LONGITUDINAL AND TRANSVERSE DUNES OF THE LAKE EYRE BASIN

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INTRODUCTION

Arid landscapes provide a sensitive record of environmental change. The geomorphic evolution of the extensive desert dunefields of central Australia can be used as a proxy for climate change during the late Quaternary period. The transverse and longitudinal dunes downwind of major playas are particularly sensitive to small changes in both climate and hydrology. Understanding the interaction between the two dune types is important for the interpretation of timing and conditions required for dune building.

At present, the evolution and dynamics of the Australian desert dunefields, which occupy well over one third of the surface area of the continent, are poorly understood. This project aims to address at least part of this issue by investigating a regional history of aeolian deposition and processes over time. The focus of this study is on the geomorphology of the transverse and longitudinal dunes within the Strzelecki, Tirari and southern Simpson Deserts, in particular those areas downwind of the major playa Lakes Frome, Callabonna, Gregory and Eyre.

READING AEOLIAN LANDSCAPES: PROJECT METHODOLOGY

The Australian continental dunefield is a fossil landscape comprising stable dune forms, some with active crests. Dune spacing, width, height and length vary across the basin and may be related to available sediment, mineralogy, topography, vegetation and climatic conditions (Wasson *et al.* 1988). The stratigraphy of the dunes, determined from eroded blowouts and rare section exposures, gives information about episodes of dune activity and pedogenesis.

The regional landscape evolution will be interpreted based on multispectral, high resolution ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) and Landsat7 satellite imagery. Geomorphic maps of the region are currently being derived from these data. The comprehensive regional coverage of landforms allows an overview of the spatial relationships between different landforms, in particular classifications of longitudinal dunes, which are not able to be observed on the ground. The 15m spatial resolution of the visible and near infrared bands of the recently acquired ASTER imagery is particularly useful in delineating individual dune morphology in plan view. In addition, the spectral characteristics of landform features may be identified using different combinations of the 14 and 7 spectral bands of the ASTER and Landsat data, respectively. For example, images compiled from short-wave infrared spectral bands in the ASTER dataset allow identification of areas where the water table is close to the surface (Harper 2002).

Field observations will include studies of dune morphology and internal stratigraphy. The sedimentology of the longitudinal and transverse dunes will also be investigated, yielding insights into the relationships between grain size, mineralogy, sediment source and climatic conditions. Initial samples from selected strategic dune sites have been taken for the preparation of oriented thin sections and grain mounts.

The geomorphic history will be placed within a chronologic framework based mainly on optical dating techniques, with additional data from amino acid racemisation of bird eggshell found within the dune stratigraphy. Initial reconnaissance activities have revealed several promising sites within the field area for stratigraphic study and systematic luminescence dating sampling. The chemical preparation of this first set of samples is underway, and will be discussed at the symposium in November. Dates derived using optical dating techniques on samples from the Lake Frome region, presented in this abstract, are the result of previous unpublished work by the author.

INTRODUCING THE DESERT DUNES OF THE LAKE EYRE BASIN

The Lake Eyre basin is a large internally drained basin encompassing a significant proportion of inland Australia (1.2 million km^2), and is defined by the drainage catchments of Lakes Eyre and Frome in northeastern South Australia (S. DeVogel *pers. comm.*). The region is arid to semi-arid, and comprises various desert landforms including large playas and widespread desert dunes. The large, dry playa Lakes Eyre, Gregory, Blanche, Callabonna and Frome are linked by a network of creeks, smaller playas and depressions, and contain water only during rare occasions of excessive rainfall. The longitudinal dunefields forming the Simpson, Tirari and Strzelecki Deserts occur downwind of this chain of extensive playas, which encircle the upland region of the Flinders Ranges. The areas of interest to this study fall within those areas of the Strzelecki and Tirari Deserts downwind of Lakes Frome, Callabonna and Gregory, the eastern edge of Lake Eyre including the source bordering dunes of the Warburton Creek, and the northern section of the Strzelecki Desert (Figure 1).

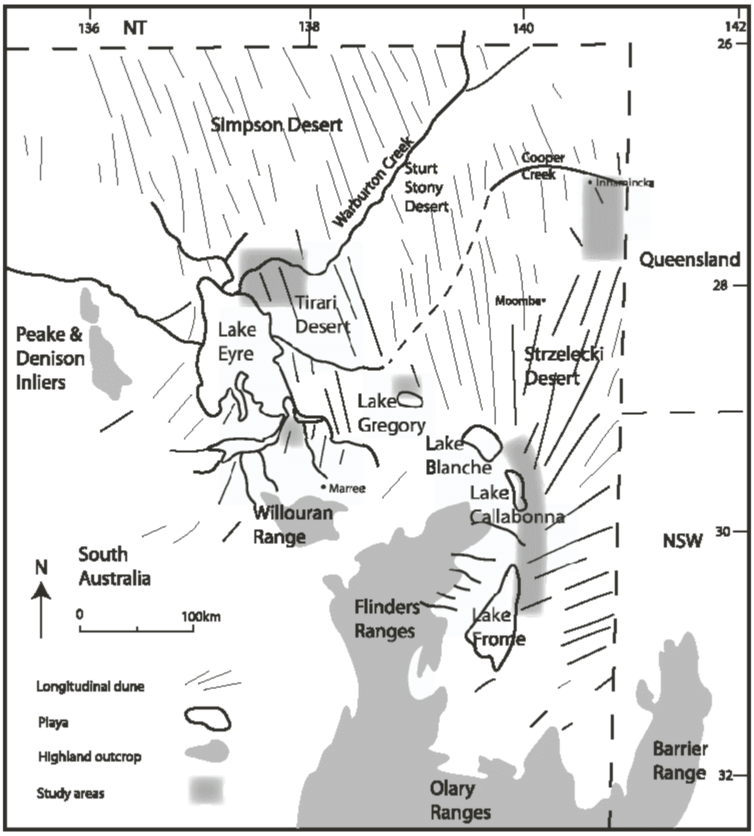

Figure 1: northeast South Australia, including the major playas and Strzelecki, Tirari and southern Simpson Desert dunefields (after Coats & Blissett 1971). General longitudinal dune orientation is indicated. Study areas are highlighted in grey.

Longitudinal dunes

Longitudinal dunes are elongated ridges of aeolian sediments, which run parallel to the resultant vector of the sand shifting winds (King 1960). The extensive longitudinal dune systems of the Lake Eyre basin vary in orientation, reflecting variations in the resultant sand-shifting wind direction at the time of dune formation (Jennings 1968). Longitudinal dunes are oriented west-southwest to east-northeast in the south of the region near Lake Frome, rotate towards the north near Moomba in the central Strzelecki dunefield, and extend north-northwest in the downstream Warburton Creek area.

Longitudinal dunes converge at “Y” shaped junctions within the longer dune systems and at points of upwind dune genesis close to the transverse dunes (Bowler & Magee 1978). Convergence occurs in the downwind direction, and indicates the termination of individual ridges and dune amalgamation, possibly due to a diminishing sediment supply (King 1960). The processes responsible for dune convergence and their implications for desert dune dynamics are not well understood, and further work on their geomorphology is required.

The sedimentological characteristics of the longitudinal dunes in the Lake Eyre basin are variable, ranging from relatively pale, clay rich dunes in areas proximal to the playas and lunettes, to strongly red, dominantly quartz sand dunes east of the Strzelecki Creek and in the northern Simpson Desert (Wasson 1983). The internal stratigraphy of longitudinal dunes preserves at least two phases of dune building and subsequent pedogenesis depending on location within the basin (Figure 2). Modern active crests are common throughout the region, and vary in thickness depending on the season and location.

Transverse dunes

Transverse dunes, by definition, are oriented perpendicular to the resultant sand shifting winds, and occur within the dunefields, generally immediately downwind of playas, creeks and clay flats. Transverse dunes within the region include lunettes, as described below, and source bordering dunes, which border the downwind banks of the largely ephemeral streams within the basin.

Lunettes are large clay rich dunes, crescentic in outline, forming along the downwind shorelines of lakes and playas which are, or have been, subject to fluctuating groundwater levels. Unstable hydrologic conditions such as these allow the efflorescence of salts in the capillary zone of the water table, resulting in the formation of sand sized clay pellets which are then transported by wind, together with other mobile particles, to form a transverse dune (Bowler 1983). The lunettes downwind of most large playas are compound features, incorporating clay rich lunette-type morphologies overlying quartz rich shoreline dunes formed by wave action during high lake levels (Figure 3). In some areas, such as the eastern (downwind) Lake Frome region, multiple transverse dune systems have developed. Each lunette system comprises several smaller parallel transverse dune crests. These are interpreted to represent different generations of lunette development as the lake basin diminished in size over time. This interpretation is supported by ASTER satellite imagery which shows longitudinal dunes, of varying lengths depending on the distance from Lake Frome, generating downwind from the transverse dunes.

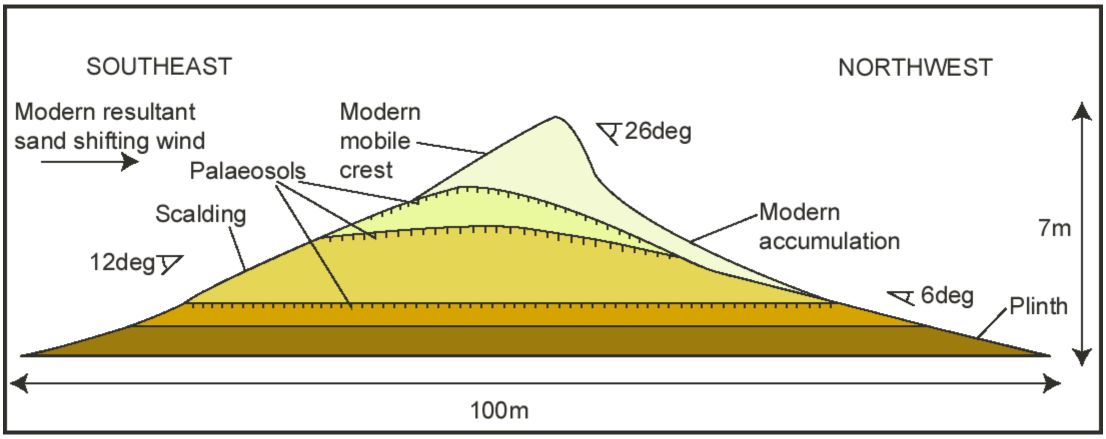

Figure 2: a schematic cross section of a typical longitudinal dune in the Lake Eyre basin. This particular example was observed in the Lake Frome region. The internal structures of palaeosols overlying the palaeodune sediments, and a modern mobile crest, are outlined.

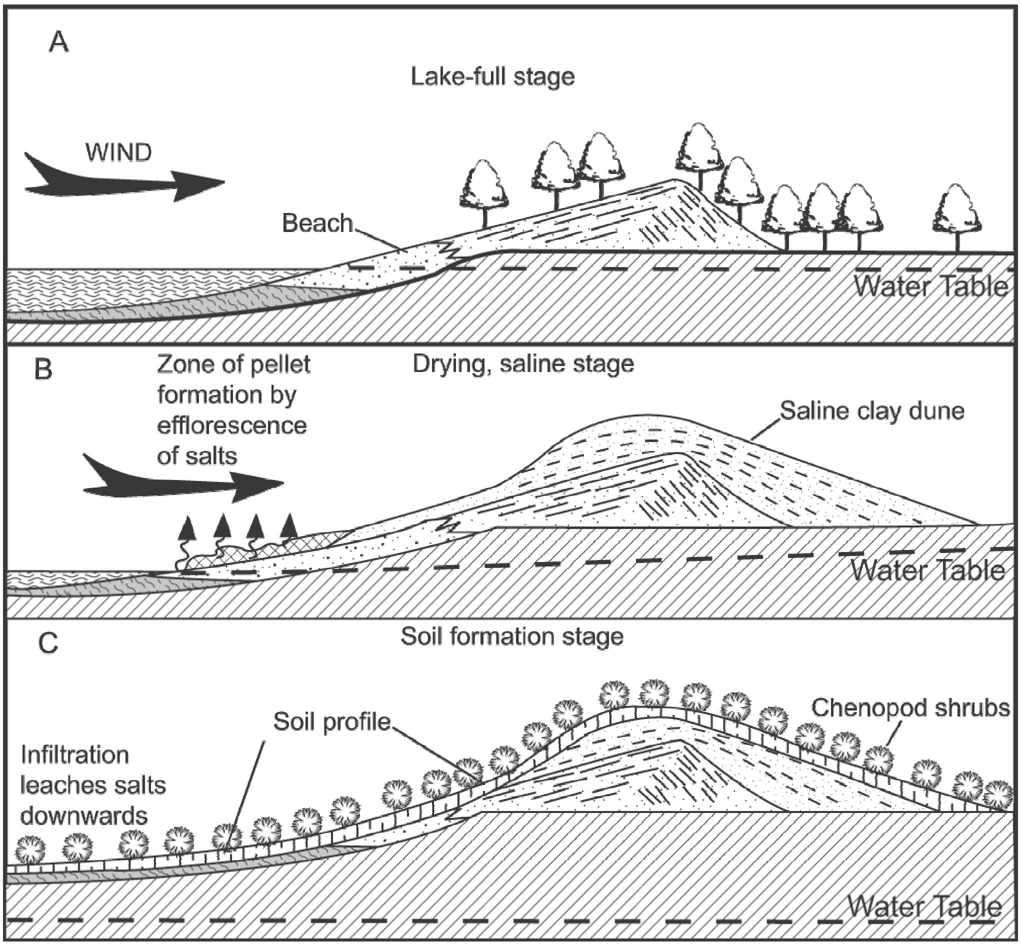

Figure 3: environmental conditions required for the formation of: A. Quartz rich shoreline dunes; B. Saline clay dunes; C. Soil profiles developed on the surface of a clay lunette. Adapted from Bowler (1983).

RECONNAISSANCE AND PAST WORK

This project is still in its initial stages; therefore limited data are available for discussion within this abstract. A study of the local geomorphology of the northeast Lake Frome area, including a chronology using optical dating, was undertaken in 2002. Significant observations arising from that work are summarized here. Observations arising from preliminary reconnaissance and sampling carried out in the Innamincka area in May this year is briefly discussed below.

Lake Frome

In the area northeast of Lake Frome, four transverse dune systems are clearly delineated on satellite images, and are oriented approximately north-south. Crests become more irregular towards the east of these large lunette systems and develop into parabolic forms oriented to the northeast. These forms appear to be a hybrid between transverse and longitudinal dune, and strongly indicate a genetic morphological relationship between the two major dune types. Individual longitudinal dunes appear to derive from different crestal lines within the lunette system, implying different stages of initiation of the longitudinal forms.

Palaeodune sediments within both the longitudinal and transverse dunes have a significant clay component, derived from the clay-rich interdune swales and elongate clay flats. This has important hydrologic implications requiring relatively high water tables to assist in clay deflation for the formation not only of transverse lunettes, but also longitudinal dunes. Dune mineralogy also comprises a dominant quartz fraction, with the addition of minor fresh feldspars and heavy minerals. The presence of feldspars indicates young aeolian sediments relatively close to their original source rock, and the proximity of this area to the crystalline rocks of the northern Flinders Ranges strongly suggests these to be the source. Studies of dune provenance (Pell 1994) support this conclusion. The preservation of laminations within both transverse and longitudinal dune sediments indicates that the sediments were deposited rapidly.

Optically stimulated luminescence dating has defined a chronology of a representative longitudinal and transverse dune within the Lake Frome region (Figure 4). Three palaeodune horizons were sampled within a transverse dune and yielded ages of approximately >100ka (saturated), 57ka and 22-14.5ka (from base to top of horizon). Ages of approximately 35ka and 11ka were derived from samples within two palaeodune horizons of a longitudinal dune, the former sample representing a palaeosol which was correlated with the middle (57ka) dune horizon of the transverse dune. The horizons dated at approximately 57ka and 20ka allow a tentative correlation with increased aeolian activity elsewhere on the Australian continent, and glacial periods interpreted from ice core data in Antarctica. The last major dune building event around 11ka yielded the most precise dates, and suggests a significant change to arid conditions conducive to dune building. Other regions of Australia do not yet reflect similar dune building events; this episode therefore warrants further investigation, and may have significant implications for climatic and environmental evolution.

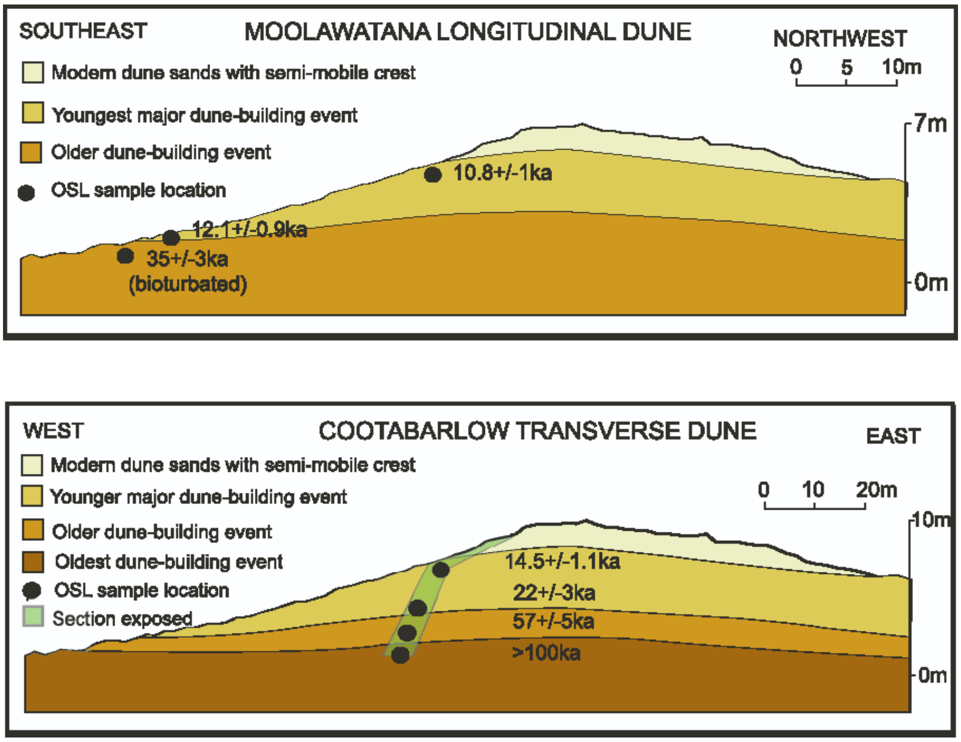

Figure 4. Optical ages, sample locations and stratigraphy of a representative longitudinal and transverse dune in the northeast Lake Frome area.

Innamincka

The Innamincka area is located toward the downwind margins of the Strzelecki Desert, and is a region containing an interesting juxtaposition of landform types visible on both satellite imagery and in the field. Close to the township of Innamincka, the Strzelecki Creek diverges southwards from the main, east flowing, Cooper Creek channel, and forms the western margin of the longitudinal dunefield. The formation of linear dunes is apparently halted to the south of Innamincka by a noticeable rise in the topography, observed as low relief gibber plains. The longitudinal dunes bound by the south of this plain, west of the Strzelecki Creek, exhibit highly variable morphologies, from closely spaced, highly disorganized forms converging frequently at "Y" shaped junctions, to widely spaced, more regular ridges overlying a gibber substrate and regular, more closely spaced dunes more typical of the Strzelecki dunefield at a broader scale. More detailed investigation of this complex geomorphology using high spatial resolution satellite imagery is planned, and will augment field work to be conducted in the area in October this year. An understanding of the factors influencing longitudinal dune morphology will be gained as a result of this work, which will also be placed within a chronologic framework using optical dating.

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