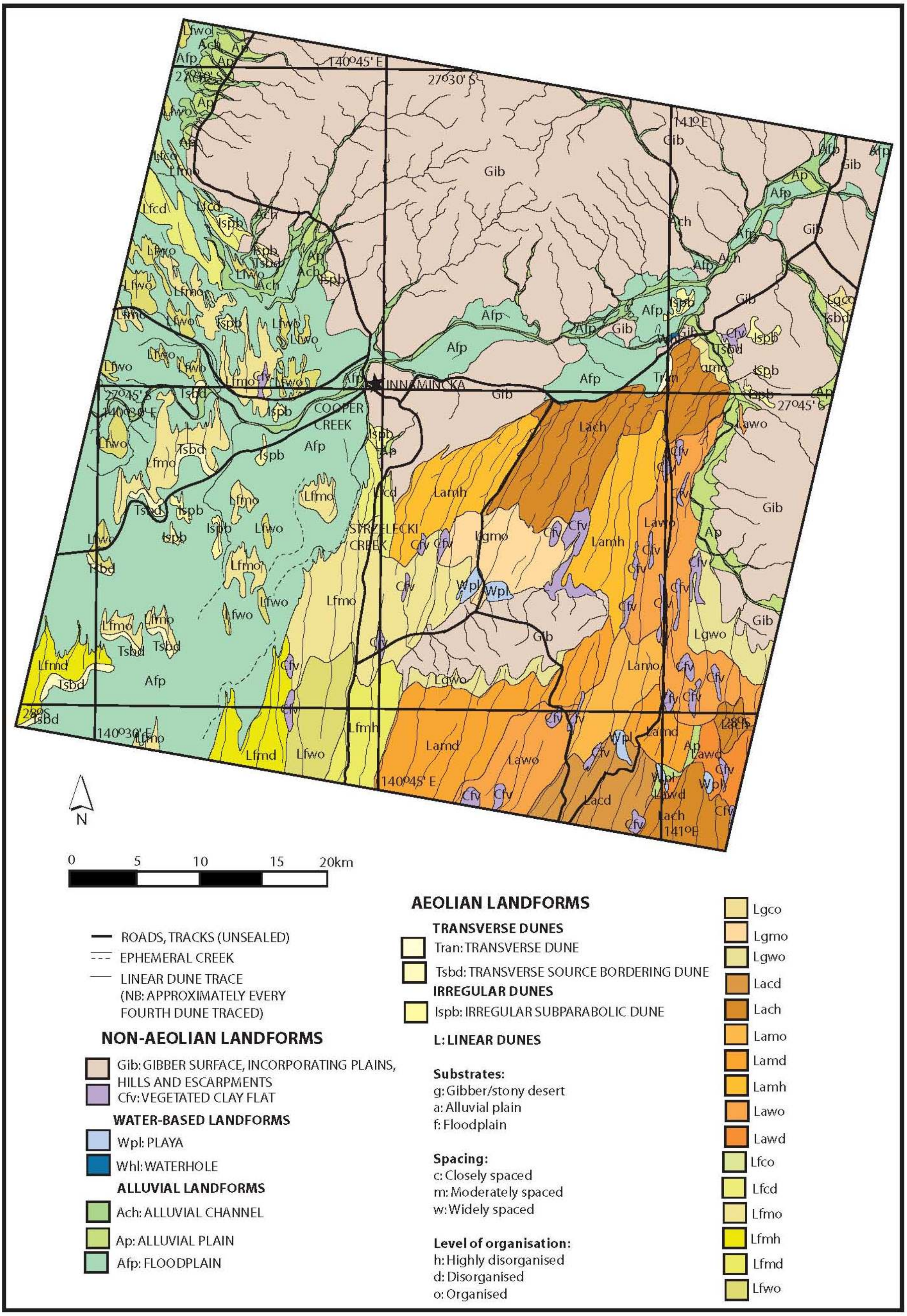

Figure 2: Geomorphic map of the Innamincka region, with focus on linear dunefield planimetric variability.

The characteristics of the dunes vary south and north of the Cooper Creek. South of the Cooper Creek, the dunefield occupies proportionally less area than the open floodplain. Dunes occur in discrete patches and are moderately or widely spaced. The linear dune patches lie downwind of degraded source bordering dunes which are visible on the satellite image, but not on the ground. These source bordering dunes once bordered stream courses which have since been abandoned (COLMAN 2002). The relatively limited dune development in this area may indicate equally limited sediment availability for transport, possibly due to the channels being dominated by suspended load which was deposited laterally onto the floodplain. This fine material requires specific hydrologic conditions to enable aeolian transport (BOWLER 1973). The high degree of organisation of the linear dunes suggests that this area is of sufficient antiquity for establishment of equilibrium prior to stabilisation (e.g. THOMAS 1986), and is possibly older than the dunefield to the north of the Cooper Creek.

In comparison, the proportion of area covered by dunes north of the Cooper Creek is greater than the open floodplain. This region is characterised by a distinct lack of source bordering dunes, and therefore old stream courses. This suggests that the Cooper Creek has migrated northwards in its course over time. Patches of closely spaced linear dunes not observed to the south of the creek indicate a greater availability of sediment. Patches of more widely spaced dunes occur immediately north, that is downwind, of the Cooper Creek, whereas more closely spaced dune patches occur closer to the northern edge of the floodplain, close to the discharge zones of ephemeral creeks flowing from the tablelands. These streams may have acted as sediment sources for the closely spaced dunes.

The main dunefield lies to the south of Innamincka and is bounded by the Strzelecki Creek to the west, gibber plains and a small stream to the east and floodplain and gibber to the north. The abrupt terminus of the dunefield at its northern extremity was noted by Breed and Breed (1979), although the mechanisms responsible were not explored. Examination of both topography and geomorphology suggests that these factors play a role in dunefield termination; topographic rises prevent the downwind transport of sediment (FRYBERGER & AHLBRANDT 1979), while creeks and floodplains may create hydrologic barriers to dune migration if the surface is regularly saturated.

Gibber rises appear to have caused the deflection of dune orientation and increased disorganisation, as well as termination by banking up of sand (FRYBERGER & AHLBRANDT 1979). This is evident both at the northern margin of the dunefield, and at a gibber hill in the centre. Limited dunes have climbed onto the gibber rise at the northern dunefield edge and are widely spaced in response to a depletion in available sediment. These dunes terminate within a couple of hundred metres of the edge of the hill. Near the central gibber rise, the dunefield resumes downwind, where drainage from the hill flows north into a small complex of minor playas and clay flats, creating a variable substrate of consisting of floodplain, alluvial plain and gibber. The role of substrate material in influencing dune spacing by making available sediment for dune formation (WASSON *et al.* 1988) is evident in the vicinity of this central gibber hill, where substrate type is spatially variable. Dunes which have developed on old floodplain surfaces are generally moderately spaced and initially disorganised, becoming more organised downwind. Linear dunes developed on an alluvial plain substrate exhibit a downwind pattern of increased spacing, indicating establishment of dynamic equilibrium through increased organisation and spacing over time (MABBUTT & WOODING 1983; WERNER & KOCUREK 1999).

CONCLUSION

The creation of geomorphic maps of the Strzelecki Desert dunefield based on criteria established as important in the creation of planimetric patterns has proven useful in identifying regional landform patterns relating to large scale dune migration and mobility. In the area near Innamincka, dunes have developed on various substrates, and their spacing and level of organisation can be related to both sediment sources and the interaction with topographic features such as rises. Dynamic equilibrium appears to have become established prior to dunefield stabilisation in areas without interference from topography, relative to sediment supply.

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