

## 7 REGOLITH GEOLOGY

### 7.1 REGOLITH MAPPING

Remote sensing data (Chapter 4) revealed a high degree of variability in the expression of the land surface within the Umbum Creek Catchment. These variations are related to landforms. The RT-Map classification system (Pain *et al.*, in press) uses a dual attribute to define Regolith-Landform Units (RLU) based on regolith material and its landform expression. RLU descriptions record the dominant regolith lithology, the dominant landform, surficial features (e.g. lag), minor features and the dominant vegetation community structure, type and species (Hill *et al.*, 2003). In this system, it is possible to map landforms and changes in regolith characteristics across the landscape. Neotectonic rearrangement alters the expression of landforms and regolith characteristics that are readily detected using regolith mapping. Other methods, such as traditional geology, geomorphology and soil maps, do not incorporate the same degree of information relevant to the detection of neotectonic landscape features as this system. Thus, the RLU mapping method is extremely useful for highlighting changes due to neotectonic rearrangement of landforms. The following sections describe associations noted on the map (Appendix C) from changes in RLU that indicate neotectonic rearrangement.

#### 7.1.1 Surficial Lag Distribution

The geological maps of the region, Warrina (Sheet SH 53-3) (Rogers & Freeman, 1996) and Lake Eyre (Sheet SH 53-4) (Williams & Krieg, 1975) 1:250 000 series, incorporate a degree of regolith information into standard geological maps. This methodology, while providing some insight into landscape processes, is ultimately unsatisfactory for recording landscape information, as the two datasets are incompatible. Whereas traditional geological mapping attempts to see through recent deposits to reveal the underlying geology, regolith-landform mapping attempts to express the association of sediment composition in relation to the geomorphology (Hill *et al.*, 2003).

Williams & Krieg (1975) on the Lake Eyre geological mapsheet (Sheet SH 53-4) provide a good regional summary of the surficial lag across much of the landscape. They describe the surficial lag in general terms as pale-brown to red-brown sandy clays and silts containing gypsum (reworked from older deposits) and mantled by a layer of silcrete and quartz pebbles. This also includes low-angle slope and lag deposits (Williams & Krieg, 1975).

Rogers & Freeman (1996) on the Warrina geological mapsheet (Sheet SH 53-3) divide the regolith further into a range of units based on their origin and use their interpretation to classify the sediment.

Gibber plains are described as 'colluvial deposits of red-brown sandy and gravelly silt and clay with a mantle of desert varnished gravel possessing gilgai structures.'

Alluvial Fan sediment is described as 'gravels of older dissected low-angle alluvial fans and fan remnants within and adjacent to the ranges.'

Modern alluvial fans are described as 'gravels of younger dissected low-angle alluvial fans and plains.'

Modern stream sediments are described as 'sand, gravel, silt and clay of modern drainage channels and floodplains.'

This interpretation identifies the processes that have contributed to the most recent expression of the sedimentary deposits, but fails to provide information on the clast composition that can

provide insight into the provenance and origin of the sediment and hence the landscape evolution.

The diverse range of gravels in the Umbum Creek catchment can be subdivided into four general zones based on clast composition and clast roundness (Figures 7.1 & 7.2).

#### Zone1: Alluvial Gravels

Flanking the range front and occupying an area between the Neales River, Umbum Overflow and George Creek are gravels associated with alluvial fans (Figure 7.1). There are several classification units occupying this zone, reflecting changes in the geology of the Davenport Ranges, mixing between units and different stages of maturity. The characteristic features of this zone include an assortment of lithologies, typically dominated by quartzite but also including quartz, silcrete, hematite and fragments of lithic material such as ferruginous sandstone, siltstone and dolomite (Figure 7.2A). Clasts tend to be larger and more angular closer to the range front, decreasing in size and becoming more rounded with increasing distance from the source (Figure 7.1).

The composition of gravel in this zone reflects the landscape evolution. Generally, angular clasts of similar composition to sources in the Davenport Ranges infer a strong genetic link to the re-activation of the Mt. Margaret and Levi faults at the foot of the Davenport Ranges during the Plio-Pleistocene. The uplift of the eastern margin of the Davenport Ranges is interpreted to have created the alluvial fans from erosion and subsequent deposition of sediments within the Davenport Ranges.

#### Zone 2: Colluvial Lags

Colluvial lags can be distinguished from alluvial gravels (Zone 1) due to their uniform composition. This zone is bounded by the Neales River and the Neales Overflow with outliers near the apex of the Neales Fan and flanking the Neales River to the west where it enters the study area (Figure 7.1). It also encompasses the land between Sunny Creek and Umbum Creek and in general occupies the middle third of the study area (Figure 7.1). This zone is characterised by sub-rounded cobbles and rounded pebbles of silcrete with minor quartz and hematite distributed widely across the land surface (Figure 7.2B).

Silicified sands (silcrete) form the capstones of Four Hills (Figure 7.1) and are the source for a large portion of silcrete clasts in Zone 2. A silcreted palaeochannel on the western side of the Davenport Ranges, the Mirackina Palaeochannel (Figure 7.3), makes a sharp deviation towards the east before outcrops are no longer present. The trend of this deviation is towards Mt. Anna and Four Hills and it is interpreted that this palaeochannel once connected these outcrops that are composed of fluvial sandstones. The broad distribution of silcrete-dominated surficial lags is interpreted to indicate that east of Four Hills the palaeochannel may have diverged into a distributary delta. Conditions here could have formed wide thin sheets of silcrete as a result of the same conditions that led to the silicification of the fluvial sandstones. Subsequent erosion broke down this thin veneer and distributed the silcrete pebbles widely across the land surface (see also Chapter 8).

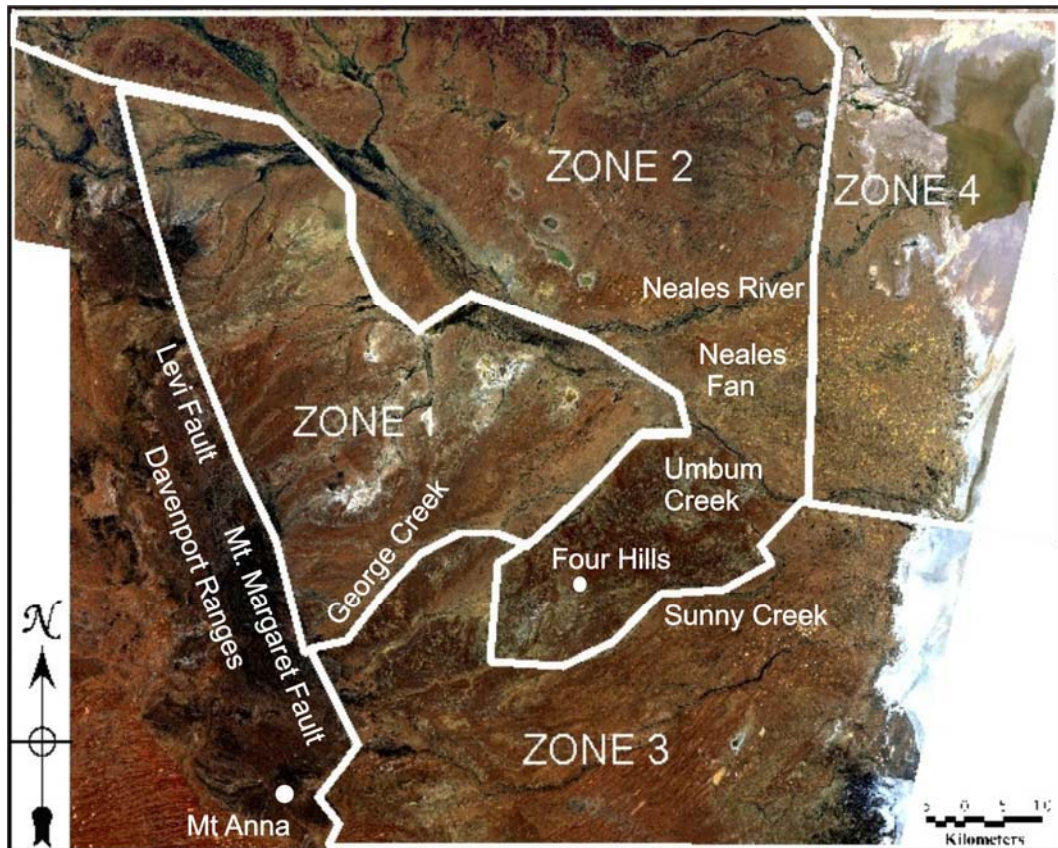
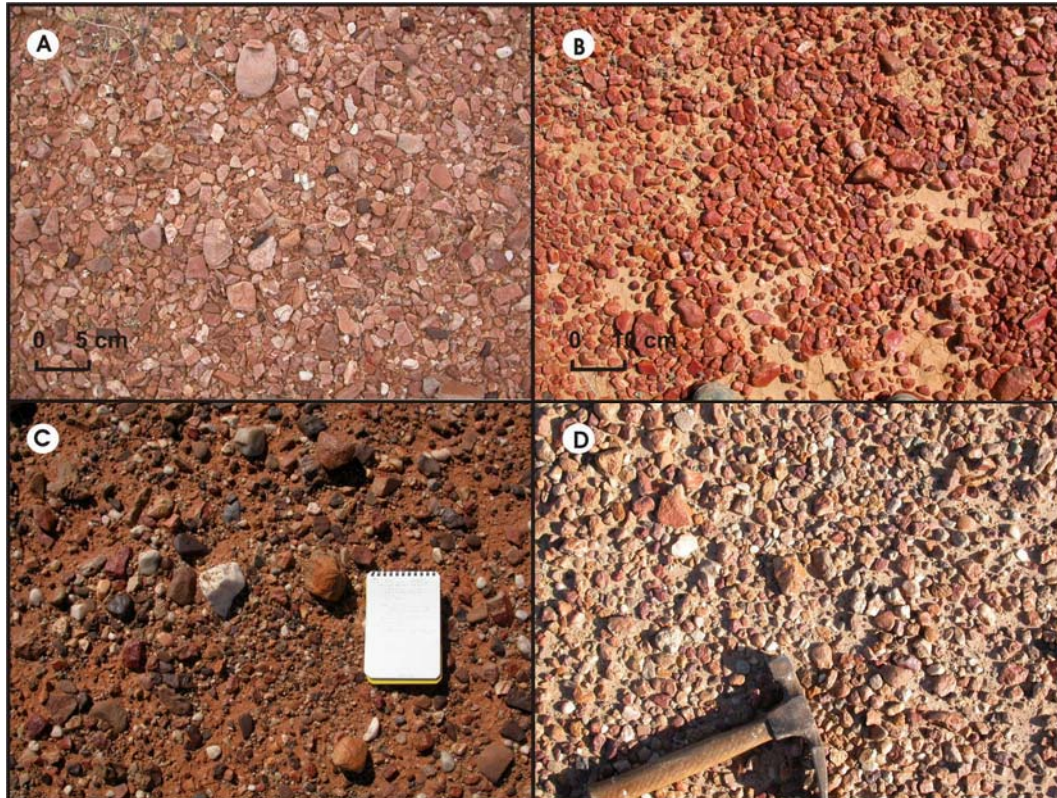


Figure 7.1: Approximate distribution of surficial lags in the Umbum Creek Catchment in four zones, showing the association with landforms. Zone 1: alluvial fans; Zone 2: silcrete outcrops; Zone 3: fluvial sediments; and, Zone 4: lacustrine influence.



**Figure 7.2: General classification of surficial lags in the Umbum Creek Catchment. A) Zone 1: angular to subangular quartzite cobble and pebble lag with minor quartz, silcrete, hematite and lithic fragments (scale= 5 cm); B) Zone 2: subangular to rounded silcrete pebble lag with uncommon quartz and hematite (scale= 10 cm); C) Zone 3: subangular to subrounded cobble and pebble lag of mixed lithologies including silcrete, quartz, lithic fragments and hematite (notebook for scale); and, D) Zone 4: subangular to rounded pebble lag of mixed lithologies including silcrete, quartz, lithic fragments and hematite (hammer for scale).**

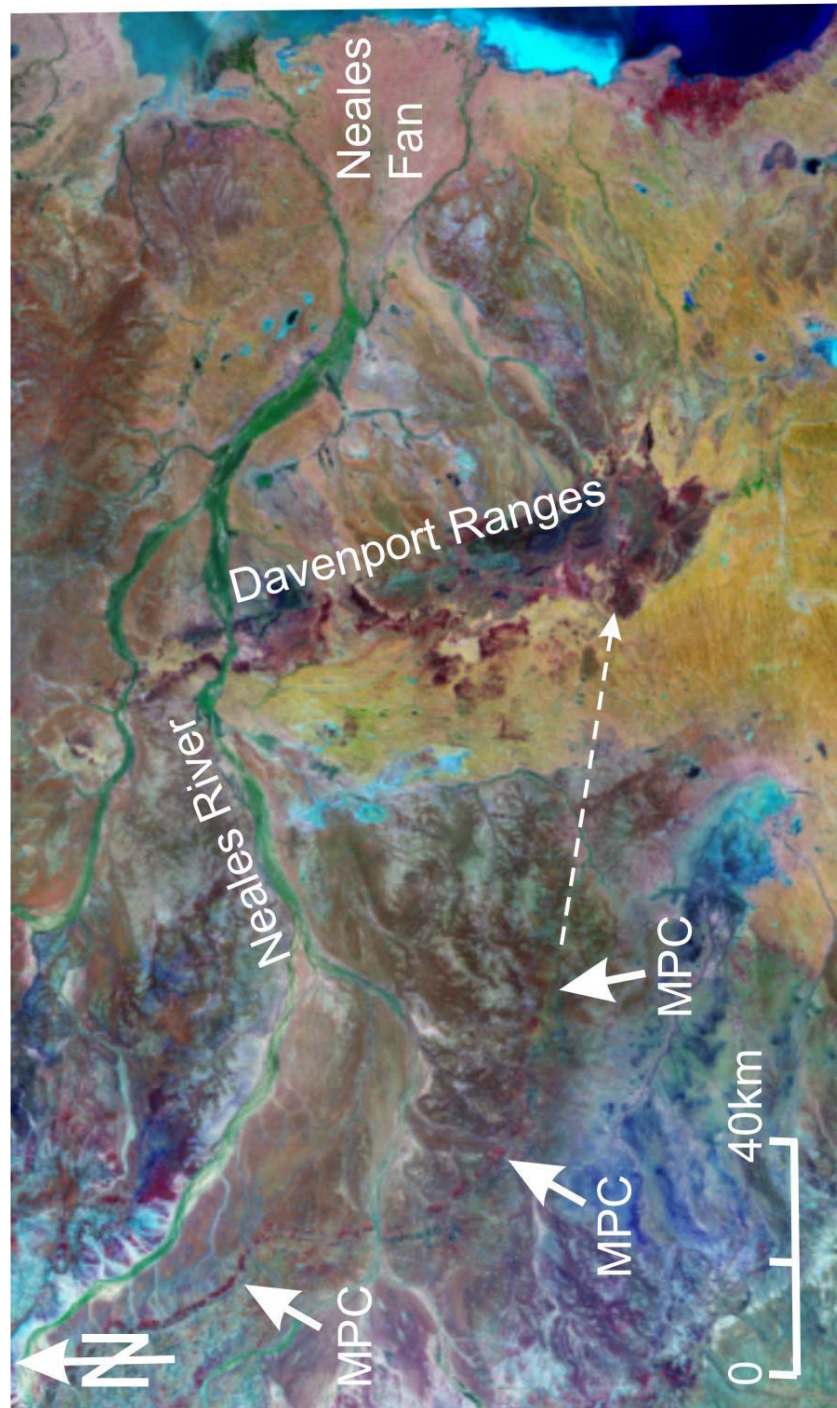


Figure 7.3: Location of the silcrete-rich Mirackina Palaeochannel (MPC) showing a trend towards the silcrete outcrops within the study area.

### Zone 3: Fluvial Sediment

Zone 3 occupies the southern quarter of the study area south of Sunny Creek (Figure 7.1). Lags are characterised by rounded clasts composed of cobbles to pebbles of silcrete, quartz, lithic fragments and hematite (Figure 7.2C). These surficial lags are interpreted as remnants of a palaeo-river that migrated laterally through this area, accumulating fluvial sands and gravels. It deposited boulders, cobbles and sands across much of the southern portion of the field area and is interpreted as an ancestral stream to either Sunny Creek or Douglas Creek.

### Zone 4: Lacustrine Influenced

Zone 4 is located along the toe of the Neales Fan and is interpreted to represent the direct influence of Lake Eyre on the surrounding landscape (Figure 7.1). Composed of mixed clastic sediments of silcrete, lithic fragments, quartz and hematite, clasts are generally subrounded and pebble sized (Figure 7.2D).

The composition and form of clasts in Zone 4 are similar to the sediments observed on Muloorina Station on the eastern shore of Lake Eyre, described as well-washed gravelly and shelly coarse sand, interpreted as lacustrine shore deposits (Nanson *et al.*, 1998). . On the Neales Fan these surficial lags are adjacent to the lake on a flat plain that is interpreted to have formed as a result of planation due to shoreline processes during a lake transgression. The clasts are rounded and have varied lithologies interpreted to be the result of mixing due to wave action. No gastropod or bivalve shell fragments, generally associated with beach ridges, were observed in the study area and no beach ridges have been identified.

## **7.2 LANDFORMS**

### **7.2.1 The Davenport Ranges, Mount Margaret Surface and Mount Margaret Escarpment**

The Davenport Ranges consist of dominantly Proterozoic sedimentary rocks that were deformed during the Early Palaeozoic Delamerian Orogeny (Drexel & Preiss, 1995). Between the Early Permian and Late Jurassic these sediments were truncated by an erosional plain that caused weathering and alteration in underlying units (Rogers & Freeman, 1993). This plain has been termed the 'Mount Margaret Surface' (Wopfner, 1968). A steep escarpment, delineated by the Mt. Margaret Fault, marks the eastern margin of the Davenport Ranges. This escarpment is preserved in indurated deposits of the Mt. Margaret Quartzite and represents the most elevated feature in the region at 412 m a.s.l. (Figure 7.4).

The Mt. Margaret Fault is expressed in the headwaters of the Umbum Creek catchment as a linear feature (Figure 7.4). Along the central section of the fault, geomorphometric measurements of range front sinuosity resulted in a value of 1.008 indicating a highly linear feature (see Chapter 5). This linearity infers recent movement along the fault. A lower age limit of fault movement can be determined from relative dating of deformed sediments in the area (Bull, 1984). Sediments of inferred Miocene age have been tilted and warped (Wopfner, 1978). Illuviation features preserved in silcretes have formed vertically along the banks of a palaeo-river valley. These show a tilt of 20 degrees indicating significant deformation along the range front. Following the reactivation of the fault via uplift of the Davenport Ranges alluvial fans developed along the range flanks (Appendix C).



Figure 7.4: The Davenport Ranges displaying the Mt. Margaret Surface (arrow), a planation surface formed during the Jurassic and subsequently uplifted. (0602495E 6859603N)

### **7.2.2 Alluvial Fans**

Two generations of alluvial fan are identified. The older alluvial fans located between the Mt. Margaret escarpment and the Neales Fan have a morphology characterised by low-angle gradients (1–5°) and elongate shape. They vary in length between 10–15 km and in width between 1–5 km. The contemporary surface drainage pattern is incised up to 20 m at the apex into the Cretaceous bedrock, indicating a significant change in base level since the fans were formed. Proximal fan deposits are approximately 5 m thick, while distal fan deposits are less than a metre thick. The surface of the proximal fan deposits is dominated by angular clasts of quartzite derived from the Neoproterozoic Mt. Margaret quartzite exposed in the ranges. These clasts become more rounded with greater distance from the range front, and clasts of different compositions are mixed with the quartzites in the more distal fan setting. The clasts form a one-to-two pebble-thick mantle at the surface. Proximal fan sediments tend to be matrix-supported, consisting of subangular pebbles to 0.1 m in a fine-grained red-brown silty sand matrix. Soil development is evident in the upper part of the profile where it is exposed along streams, as is the development of gypsum-cemented layers close to the contact with the Cretaceous Bulldog Shale. Distal sediments are also matrix supported with subrounded pebbles up to 0.05 m. Clasts are generally concentrated in channels amongst the dominantly fine-grained red-brown silty sands in distal fan deposits.

The surface of the older fans is modified by modern braided tributary channels and shows minor gullying. The formation of the pebble mantle is probably due to similar processes as those active on the gibber plains (see Chapter 7.4). Lobate structures and banded vegetation are well-developed on the fan surfaces, inferring a more dominant contribution from colluvial processes due to the gently sloping surface. Most of the soils do not have a well-developed B-horizon suggesting that accretionary mantle development is not a strong factor in the development of the pebble mantle. The primary processes responsible for the development of the pebble mantle indicate that the formation of the alluvial fans is dominated by fluid-gravity processes such as sheelfloods and incised channel flows (Blair & McPherson, 1994).

Younger alluvial fans are characterised by gradients of 10–20°, lengths of 1–5 km and widths of 5–7 km. They form on the flanks of the Mt. Margaret Escarpment and lap onto the older alluvial fans. They are composed of angular clasts of quartzite that range up to 80 cm in size and are generally clast-supported with minor fine-grained, red-brown silty sand matrix. They possess lobate colluvial structures 1–5 m wide and, in contrast to the older alluvial fan systems, are currently dominated by debris flow processes.

Major streams in the area are eroded into the older alluvial fan deposits and the underlying Bulldog Shale. This has produced three distinct geomorphic surfaces. The oldest surface, inferred from its elevation of approximately 100 m a.s.l., is associated with the original deposition of the alluvial fans. This surface was dissected by streams to produce broad terraces. These in turn are dissected by the modern fluvial systems. The two dissection events infer two changes in base level, but the relative contribution of tectonic change as opposed to climate fluctuation has not been empirically determined. The climate record indicates a major phase of aridity at approximately 20 ka (Croke *et al.*, 1996). Sampling spatial patterns of hillslope form is equivalent to sampling through time (Campbell, 1997), therefore it is likely that the broad terraces were formed sometime during the Early to Mid Pleistocene with the modern fluvial systems incising due to the onset of aridity during the Late Pleistocene.



These surfaces and terraces do not appear to be at consistent elevations (Figure 7.5), implying either that the landscape at the beginning of the Pleistocene was heterogeneous in nature and possessed variable topography, the result of terrestrial exposure since the Cretaceous, or that neotectonic rearrangement has restructured the topography.

### **7.2.3 Reworking of Jurassic Sediment**

Outcrops of Jurassic Algebuckina Sandstone and Early Cretaceous Cadna-Owie Formation are exposed more-or-less concentrically around the Davenport Ranges (Rogers & Freeman, 1996). They are composed of sandstones containing gravel beds and clasts of white, well-rounded quartz (Figure 7.6). These clasts are the product of Jurassic fluvial processes (Rogers & Freeman, 1993). The Cadna-Owie Formation is ferruginised and possesses a deep brown patination. When the quartz pebbles are weathered out of the outcrop they concentrate as sheets of white pebbles in stark contrast to the surrounding black hematite-rich pebble lag (Figure 7.7 & Appendix C). These sheets are restricted to the flanks of the ranges associated with outcrops of Algebuckina Sandstone and Cadna-Owie Formation. They occur in the headwaters of Sunny and Davenport Creeks and along the Lambing Creek floodplain. Sand is also winnowed from the outcrops and forms broad sand sheets in the headwaters of Davenport Creek. These sands are then re-incorporated into the modern fluvial system as mature, well-rounded sand grains. This leads to grain-size coarsening downstream as material is added from the interfluves and fine particles are winnowed out by wind (Menacherry *et al.*, 2005).

### **7.2.4 Tilted Silcrete Outcrops**

Prominent rises of silicified regolith occur approximately 1 km south of Davenport Creek (Figure 7.8a) and adjacent to Bulldog Creek (Figure 7.8b). Both outcrops are located at the base of the ranges and display an unusual morphology. Silicified sediments form a distinctive asymmetric double peak with the higher peak located towards the ranges and the lower peak located towards the lake. A valley in which Bulldog Shales are outcropping separates the two peaks. A surface lag of colluvial debris derived from the outcrop radiates from the peaks. At the Davenport Creek silcrete outcrop, the lower peak demonstrates a division in chemical composition laterally across the exposure, with a distinct boundary marking the change from pure silicification to dark brown ferruginisation (with possible silicification) developed in the Bulldog Shales that forms the eastern peak (Figure 7.8).

The original regolith host consists of fine sandy silt and clay. The fine sand is composed of quartz grains; the finer grains of silt and clay have been replaced by microcrystalline quartz induration. Interbeds of matrix-supported gravel contain common sub-rounded to rounded pebbles 1–5 cm in size in a fine-grained matrix. Pedogenic features are developed in silt and clay layers. This assemblage is interpreted as a channel sequence with sandy point-bar sediments, coarse-grained to pebbly channel fill and floodplain silts with well-developed pedogenic features. Bulldog Shale in this area is heavily weathered and is present as white, friable kaolinitic clay.

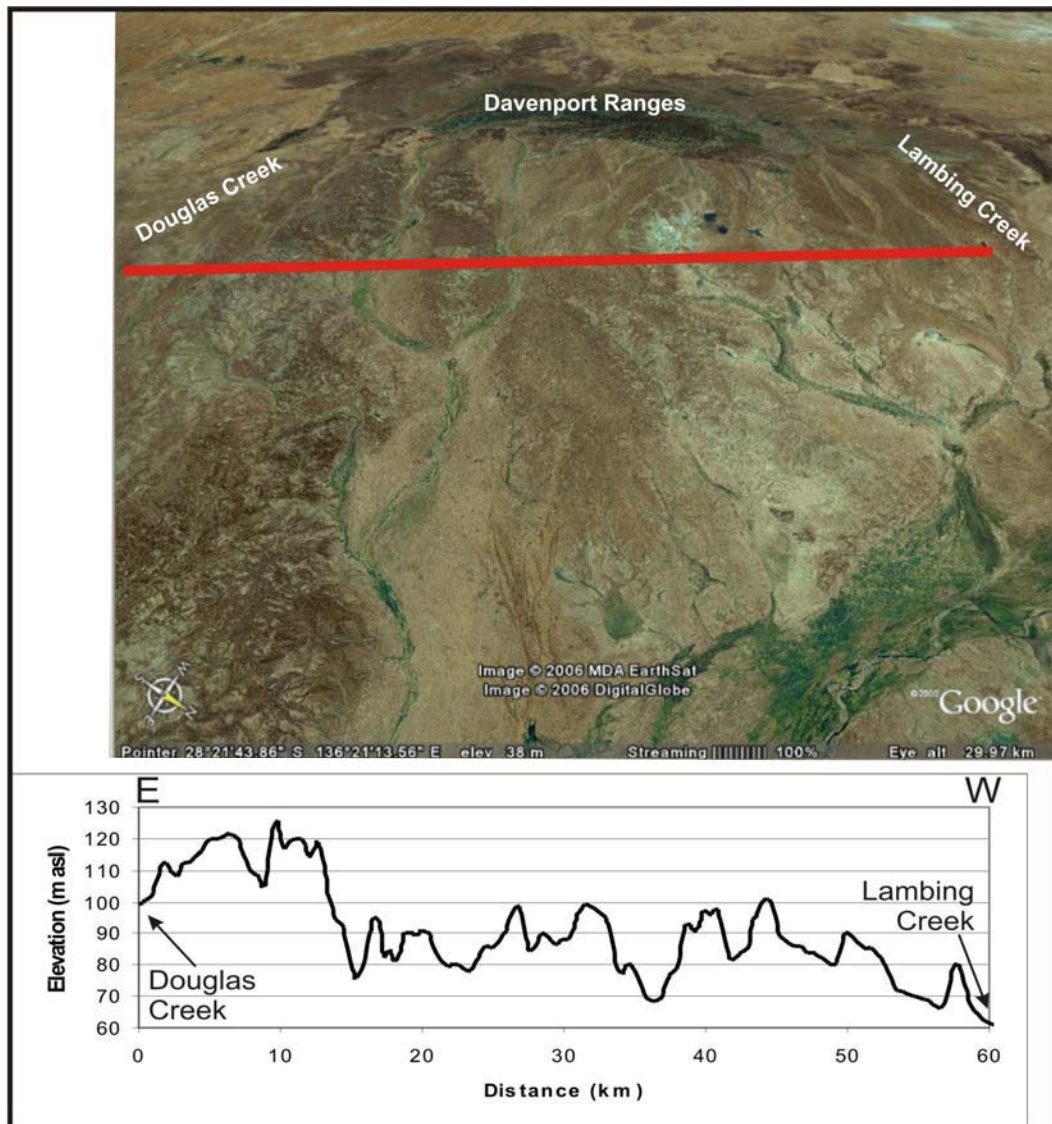


Figure 7.5: Topographic section across the base of the Davenport Ranges from Douglas Creek to Lambing Creek looking west, derived from the DEM 9-S, showing the irregular nature of terraces. The section location is shown in the oblique view diagram above.



**Figure 7.6: Outcrop of Algebuckina Sandstone showing a coarse conglomeratic layer in the middle of the picture weathering to contribute rounded quartz clasts to the modern system (~0616126E 6830409N).**



**Figure 7.7: Surficial lag composed of predominantly rounded quartz pebbles sourced from Algebuckina Sandstone and Cadna-Owie Formation, indicating the reworking of ancient fluvial sediments into the modern system (0616440E 6830635N).**



Figure 7.8: Tilted silcrete outcrops adjacent to the Davenport Ranges indicating tectonic activity following silcrete formation at a) Davenport Creek (view towards north 0616575E 6831738N) and b) Bulldog Creek (view towards north 0602476E 6861563N).

The three host units display individual morphologies primarily based on the original texture of the host material (Figure 7.9). Fine sands, silts and clays display massive tabular silicification. Channel gravels display 'glaebular' silicification (Figure 7.10) and floodplain silts possess 'Reed Mould' structures interpreted as silicified pedogenic features (Figure 7.11). Silicification occurs as grey microcrystalline quartz with 'glaebules' (clasts) being formed from silica. In some cases clasts contain prior silcrete granules preserved within them and show evidence for up to three phases of silicification. The silcretes weather to a red-brown colour, possibly representing the presence of iron and titanium oxides (anatase). Silicified Bulldog Shale forms a black to red-brown ferruginised clay.

Individual beds of silcrete on the western outcrop are dipping towards the east with angles between 19 and 32 degrees. Pedogenically derived 'reed mould' structures develop vertically due to gravity and, since these are tilted, indicate that the layers have been displaced from the horizontal by tectonic forces. Layers on the eastern outcrop are subhorizontal at the base of the valley and dip up to 12 degrees to the west, moving uphill towards the east. However, in this area true bedding planes are difficult to identify. The axis of the valley across which this dip occurs is subparallel to the trend of the Mt. Margaret Fault and suggests that the deformation of the silcretes is the result of drag caused by movement along this fault. These silcretes have been tentatively correlated as equivalents to silicified sediments of the Eocene-Pliocene Mirackina Palaeochannel, implying at least a Plio-Pleistocene age for neotectonic activity. The approximate 20 m of relief of the peaks implies substantial erosion of surrounding material during the Quaternary (Rogers & Freeman, 1996).

### **7.2.5 Silcrete and Well-rounded Cobble Float**

The Cadna-Owie Formation is a heavily ferruginised conglomerate and sandstone containing clasts of quartz and lithic fragments (Rogers & Freeman, 1993). It does not contain clasts of silcrete. The occurrence of subangular cobbles of silcrete at the top of elevated ridges of Cadna-Owie Formation therefore implies that the silcrete was either laterally transported or existed higher in the landscape than the surface upon which it rests (Figure 7.12). Along the northern edge of the Cadna-Owie Formation outcrop near the Davenport Creek silcrete, a contact between silcrete lag and ferruginised sandstone lag is clearly evident (Figure 7.13). The silcrete lag occupies the low depression and the ferruginised sandstone is associated with the crests or rises. The silcrete lag laps onto the Cadna-Owie Formation, indicating it is stratigraphically younger (Rogers & Freeman, 1993). However, its location downslope implies that the silcrete has not been located topographically higher. This silcrete is probably related to degradation of the Davenport Creek silcrete, whereas the cobble float may be derived from Mt. Anna in the ranges 17 km upstream to the west. This does not account for unidentified or degraded pods of silcrete that may have existed upslope. However, it does suggest that this ridge was elevated prior to the development of gibber plains.



**Figure 7.9: Detail of the Davenport Creek Silcrete showing tabular style at base, reed mould style in the middle and glaebular style at the top (hammer for scale ~0616575E 6831738N).**



**Figure 7.10: Detail of Davenport Creek Silcrete showing glaebular style silcrete (hammer for scale ~0616575E 6831738N).**



Figure 7.11: Detail of Davenport Creek Silcrete showing tilted reed mould style silcrete (hammer for scale ~0616575E 6831738N).



Figure 7.12: Silcrete cobble float (pale red clasts in picture) located atop mesas of highly ferruginised Cadna-Owie Formation, indicating that the silcrete originated higher in the landscape than the hilltop (Scale 10 cm 0616139E 6830029N).



**Figure 7.13: Silcrete pebble mantle overlying a pediment developed on Cadna-Owie Formation (foreground) and weathered Bulldog Shale (hills in background), indicating that the silcrete originated within the confines of the modern valley (View towards east 0619657E 6830240N).**



On the surface of Spring Hill and Four Hills are rare well-rounded, highly spherical lithic cobbles (Figure 7.14). Excluding the possible anthropogenic influence of Aboriginals and mischievous geologists, these cobbles have travelled large distances probably in a fluvial system in order to obtain their well-rounded and spherical morphology. Two geomorphic possibilities exist: either they were deposited as a direct consequence of a fluvial system topographically higher than the hilltops, or they are clasts that have weathered out of the glacio-marine Bulldog Shale. In both of these scenarios a significant volume of sediment must have been removed to create the topographic relief of the hills. In the case of Four Hills, the Miocene silcrete cap overlies Bulldog Shale, indicating that this relief has developed since the Pliocene. It is noted, however, that both sites possess excellent stone for toolmaking and it is possible that Aboriginals transported these erratics for use as hammer stones.

### **7.2.6 Mound Springs**

Mound springs in the Great Artesian Basin have been attractive to researchers due to their unique nature and eco-systems (Aldam & Kuang, 1989; Boyd, 1990; Habermahl, 1986; Thomson & Barnett, 1985). Within the field area they provide evidence for tectonics and are agents for change as they form deposits at the mound head and their streams cause erosion in the surrounding landscape (Appendix C).

Deposits forming the spring mound are generally composed of brown, yellow and white fine-grained travertines incorporating clasts and rhizomorphs. The spring mouth discharges black sulphurous muds. Extant springs are characterised by the vigorous growth of vegetation around the spring, dominated by *Phragmites australis* (common reed) and *Chenopodium nitriaceum* (nitre bush). Rhizomorphs are identified as *Phragmites spp.* roots and there are trace fossils of wasp, spider and beetle species (Krapf & Lang, 2005).

Springs are formed when the aquifer is brought closer to the surface by a basement high (Aldam & Kuang, 1989). The confining bed is made thinner by erosion and may be locally breached. Basement faults have been reactivated and reach the surface, acting as conduits, bringing water to the surface via the main fault or subsidiary faults or fractures. Springs may occur at the intersection of two fault planes that have formed trapdoor structures. These structures allow relative movement of the constituent blocks, and depending on whether the blocks are undergoing relaxation or compression will form a barrier or a conduit to groundwater flow. Springs are typically associated with eroding streams that are structurally controlled (Aldam & Kuang, 1989).

The interpretation by Aldam & Kuang (1989) that streams are structurally controlled, further adds to the argument that the basement tectonic fabric is reflected in the surface sediment. Additionally, their interpreted seismic line from the southwest margin of the Eromanga Basin (Figure 1.14) suggests that the underlying fault structures consist of flower and half-flower structures (Aldam & Kuang, 1989). The faults that form these structures are reflected by channel diversions in the surrounding landscape (see Chapter 5 & Appendix C).



**Figure 7.14: Rounded clast located atop Four Hills possibly indicating fluvial systems were active higher in the landscape. These outcrops were, however, used as stone tooling sites by Aboriginals and the rounded stones may represent anthropomorphically transported material for use as hammer stones (hammer for scale 0648859E 6846176N).**

There is no geological evidence to associate the springs with neotectonic activity in this area. They may represent continuous outflow from basement faults and fractures. However, the mound at the springhead is often raised in relation to the surrounding topography. This is partially due to the precipitation of muds and travertines around the mouth of the spring, but is also likely to be a result of base-level change via either climate or neotectonics. Many of the springs in the study area have been broken open to provide greater access to cattle that destroyed their original form, making interpretation of surfaces problematic. Anecdotal evidence also indicates that at least one spring, Loudon Springs, has run dry. This indicates that within the period of colonisation, the fault conduit supplying this spring was blocked via movement of the tectonic blocks, either from compression or relaxation. The drilling of water bores for stock and nearby mining operation is considered to have had little effect on the potentiometric surface (Sibenaler *et al.*, 2000).

### **7.2.7 Alluvial Overbank Plains and Channel Cross-section Morphology**

Channels are complex entities and major studies are singularly devoted to the evolution of the morphology of channels and channel forms. Due to the scale of mapping, the complexity of the channels in the Umbum Creek Catchment could not be captured, except where large-scale floodouts and overbank deposits occur where the channel could be distinguished from the floodplain. In addition, channels tend to change morphology downstream as they pass through different conditions such as confining landforms, differing bedrock lithology, gradient changes and vegetation bank stabilisation (Tooth, 2000a). This has been partially captured in the study area with a variety of differing RLUs recorded downstream (Appendix C), but channel cross-section morphology could not be recorded within these units accurately at this scale.

Major rivers in the area tend to have a cross-sectional morphology that reflects flow events at different scales: flows from localised rainfall; from regional rainfall, and from catchment wide rainfall. Similar morphologies have been observed on the Ross River, central Australia (Patton *et al.*, 1993). In general this creates a three-tiered, or tri-modal, system (micro-, meso- and macro-scales).

Localised rainfall from, for example, a single cumulus cell will cause one or two tributaries to flow. These tend to activate a pathway through the centre of the main channel that closely reflects the thalweg profile. Events of this scale are common throughout the study area. Regional rainfall from a strato-cumulus front, for example, may cause several tributaries to flow, filling the active channel. The river may top its banks, inundating inner floodplains and activating chute channels. This scale of event corresponds to a 1:10 year flood. Catchment-wide catastrophic flooding is likely to occur with the convergence of a front from the Southerly Oscillatory System and a tropical depression from the Northern Monsoon. This situation feeds large amounts of rainfall into the catchment, activating all streams, resulting in flooding. These events first fill the active channel and floodplains. They overtop the levees and form true overbank flow, spreading out across broad areas of the landscape. They occur rarely and are equivalent to a 1:100 year flood. These events are preserved in the landscape on the flanks of several major streams, being particularly evident on the Neales River and Neales Overflow, Umbum Creek and Overflow, Davenport and George Creeks and Sunny Creek.

Along most of the streams the overbank deposits are generally characterised by fine-grained red-brown sands that form hummocks (Appendix C). These are typically well-vegetated with the hummocks occurring on the lee-side of established plants. These hummocks have been

termed 'shadow bars' and both constructional and destructional types have been observed (Reilly in Krapf & Lang, 2005). They are often associated with *Chenopodium nitrariaceum* (nitre bush) and *Melaleuca glomerata* (desert paper bark)

Destructional shadow bars form in the lee of established vegetation that protects the land surface from erosion via fluvial processes. Constructional shadow bars form in response to low velocity eddy currents created in the lee of an obstacle during flow events. Sediments are deposited in the shadow zone, aggrading to form the shadow bar. The resultant landform assemblage is distinctive and clearly delineates those areas that have been inundated via flooding. Given the rarity of these large-scale flooding events, it is possible that neotectonic changes to the landscape could result in changes in topography that would facilitate overflow.

#### Neales River

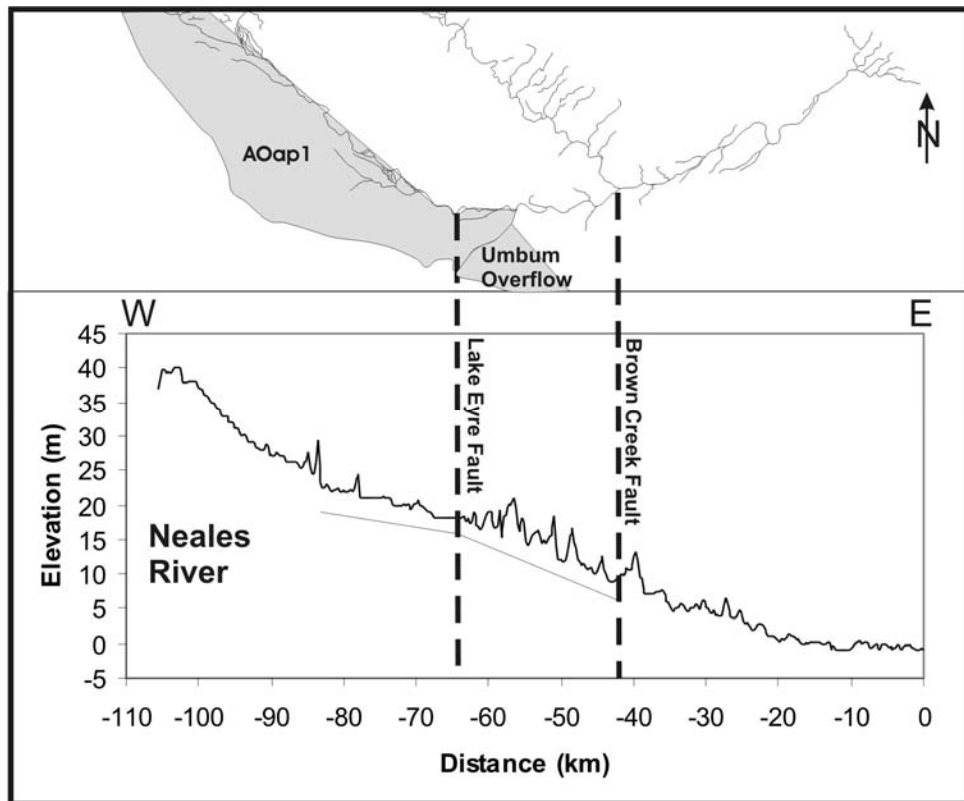
The overbank deposit along the Neales River (RLU AOap1 Appendix C) coincides with a relatively flat section of the DEM-derived stream profile (Figure 7.15). Where the Neales River deviates and crosses the Lake Eyre Fault, there is a sudden change in the form of the stream profile (Figure 7.15). It becomes more erratic and coincides with exposed Oodnadatta Formation in the channel. It is interpreted that this broad area of overbank deposit is the result of movement on the Lake Eyre Fault causing relative downthrow of the western fault block. This has created a partial barrier to large flows down the Neales River resulting in overbank flooding and diversion of floodwaters to the Umbum Overflow (Figure 7.15).

#### Davenport Creek and George Creek

Along the banks of Davenport and George Creeks, adjacent to Brinkley Springs, the development of overbank deposits coincides with an observed lineament (Figure 7.16). This lineament is parallel to observed faults between the Coorikiana Sandstone and the Bulldog Shale. It is approximately coincident with Brinkley Springs and The Fountain Springs. Stream reaches in Hope Creek and Hawker Creek are diverted to follow the trend of this lineament. This strongly infers the existence of a fault because mound springs are typically associated with faults in the study area. The overbank flow is a direct response to changes in the landscape morphology as a result of the activation of this fault. In this case, relative downthrow of the eastern side of the fault allows the stream to become unconfined at this point, resulting in overbank flow. This is evident as orange, medium-grained, well-sorted sand forming hummocks that are predominantly colonised by *Chenopodium nitrariaceum* (nitre bush).

#### Neales Overflow

The Neales Overflow forms a distributary avulsing north from the main Neales River, 15 km west of its mouth (Appendix C). This distributary follows the trend of a lineament observed across the Neales Fan; however, it also closely follows the lateral easternmost extent of the Etadunna Formation. The location of this lineament and the formation boundary may be related. The channel morphology of the Neales Overflow is characterised by large hummocks and swales with up to two metres of relief composed of coarse-grained, poorly-sorted quartz sands and gravels. The spillway into the Neales Overflow is elevated 3 m above the Neales River channel. This indicates that the Neales Overflow is only activated by extreme flood (macro-scale) events with flows capable of filling a channel complex over a kilometre wide and 3 m deep. The Neales Overflow is likely to have formed by exploiting a structural or lithological weakness in the landscape that provides a less resistive pathway to flow than the route downstream which passes through a set of significantly incised meanders.



**Figure 7.15: Comparison of spatial distribution of alluvial overbank RLU and the longitudinal stream profile of the Neales River showing the locations of major faults. The gradient across the Lake Eyre Fault shows a marked steepening and is associated with the termination of alluvial overbank sediments, indicating neotectonic control on landforms.**

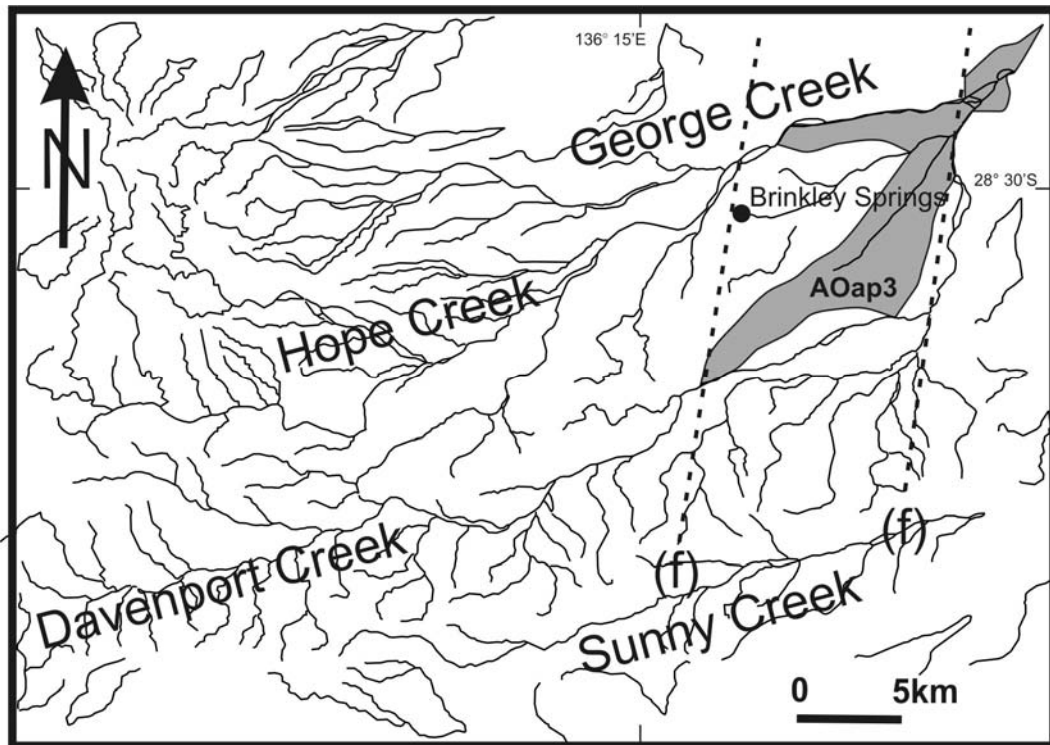


Figure 7.16: Comparison of the spatial distribution of alluvial overbank RLUs and stream planform along Davenport and George Creeks, showing the locations of faults (f) associated with Brinkley Springs. The occurrence of alluvial overbank RLUs downstream of the faults indicates the development of landforms associated with neotectonic activity.

### Sunny Creek and Umbum Delta

Sunny Creek has an orthogonal bend between two straight reaches upstream from its junction with Umbum Creek. At this point on the ASTER/JERS-1SAR merged image (Figure 7.17) a feature is clearly visible heading east from this elbow. On-ground investigations reveal this to be a sandsheet that is represented by small hummocks composed of fine-grained orange sand at its head and by pebbly, fine-grained orange sands spread broadly across the landscape near Horseshoe Dam. These sands are of alluvial origin and may represent the degraded palaeochannel of the ancestral Sunny Creek prior to structural rearrangement of the drainage network by neotectonic activity. This accords well with evidence that an avulsion occurs in Umbum Creek along a lineament directly down-strike of this location. Neotectonic faulting has caused the channel to avulse as a consequence of the relative uplift of the eastern block via normal faulting. The palaeochannel was then abandoned in favour of the new structurally controlled channel of modern Sunny Creek.

### **7.2.8 Claypans**

Claypans are one of the few depositional zones within the study area. They are typically filled with fine brown clay and have desiccation cracks and halite efflorescence when dry. They are devoid of vegetation except on the margins where halophytes grow. Claypans are associated with slight depressions in the landscape. It is the arrangement of these depressions that provides information with regards to structure and tectonics.

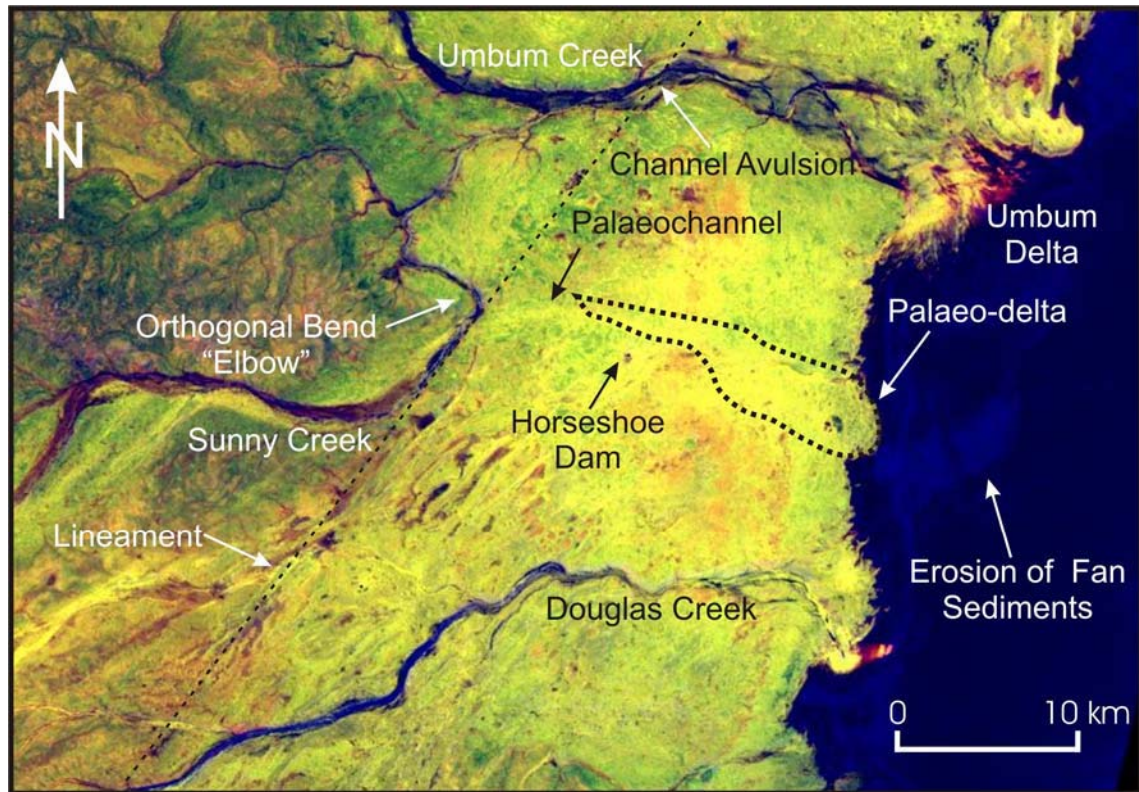
Claypans are associated with three areas (Appendix C):

- surrounding the Neales Delta;
- across the Neales Fan; and,
- flanking the Neales River.

The claypans surrounding the Neales Delta are developed by fluvial and lacustrine processes and may represent either past embayments of the lake or previous deltaic channels.

On the Neales Fan, there are many small-scale claypans 3–30 m in diameter associated with sand dunes. These interdune areas are too small to be mapped effectively at 1:250 000 scale. However, along the central axis of the fan a series of larger claypans exist. These claypans and associated dune fields are interpreted as remnants of a palaeochannel that extends across the fan and shows bifurcation to the east (Figure 7.35). Near Bando Hill, a triangular-shaped claypan may be part of a distributary palaeo-delta (Figure 3.7).

North of the Neales River (Appendix C), a series of elongate-shaped claypans have formed along a trend parallel to the Lake Eyre Fault and Browns Creek Fault (Figure 7.18). A similar set has formed on the opposite bank in the vicinity of Lagoon Hill. The geomorphology of the landscape across this region is consistent with a series of fault blocks tilted to the east. This morphology controls the major streams in this area and creates the necessary depressions for the formation of claypans. These claypans therefore reflect that there are a series of faults trending northwest.



**Figure 7.17: ASTER/JERS-1 SAR melt image showing the neotectonic deviation of Sunny Creek. Movement along the fault has led to channel deviation in Sunny Creek and channel avulsion in Umbum Creek. This has left the palaeo-delta of Sunny Creek abandoned and it has since been degraded.**



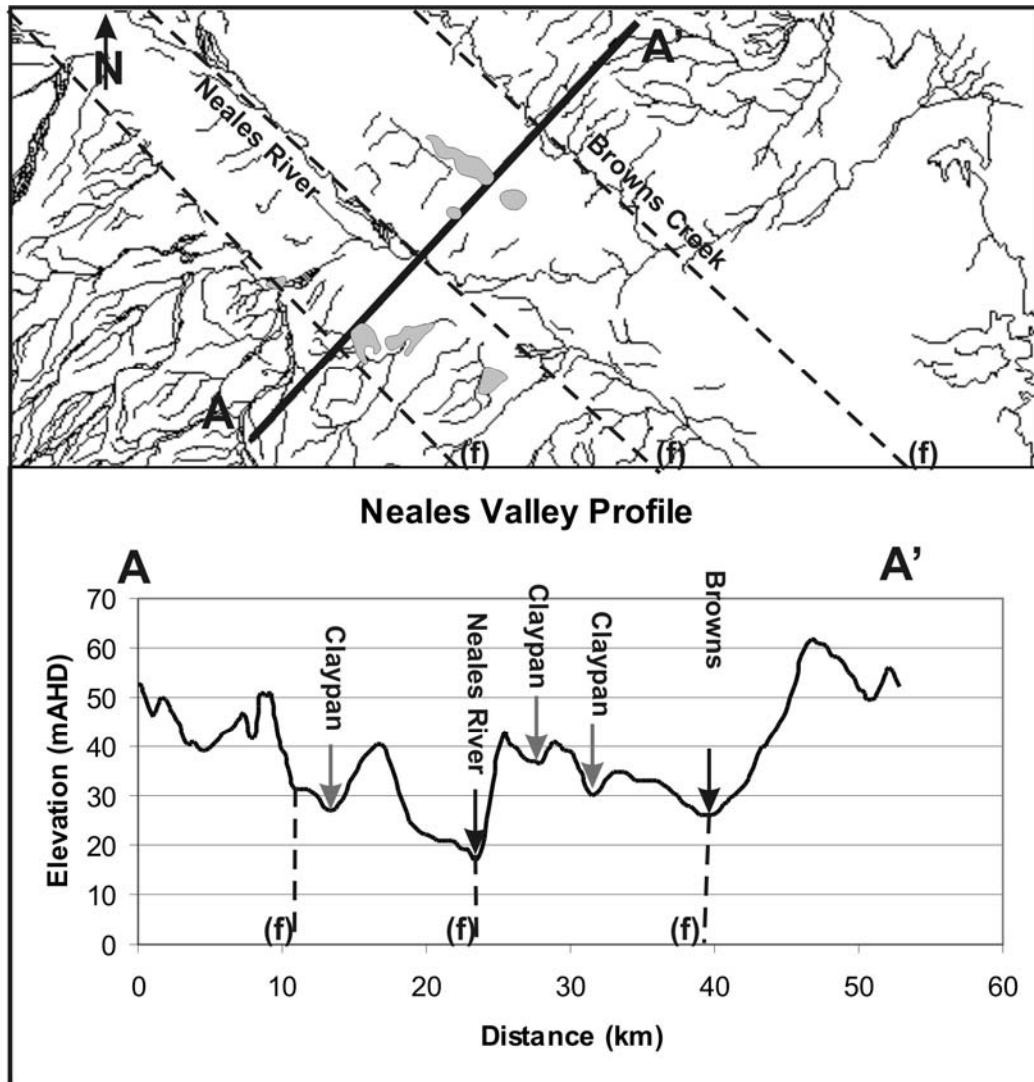


Figure 7.18: Comparison of landform and topography showing the association of claypans (grey) with valleys parallel to the Neales River and Browns Creek, indicating the disruption of the land surface by faulting (f).

### **7.2.9 Umbum Overflow**

ASTER thermal imagery (Figure 7.19) shows the inferred pathway of a palaeochannel across the surface of the Neales Fan. This is the same palaeochannel that is related to the dunes and claypans (see Chapter 7.2.8). This palaeochannel follows the trend of the Lake Eyre Fault to the point where Umbum Creek intersects the Umbum Overflow. At this location, the palaeochannel diverts and spreads out across the fan. The topography across the Umbum Overflow at this point shows a significant change in elevation from the base of the stream to the surface of the Neales Fan (Figure 7.20). This change in elevation coincides with the Lake Eyre Fault. It is therefore likely that movement along the fault caused the ancestral Neales River/Umbum Creek to be redirected. At some point the system was diverted down the modern Neales River course probably as a result of stream capture via headward erosion by the northern arm of the system. The relative timing of these two events is uncertain and the movement on the fault may be related to the stream capture. If the fault-driven drainage adjustment occurred first, flow would be redirected down Umbum Creek and could account for the sediment that formed the Umbum Delta.

### **7.2.10 Four Hills and Surrounds**

In the lower half of the Umbum Creek Catchment, Four Hills (Figure 1.2) is the most prominent landmark at 105 m a.s.l. and is visible from considerable distances (Figure 7.21). Likewise, the view from Four Hills is spectacular as the landscape is very flat (Figure 7.22). This unusual elevation, in comparison to the surrounding landscape, is the result of silcrete caprock forming the mesas of Four Hills by topographic inversion (Appendix C). The relief on the caprock indicates that a significant amount (approximately 50 m) of sediment has been removed via erosion. The caprock is situated on top of Oodnadatta Formation that consists of friable claystones. The caprock is a grey massive silcrete that weathers to a tan/red colour and contains 'reed mould' structures (Figure 7.23), brecciation (Figure 7.24) and conglomeratic bands. The conglomeratic bands display clasts of silcrete that have granules of silcrete within them, providing evidence for three phases of silcrete formation and reworking (Figure 7.25). By interpreting these silcretes as equivalents of the Mirackina Palaeochannel silcretes, a Pliocene age can be deduced (Rogers & Freeman, 1996). This would indicate rapid denudation rates in this area of approximately 0.056 mm/a. Significantly, conglomeratic beds in the silcretes are tilted at various attitudes between 20 and 30 degrees indicating tectonic deformation after the Pliocene.

The landscape surrounding Four Hills is startlingly different to other parts of the Umbum Creek Catchment because the surface lag is composed almost entirely of silcrete pebbles (Appendix C). These have formed by calving off from silcrete outcrops and have been transported laterally via colluvial and alluvial processes. They weather to a distinctive red and this gives the landscape its characteristic colour. The widespread distribution of this red unit suggests that outcrops of silcrete were more prevalent in this zone than currently preserved. Remnants of silcrete still remain as part of a chain of hills, and outcrops of silcrete extend east from Four Hills (Appendix C). These silcrete remnants display similar fluvial sandstone and conglomeratic character to the host regolith material. The outcrops probably are a remnant of a former fluvial channel in this area during the Pliocene. Some of these silcretes have been modified by rivers following silicification. Low outcrops north of Sunny Creek have water-worn features consistent with erosion in a riverbed (Figure 7.26). Other outcrops nearby possess round, highly polished pebbles as a component within the surface lag (Figure 7.27). The degree of polishing on these pebbles indicates that they were probably formed by a high-energy fluvial environment. It is probable that they have weathered out of the underlying silcrete and have been redeposited across the surface.

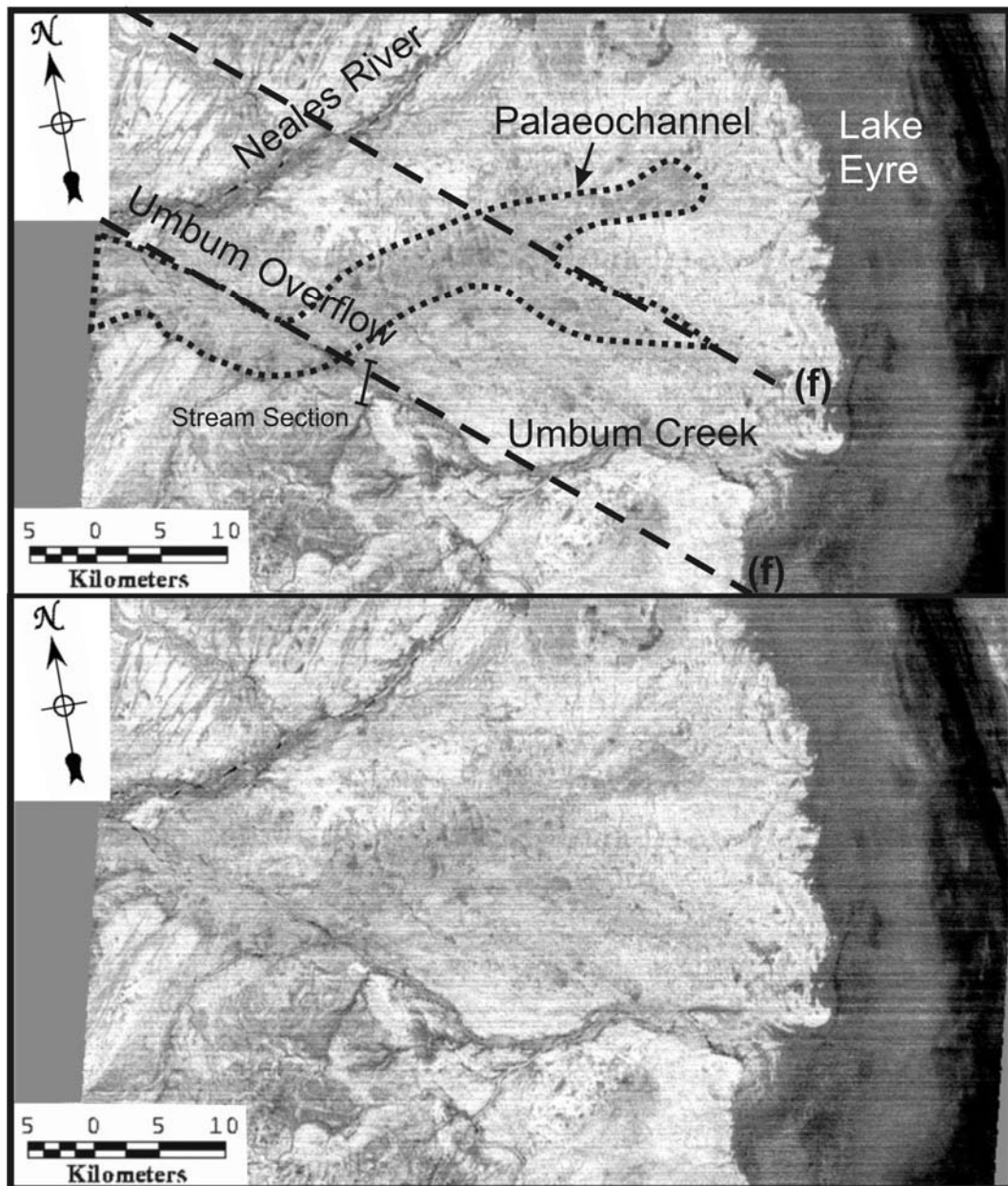


Figure 7.19: Inferred palaeochannel across the surface of the Neales Fan defined by low thermal absorption on ASTER TIR. The low absorption areas are associated with claypans that represent a remnant channel plug.

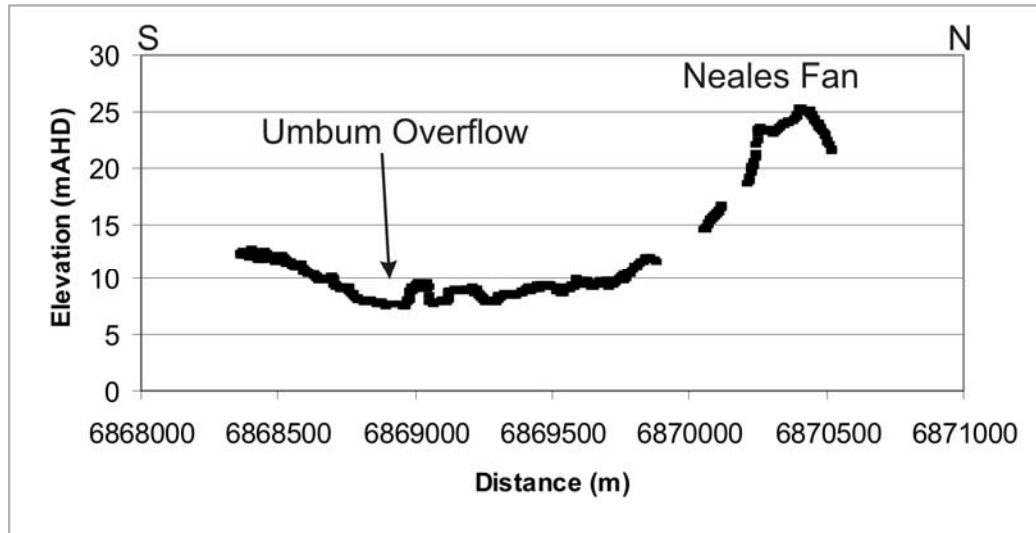


Figure 7.20: RTK-DGPS stream section Western Fan, indicated on Figure 5.24 across Umbum Creek channel showing the elevated eastern bank.



Figure 7.21: Four Hills and surrounding landscape showing the dominance of silcrete surficial lags across the region and the significant topographic inversion of the silcrete caprocks (view towards east 0645725E 6845784N).



**Figure 7.22: View towards the northwest from Four Hills displaying the low topography that dominates the region. Broad colluvial plains of red subangular to subrounded silcrete pebbles radiate from topographically inverted outcrops (car for scale 0645725E 6845784N).**



**Figure 7.23: Tilted 'reed mold' structures present in Pliocene silcretes of Four Hills, indicating tectonic activity in the Pleistocene following the formation of the silcretes in the Pliocene (hammer for scale 0646370E 6846176N).**



**Figure 7.24:** Brecciation in silcrete at Four Hills (pen at top for scale 0645756E 6845838N).



**Figure 7.25:** A silcrete boulder displaying clasts of silcrete and matrix-supported silcrete conlomerate clasts. These clasts possess micro-clasts indicating at least three phases of silcrete generation (Scale 10 cm 0669537E 6845115N).



**Figure 7.26:** In-situ silcrete outcrop showing water-worn surfaces with pebble-holes, indicating a river of significant power and volume flowed across this surface following the formation of the silcrete (scale 10 cm 0664347E 6846169N).



**Figure 7.27:** Highly polished, well-rounded pebbles located atop low hills of silcrete east of Four Hills. The polishing indicates these pebbles were transported in a high-energy fluvial environment (scale 10 cm 0657021E 6845979N).

Similar polished pebbles have been identified as the basal member of the Eyre Formation. (Alley, 1998; Krieg, 2000). This implies that these silcrete outcrops are equivalents of both the Eyre Formation and Mirackina Conglomerates and may represent the transition from channel to braid plain environments. Trace fossils, identified within the host regolith material of the silcrete in the area surrounding Four Hills, have been identified as *Muensteria isp.* (Figure 7.28). These trace fossils were probably created by dung beetle larvae and represent evidence of a fluvial or floodplain environment (Hasiotis in Krapf & Lang, 2005).

### **7.2.11 Sunny Creek/Douglas Creek Interfluvium**

The interfluvium between Sunny Creek and Douglas Creek is characterised by predominantly alluvial-derived sediment (Appendix C). Subrounded cobbles of silcrete, lithic fragments, rounded quartz and angular quartzite, pebbles and granules of rounded milky quartz, subrounded quartz, hematite, silcrete and lithic fragments with fine-grained red-brown silty sand, cover broad areas in the lower catchment where they are associated with longitudinal sand dunes. In the upper catchment of the streams the surface lag consists of boulders, cobbles and pebbles of rounded to subrounded lithic fragments, ferruginous sandstone, silcrete, milky quartz, hematite and angular quartzite with fine-grained red-brown silty sand, suggesting that clast size reduces downstream. Directly down-strike of the fault between the Coikiana Sandstone and Bulldog Shale, the topography of the landscape alters, with the upper catchment to the west underlain by a gypsum escarpment dropping down to the plains of the lower catchment. The change in topography, the margin of the gypsum escarpment and the rapid change in surface lag character, indicate that a fault underlies this area and has resulted in the relative downthrow of the eastern block. The sharp nature of the change suggests that the rupture may have been catastrophic and caused Sunny Creek and Douglas Creek to spill out across the plains depositing alluvial sediment until they became aligned to their current courses. This is direct evidence of drainage rearrangement due to neotectonic activity within the study area.

### **7.2.12 Midla Milda and Wadlalglia Hills**

The region north of the Neales River, bounded on the east by the Neales Overflow, surrounds Midla Milda and Wadlalglia Hills. This region has a surface lag that consists predominantly of silcrete on a gypsum surface that is overlain by longitudinal sand dunes (Appendix C). The underlying geology includes younger units towards an easterly direction from Bulldog Shale in the west through Oodnadatta Formation to Winton Formation in the east. The topography possesses a cuesta ridge morphology that is controlled by the Lake Eyre Fault and Browns Creek Fault. The silcrete clasts, although transported laterally, are concentrated in this area and are likely to have been derived from a relatively local source. No silcrete outcrops have been observed in this region but the Cordillo Surface occurs to the north (Alley, 1998) and the clasts are interpreted to be derived from the reworking of this unit.





Figure 7.28: Backfilled burrow similar to *Muensteria isp.* probably created by dung beetle larvae and represents a fluvial or floodplain environment (scale 10 cm 0673836E 6846500N).

### **7.2.13 Dunes**

Several styles of dune occur within the study area. To some degree the dune orientations reflect the modern prevailing wind directions with dune trends aligning either to the northeast or north. The spatial distribution may reflect the influence of the Davenport Ranges in deflecting winds around the ranges. It is noted that no dunes occur at the eastern base of the ranges; however, this area is coincident with the degraded alluvial fans, and substrate probably plays a stronger role in defining dune style. Five dune types have been identified (Appendix C).

#### Longitudinal Dunes

These dunes are characterised by red, well-sorted, well-rounded medium-grained sands. They overlie gibber plains in all of the areas they occur in and are considered to be sourced from the deflation of gibber plains and other landforms (e.g. claypans and rivers). They form in a northeast orientation (Figure 7.29). Their distinctive red colour is imparted by iron oxide grains and iron oxide coatings on sand grains (Krieg, 2000).

#### Neales Fan Dunes and Interdunes

Across the Neales Fan are a series of north-south trending dunes (Figure 30). These dunes are distinguished by the granule mantle on their flanks and their mobile crests. The core consists of clay-indurated sands that contain granule-rich layers and rare mud-drapes. The western, stoss side of the dune generally includes signs of wind erosion and the formation of a soil carapace. Erosion winnows out the granules from the dune sediment and redistributes them downslope onto the interdunal areas (Figure 7.31). These areas are characterised by interdunal claypans and gibber plains. Excavations at the base of one of these dunes failed to find pebble lags that form the gibber plains. The dunes therefore may represent 'anti-dunes' excavated out of the surrounding landscape. While in some instances the gibbers may be laterally transported, it is probable that others are the result of excavation via deflation of underlying alluvial sediment. This sediment coincides with the ephemeral facies of Croke *et al.* (1996). This patchwork of in situ and transported surficial lags interspersed between sand dunes forms a complex erosional system across the surface of the Neales Fan. Dunes at the Neales Cliff have been dated between 22 ka and recent (Croke *et al.*, 1996).

#### Structure-related Dunes

Lineaments can be observed crossing the Neales Fan trending southeast-northwest (see Chapter 5). From air photo and satellite interpretation, these were at first interpreted as palaeochannels. Ground-truth investigations revealed that these linear features were associated with sand dunes, typically with a modern drainage channel or claypan collecting run-off from the dune (Figure 7.32). In some locations these dunes have been degraded by deflation and run-off to a series of disconnected yardangs held together by vegetation. The space between them is an unvegetated elongate claypan.

Why these dunes should form along a fault lineament remains unresolved. It is possible that deep linear fractures could attract vadose waters (Twidale, 2004), leading to stabilisation of the ground surface from erosion via deflation. They may also represent the deflated remains of a palaeochannel that formed in a depression created by an underlying fault.

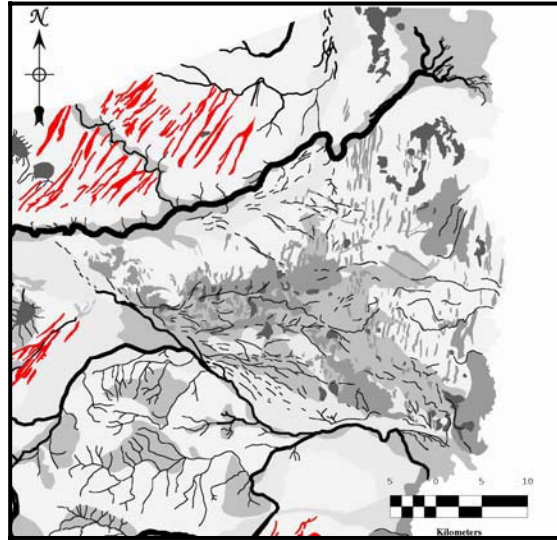


Figure 7.29: Location diagram of northeast trending longitudinal dunes shown in red.

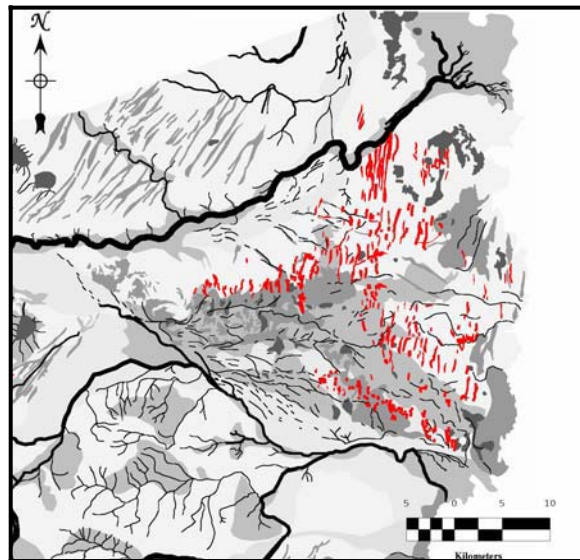


Figure 7.30: Location of north-south trending dunes on the Neales Fan shown in red.

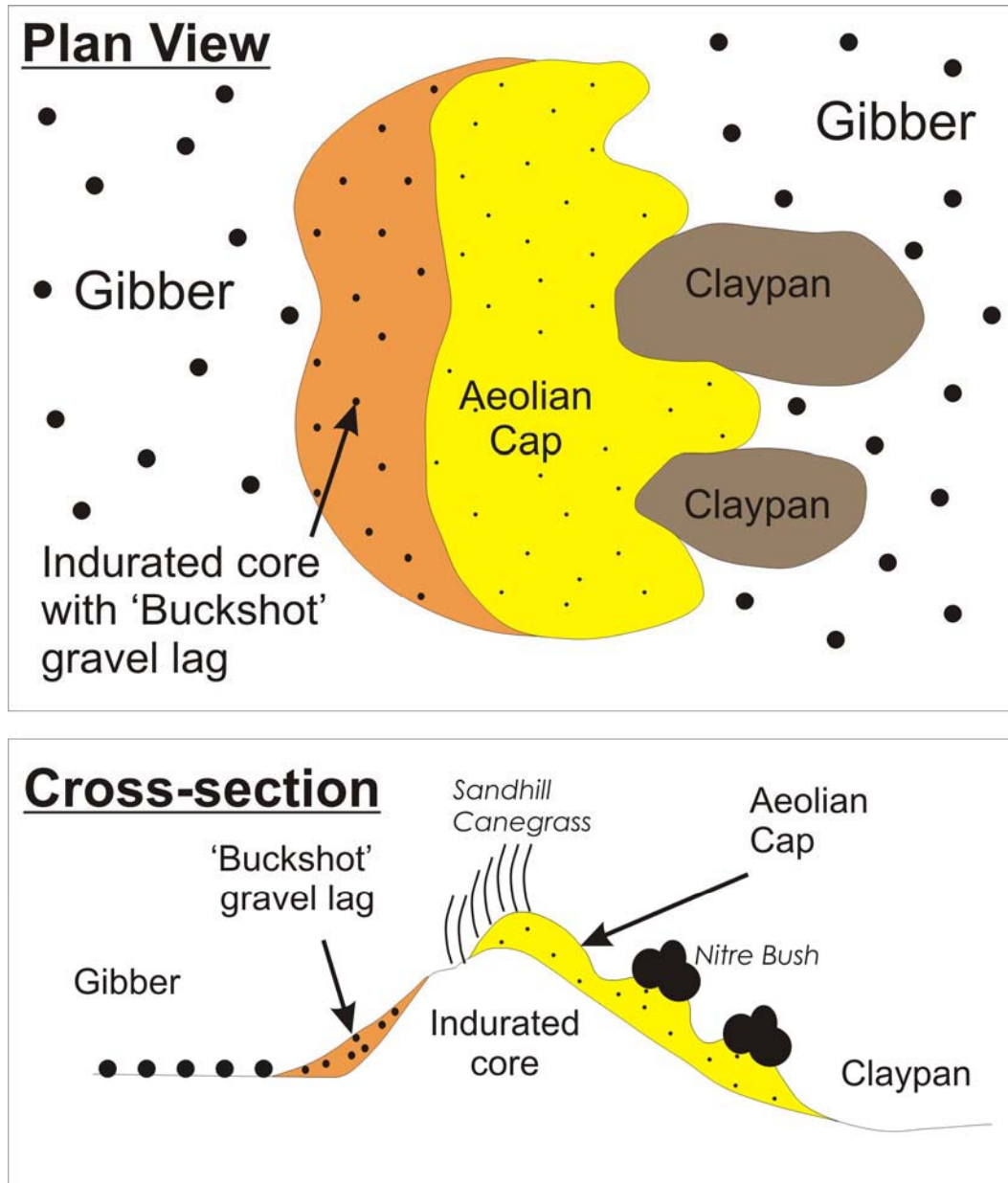


Figure 7.31: Idealised plan and cross-section of north-south trending dunes on the Neales Fan showing the 'buckshot' granule lags being reworked from the indurated core and redeposited downslope contributing to the gibber plain.

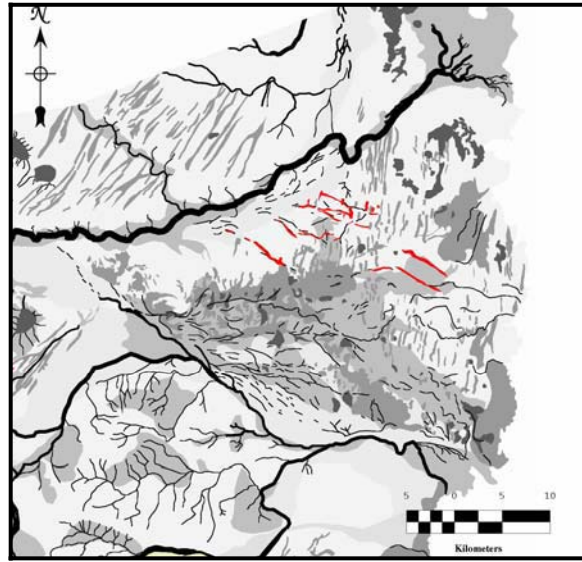


Figure 7.32: Location of structurally related dunes on the Neales Fan shown in red.

### Sand Plains

The major palaeochannel identified on the Neales Fan (Figure 7.19) and its associated fluvial deposits are no longer expressed as a channel sequence deposit. The fluvial sediment that was deposited has been deflated. Part of that sediment now forms the sand dunes and sand plains that run alongside the mud-plug of the palaeochannel. The palaeochannel sediment has been exhumed and deflated to form the broad sand sheets and dunes. Some of these have also been remobilised by colluvial flow to form broad flat sand sheets across the gibber plains (Figure 7.33).

### Coastal Dunes

Along the shore of Lake Eyre are a series of what are here termed coastal dunes, as they resemble the coastal dunes seen along oceanic coastlines (Figure 34). Bando Hill is approximately +9 m a.s.l. with a relief in the order of 20 m. The dunes are currently inactive, possessing a cemented core with mobile crests. They are located in close proximity to the Umbum Delta, and the poor maturity of the sediments suggests that sand has been sourced from the delta (Krapf & Lang, 2005). The form and location of the dune field tends to indicate that southerly winds have deflated the Umbum Delta to produce these dunefields. Interestingly, a space exists between this set of coastal dunes and the next coastal dunefield to the north. This dunefield is located north of the interpreted palaeochannel, with exactly the same relationship to a hypothetical palaeo-delta as seen at Umbum Creek.

#### **7.2.14 Neales Fan Drainage**

Along the margin of Umbum Creek, a series of channels appear to splay out from Umbum Creek across the fan (Figure 7.35). These were originally interpreted as palaeochannels, but ground-truth investigation proved that they are incised modern channels that flow away from the lake and drain west into Umbum Creek. These channels are the result of alluvial erosion across the surface of the fan. Their flow direction demonstrates that the modern surface of the fan is tilted to the west. Similarly, there is a north-south divide across the fan that separates drainage to the west from drainage to the east. This coincides with a lineament and could be interpreted to represent the influence of neotectonics on the modern drainage system. This lineament also coincides with the known extent of the Etadunna Formation and may also represent underlying lithological control on drainage.

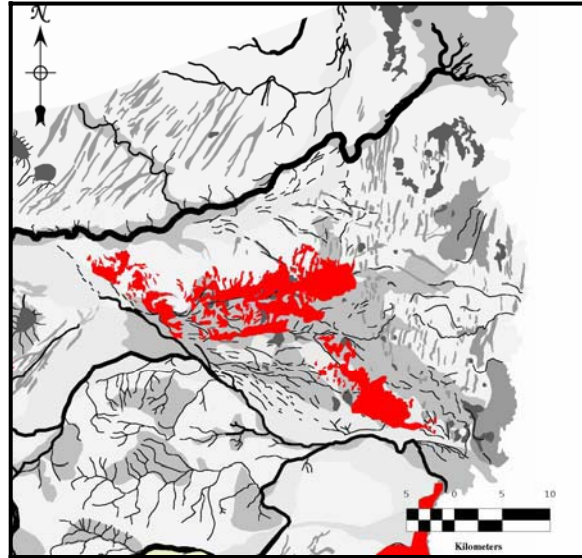


Figure 7.33: Location of sand sheets shown in red.

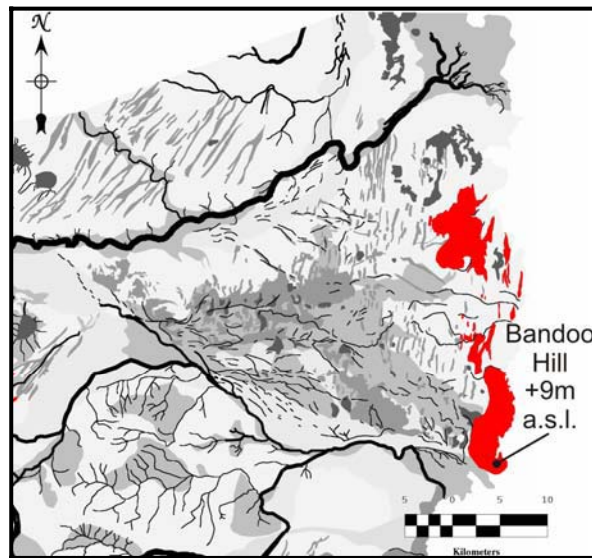
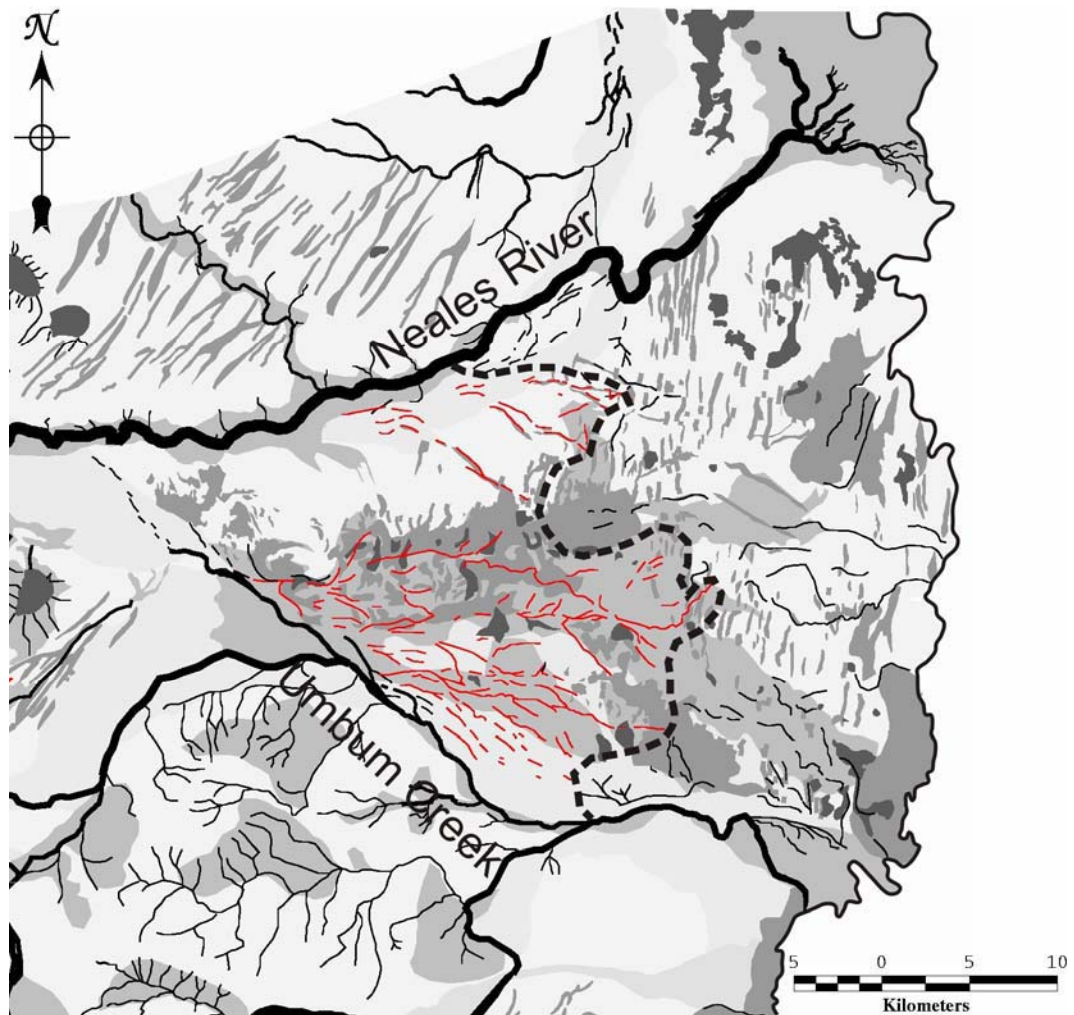


Figure 7.34: Location of coastal dunes.



**Figure 7.35: Modern drainage on the Neales Fan surface. Red marks drainage from east to west, indicating a drainage divide (dashed line) formed across the mid-section of the fan.**



### **7.2.15 Neales Fan Palaeochannels**

The Neales Fan has always been considered to be a feature of fluvial origin but the identification of the palaeochannels that create it has been problematic. There have been several candidates for palaeochannels considered (Appendix C):

- Modern drainage channels;
- 'Reverse' drainage channels;
- Structurally controlled sand dunes; and,
- Interpreted palaeochannels from ASTER satellite imagery.

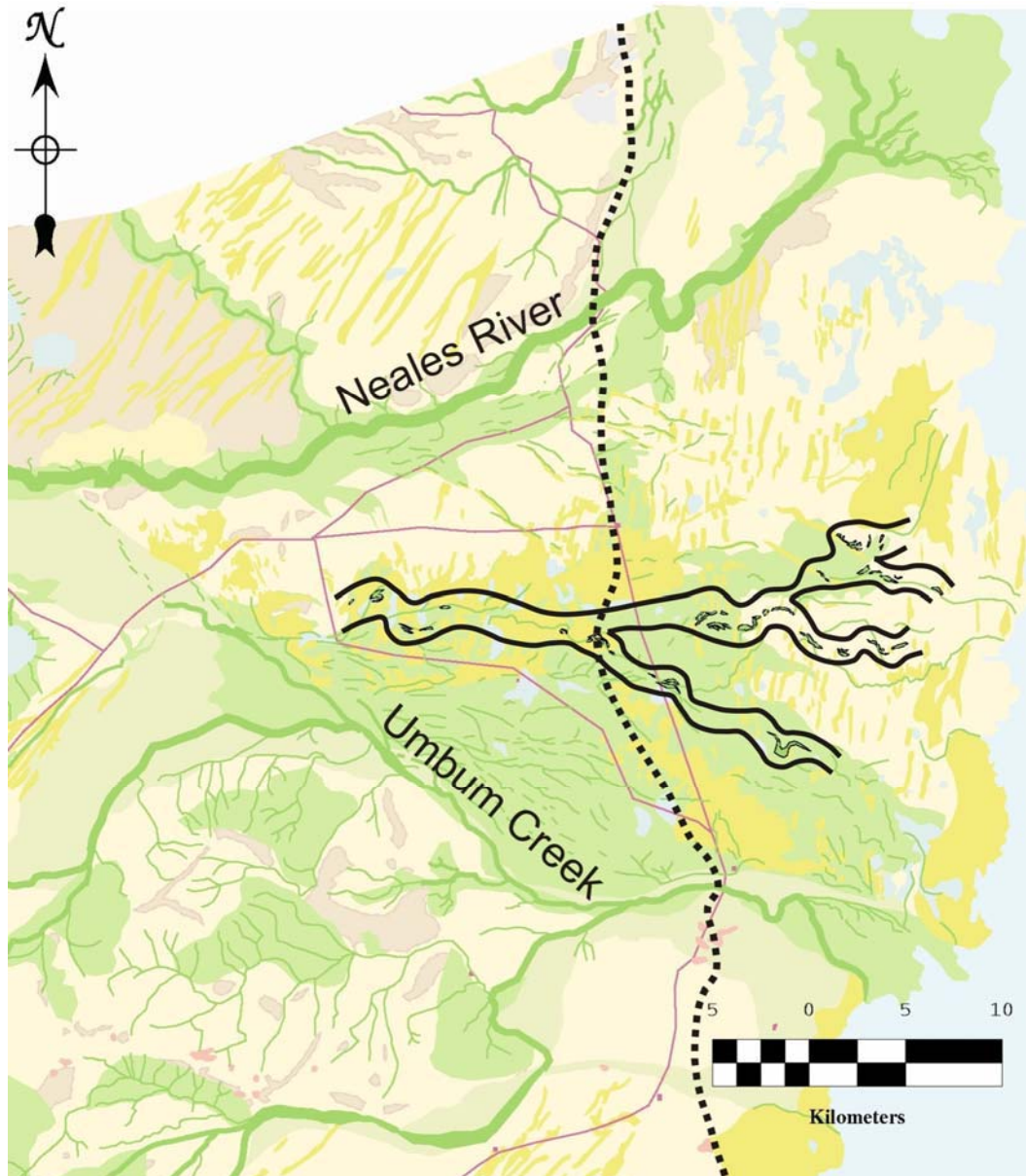
Of these, the ASTER satellite channels are the most likely candidate. They possess a range of features consistent with palaeochannels and the associated landforms are consistent with the degradation by erosion and deflation of palaeochannels.

One identified palaeochannel has a planform that is consistent in scale with other rivers in the area. It has a meander in it at the location of the north-south lineament (Figure 7.36). This indicates that this stream was also lithologically controlled by the underlying Etadunna Formation. The bifurcation of this palaeochannel coincides with the trend of the Browns Creek Fault and indicates structural control of the palaeo-system as well. Sand dunes and sand sheets were formed within the channel belt and blown north of it by deflation. At its terminus, where the palaeo-delta would be expected, the shoreline is scalloped in a way that is similar to that observed around the Umbum and Neales deltas (Figure 7.36). Additionally, the location of the coastal dunefield downwind of the probable location of the palaeo-delta further adds to the likelihood of a palaeochannel (Figure 7.36).

Remnant palaeochannels were identified on the Neales Fan. They are expressed as cobble armoured arcuate mounds that in places display features reminiscent of meander point bars (Figure 7.37). They are topographically inverted, with winnowing of the fine-grained fraction leaving the coarse-grained material behind. This material accumulates predominantly in the thalweg of the channel. These armoured mounds are located along the identified palaeochannel belt and represent the meanders of the main channel as they were deposited across the surface of the fan. The topographic inversion of these armoured lags suggests again that there has been considerable stripping of material from the surface of the fan since its deposition.

### **7.2.16 Deltas/Terminal Splays**

Three 'deltas' occur within the field study area: the Neales Delta, the Umbum Delta, and the Douglas Delta (Appendix C). Although classified here as deltas under the RT-map system, it is acknowledged that, as the final outflow of a dryland system, these 'deltas' may operate anywhere between the range of a true delta flowing into a standing body of water and a terminal splay complex terminating onto a dry lake/playa surface. An in depth assessment of these deltas is beyond the scope of this study and is being pursued separately by other workers (Reilly, M. and Fisher, J. in Krapf and Lang, 2005.) Some general observations are noted concerning these deltas. The deltas become larger and more expansive from south to north with the Douglas Delta being much smaller in size and scale than the Neales Delta. The Neales Delta and Douglas Delta are notably more fan-shaped than the Umbum Delta, which is more elongate and narrow. Of the three, the Douglas Delta displays the least degree of structural control. The Neales Delta appears to be dominated by a lineament that runs down the centre of the fan axis, while the Umbum is bounded by the Lake Eyre Fault and the Browns Creek Fault and appears to be controlled by intersections with smaller northeast trending cross faults.



**Figure 7.36:** Location of identified palaeochannel mounds (in black) on the Neales Fan, showing the association with coastal dunes that are interpreted to have been sourced from the palaeo-delta and meanders in the palaeochannel, possibly related to lithological control from the underlying Etadunna Formation (extent of Etadunna Formation marked by dotted line). For designated RLUs see accompanying Regolith-Landform map (Appendix C).

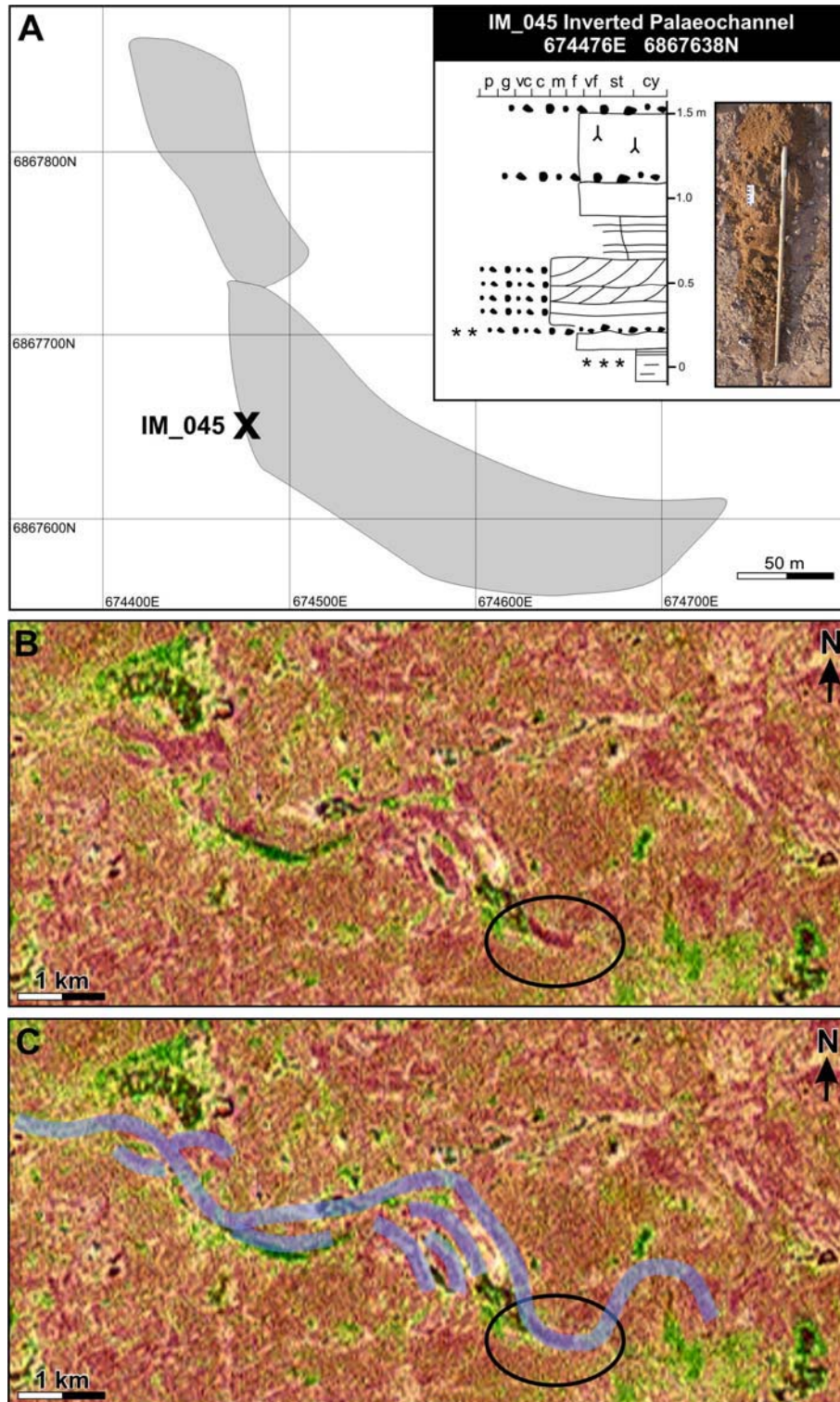


Figure 7.37: A: Log through an inverted palaeochannel on the Neales Fan. B: Landsat ETM7 image showing the surface expression of the outcrop. C. Interpretation of Landsat ETM7 image showing a meander of a palaeo-river on the Neales Fan (after Krapf & Lang, 2005).

These smaller faults appear to have influenced the formation of channel avulsions in this delta (Figures 6.17 & 7.17). All three deltas are currently discharging mainly through a southern distributary with more inactive distributaries located north of the active channel. This is potentially due to either regional or local block tilting to the south, causing adjustment of the channels in a southerly direction.

### **7.2.17 Carbonate-cemented Conglomerate Palaeochannel Equivalents**

From a regional perspective, the silcretes that form the Mirackina Palaeochannel deviate towards the end of the defined channel, trending directly towards Mt. Anna, which is another silcrete outcrop. Most other outcrops of silcrete in the study area are located along a narrow zone between Mt. Anna and Flint Mound (Figure 7.38). All of these outcrops display evidence of deposition of the host regolith in a fluvial environment. These palaeochannel silcretes have all been topographically inverted and now form an erosional rise extending along a northeast axis. They have been identified as Mirackina Palaeochannel equivalents by Rogers & Freeman (1993). They may represent the continuation of the Mirackina Palaeochannel itself, but there is such distance between them to doubt a definitive correlation. They probably represent a palaeochannel flowing from the antecedant Davenport Ranges topographic ridge towards the palaeo-lake. Additionally, small outcrops of limestone-cemented conglomerate have been identified adjacent to Sunny Creek along this ridgeline. These are composed of rounded to subrounded cobbles and silcrete pebbles, lithic fragments, and hematite in a carbonate matrix (Figure 7.39). They overlie Bulldog Shale and are therefore younger than Mesozoic in age (Figures 7.40 & 7.41). They are likely equivalents of the silcretes but may represent remnants of Plio-Pleistocene alluvial fans. These carbonate-cemented conglomerates correspond to the area covered by large subrounded clasts of variable origin, dominated by lithic fragments from the Davenport Ranges. These clasts are most likely not reworked from the Bulldog Shale, but are the product of this degraded palaeochannel. This is consistent with lags deposited over the Coorikianna Sandstone and the absence of this lag from other areas underlain by Bulldog Shale. These stranded river gravels, along with water-worn surfaces in the silcretes and highly polished silcrete pebbles preserved on topographic highs, are strong indicators of fluvial activity down this axis during the Plio-Pleistocene.

## **7.3 DATASET COMPARISON**

### **7.3.1 Sand Dunes and Gravity**

A comparison between the occurrence of sand dunes and the gravitational variation of the basement demonstrates that there is a link between basement behaviour and contemporary landscape expression of landforms. It is quite clear that most sand dunes are associated with areas of low gravity deflection, interpreted as basins (Figure 7.42). However, the southernmost sand dunes mapped in the field study area display an association with the large southern basement gravity high. These sand dunes are large, red, longitudinal dunes and form part of a dune field to the south of the study area. As the edge of the map is defined by Douglas Creek, dunes to the south of Douglas Creek have not been mapped. However, the dunes do form a ring around the basement high.

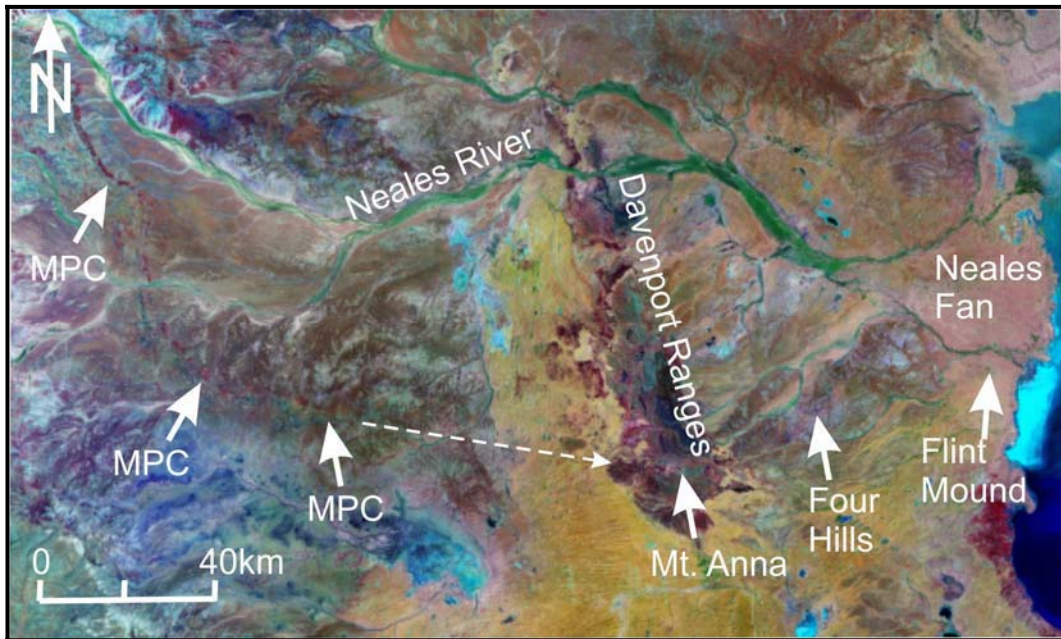
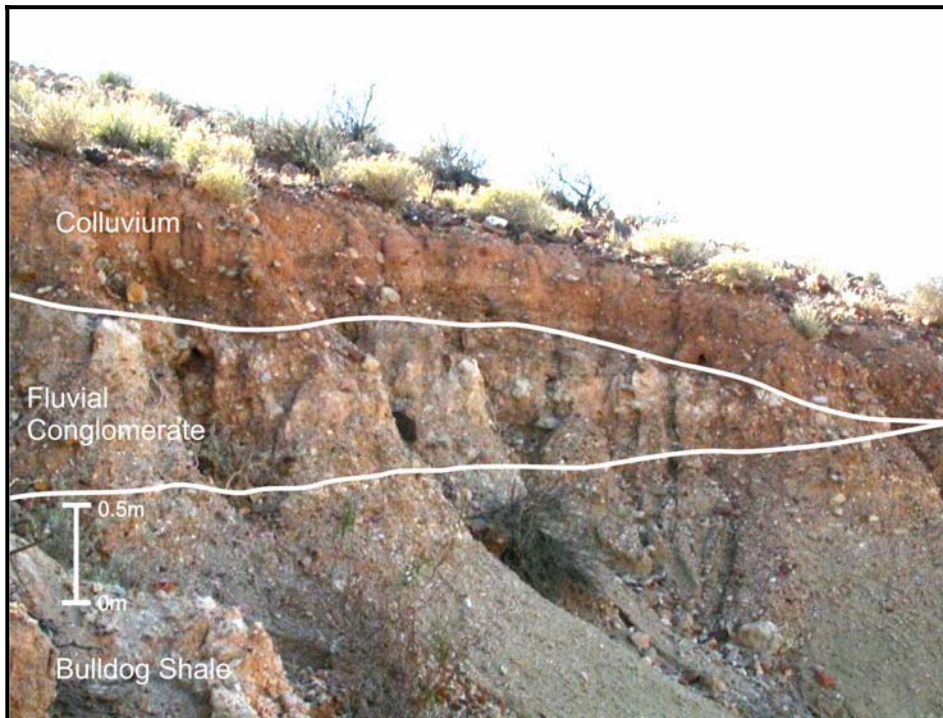


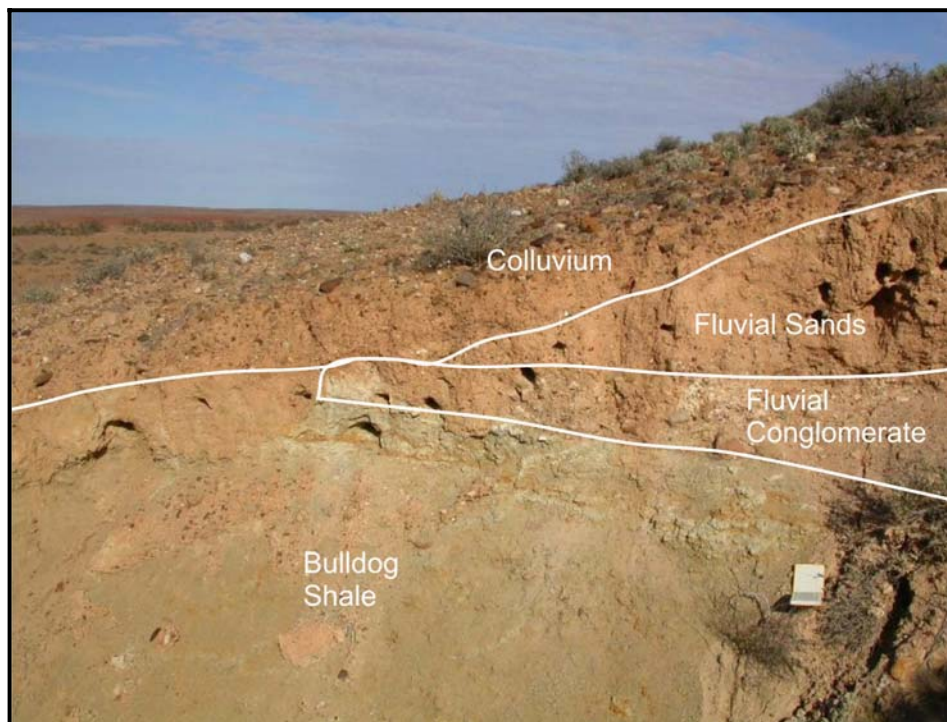
Figure 7.38: Diagram of the Mirackina Palaeochannel (MPC) showing the location of remnant silcrete outcrops in the area and the proposed missing link between the silcreted areas of the MPC, Mt. Anna, Four Hills and Flint Mound.



Figure 7.39: Carbonate-cemented fluvial conglomerate overlying Bulldog Shale, located in the headwaters of Sunny Creek, indicating the presence of Plio-Pleistocene palaeochannels through this area (foot for scale 0622618E 6830143N).



**Figure 7.40: Colluvial mantle overlying carbonate-cemented fluvial sandstone overlying Bulldog Shale, located between Sunny Creek and Davenport Creek, indicating the presence of Plio-Pleistocene palaeochannels (looking east 0625233E 6830453N).**



**Figure 7.41: Colluvial mantle unconformably overlying fluvial sands and carbonate-cemented fluvial conglomerates overlying Bulldog Shale (notebook for scale, looking west 0625233E 6830453N).**

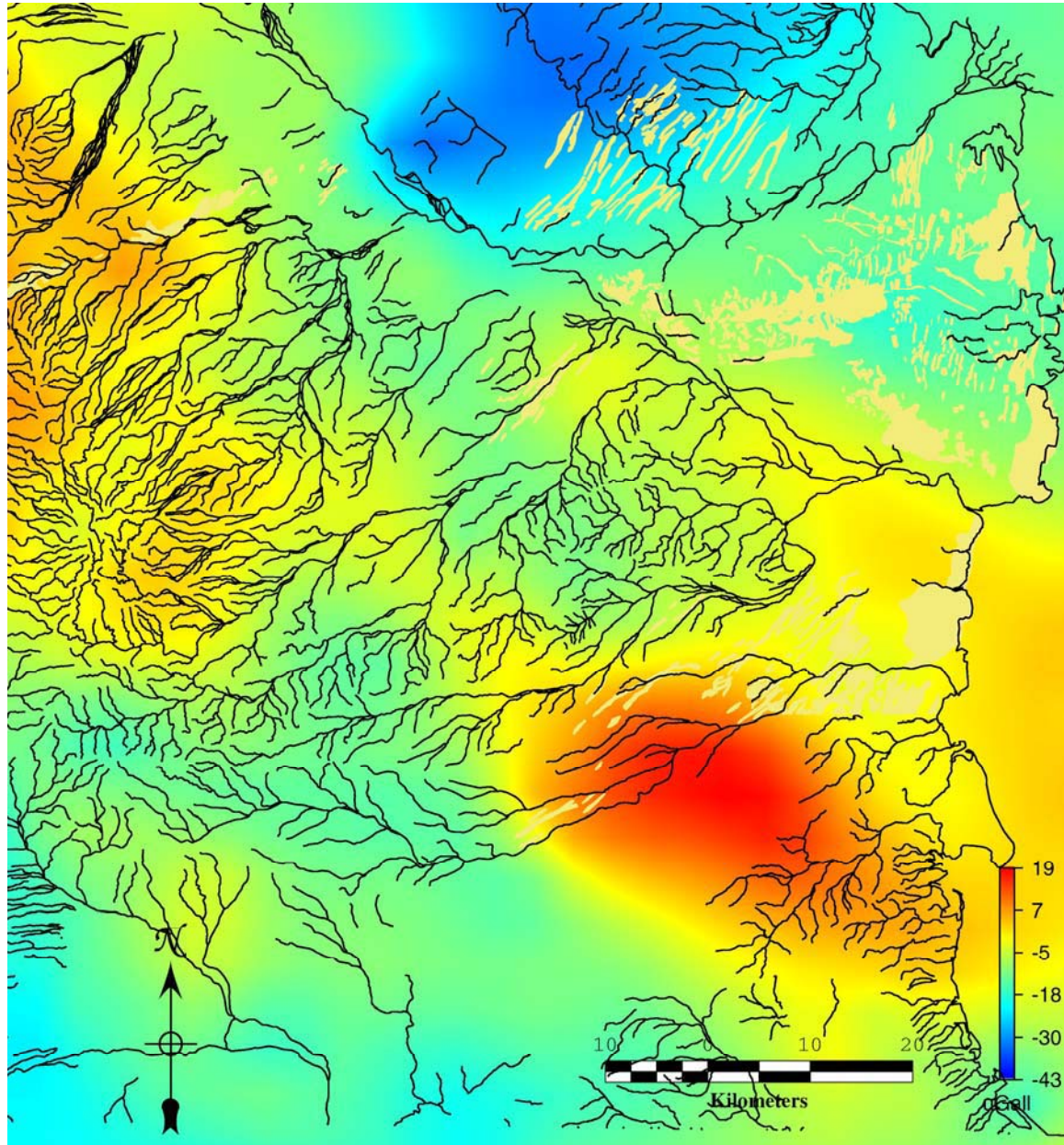


Figure 7.42: Comparison of gravimetric data to sand dune distribution showing the concentration of sand dunes (shown in yellow) over gravity lows and the general absence of sand dunes over gravity highs. Purple to blue colours show low gravity, yellow to red colours indicate high gravity.

By observing the stream profile of Douglas Creek it is evident that the medial section of the stream displays a positive deviation from the assumed base level (Figure 7.43). This region of deviation is coincident with the basement gravity high and represents a zone of uplift (Figure 7.42). Field evidence supports this observation – channels upstream and downstream of the basement gravity high form low banks less than a metre in relief but across the uplifted zone the channel is significantly incised with up to 10 m of relief, from thalweg to hillcrest. It is uncertain whether the dunes were deposited prior to uplift or if they formed around this mild topographic high. Since it is conceivable that sand dunes may encroach over a topographically raised surface, particularly in a region with such low relief as Lake Eyre, it is interpreted that the uplift of this zone has resulted in erosional stripping of dunes from the upland surface. This evidence not only demonstrates the direct influence that the basement has on landforms in the region, but it is a clear demonstration of neotectonic activity in the Pleistocene which is also reflected in related sediments as the sand dunes are Pleistocene in age.

### **7.3.2 Regolith and Magnetics**

When the Total Magnetic Intensity data is viewed as a colour intensity image and compared with regolith units (Figure 44) there is a strong spatial correlation with areas displaying gypsum-patterned ground and areas of low magnetic intensity. It appears that those regions displaying high magnetic intensity are associated with faults such as the Lake Eyre Fault along Umbum Creek. The absence of gypcrete from these areas may indicate that those regions have had gypsum surfaces removed, but only if it could be demonstrated that the gypsum surfaces represent a palaeo-landsurface. This is not certain, as it has been shown that gypsum sedimentation in the study area is subject to karstic dissolution, weathering and reprecipitation, making the definition of surfaces and even mapping the boundaries of these units fraught with potential errors.

### **7.3.3 Regolith Landforms and Magnetic Lineaments**

When examining the combination of magnetic lineaments and observed landforms, it is intriguing to see that there are many instances of coincidence between the two datasets even though they were mapped independently (Figure 7.45). Many channels align with magnetic lineaments and in many cases alluvial erosional depressions are bounded by or have an axis that follows one. On the Neales Fan, variation in the topography is coincident with these lineaments. The northwest trending sand dune and channel complex units align directly along these same lineaments. In addition, the palaeochannel remnants are observed to follow the trends of these lineaments with apparent channel deviations (meanders) directing flow from one magnetic lineament to the next as though the palaeo-topography controlled channel formation. This implies that the basement structure has had a direct influence on the formation of landforms in the study area.



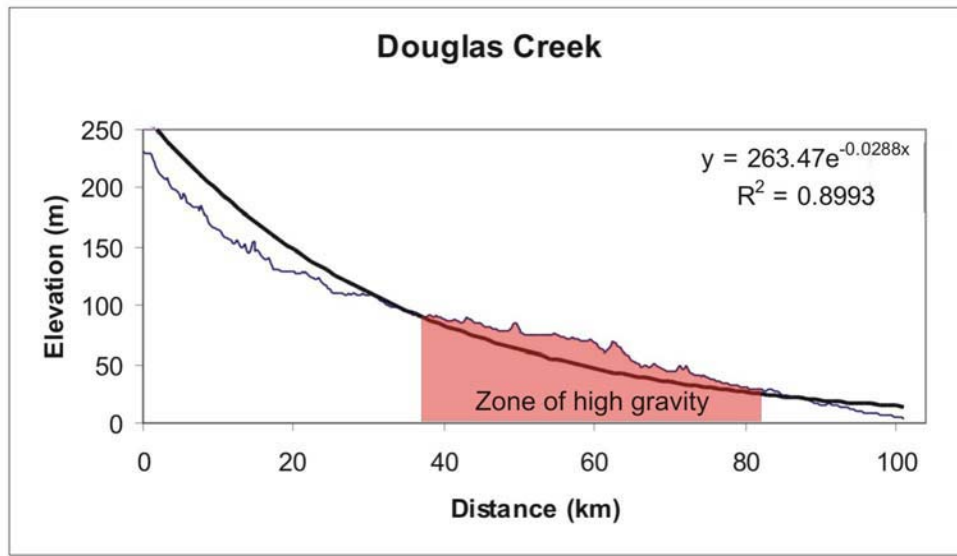
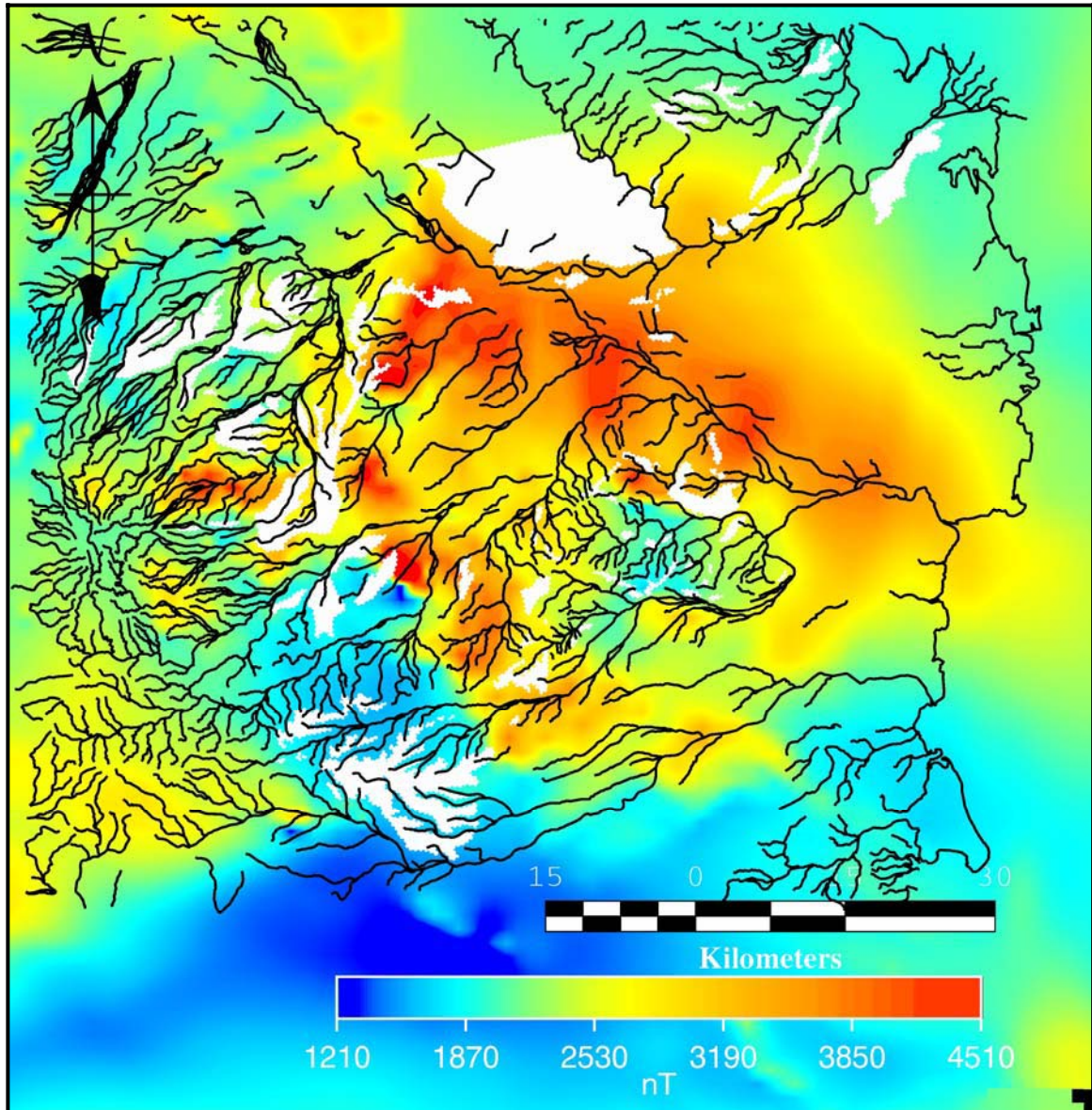
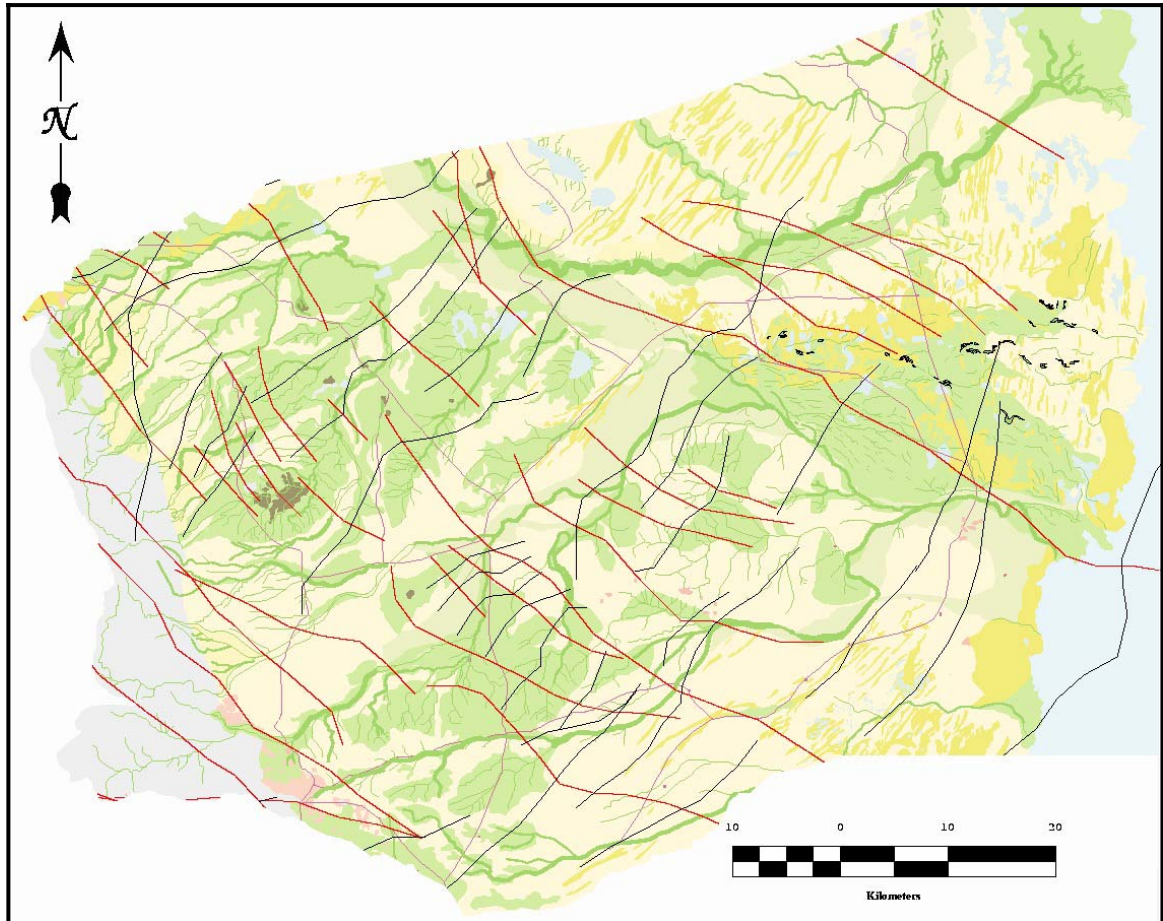


Figure 7.43: Stream profile of Douglas Creek showing the positive deviation in the medial section of the stream associated with the gravitational high in red.



**Figure 7.44: Comparison of Total Magnetic Intensity and the distribution of gypsum patterned ground surfaces showing the general correlation between areas of low magnetic intensity (blue-green) and gypsum patterned ground surfaces. Areas of high magnetic intensity are recorded in orange-red.**



**Figure 7.45: Comparison of interpreted magnetic lineaments and regolith-landform units showing many instances of correlation between basement structure and surface landforms. Red lines indicate northwest-southeast trending magnetic lineaments; black lines indicate northeast-southwest trending magnetic lineaments. For designated RLUs see accompanying Regolith-Landform map (Appendix C).**

## **7.4 REGOLITH SUMMARY**

Regolith-landform associations observed within the study area have shown that it is highly probable that neotectonic activity has influenced the landscape evolution of the Umbum Creek Catchment.

The surficial lags within the study area may be divided into four zones. These four zones correspond to the influences of different processes within each of the zones. These processes are alluvial fan deposition, colluvial processes, fluvial deposition and lacustrine reworking of fluvial sediment for each of the respective zones. The boundaries of each zone largely coincide with observed structural lineaments. Both the boundaries and lineaments are interpreted, but their association is considered indicative of a genetic link where neotectonic movement has triggered the relevant processes within each zone.

Movement along the major faults bounding the Davenport Ranges, the Mt. Margaret and Levi Faults, created the escarpment along the eastern range front as a result of major uplift. This movement caused the tilting of silcreted palaeochannel sediments along the base of the ranges, estimated to occur during the Pliocene-Pleistocene. This resulted in the formation of the escarpment, elevating the Mt. Margaret Surface to its present elevation, and deposition of alluvial fans radiating towards the east from the ranges.

Faults are interpreted between the base of the ranges and the Neales River from the presence of mound springs that form along these faults, where the faults act as conduits for water under pressure in the subterranean aquifer which can then break through to the surface. These faults can be identified on TMI images and there is a strong association between stream trends in the catchment and the location of basement structures. This implies that streams are structurally controlled. In some cases streams are observed to change direction. Where this occurs there is associated evidence that indicates an underlying fault. Where streams are developed on alluvial fans they generally show distributary planform consistent with reworking of alluvial fan surfaces. Towards the base of the alluvial fans, several streams divert within the horizontal extent of the alluvial fan implying that the stream diversion has occurred after the deposition of the alluvial fan, and was therefore formed by a later stage of neotectonic activity. This is supported by evidence from structurally controlled overbank sediments associated with interpreted faults and by the presence of younger, less eroded alluvial fans on the flanks of the Davenport Ranges that overlie older fan sediments. From inferred Pliocene silcrete that is tilted at Four Hills, a Pleistocene age is proposed for this phase of tectonic activity.

The silcretes at Four Hills also indicate a palaeo-environment different to that seen in the present day. Reed mould structures, conglomeratic texture, water worn surfaces and trace fossils indicate a much wetter environment during the Pliocene. These features also indicate that a large meandering river system dominated the southern half of the study area with its headwaters further west of the Davenport Ranges. This river system may have ceased to flow following the uplift of the Davenport Ranges that altered the topography of the landscape, and as climate fluctuated throughout the Pleistocene. A younger river system then formed on top of the older system depositing conglomerates that later became carbonate-cemented. This system was probably shorter than the previous system and would have had its headwaters within the Davenport Ranges. This system probably represents the ancestral Sunny Creek. Following the later phase of tectonic activity in the Pleistocene, the carbonate-cemented conglomerates were uplifted along with the silcretes of the Four Hills region. The stream that formed this system appears to have been redirected by the tectonism, causing flooding on the

interfluvium between Sunny and Douglas Creek and depositing alluvial sediment in this area as it developed into the modern Sunny Creek and Douglas Creek.

The topographic inversion evident at Four Hills implies rapid erosion rates probably as a combination of climate change and tectonic uplift. This is also evident on the Neales Fan where a large palaeochannel has been identified from ASTER TIR imagery. The trunk stream of this palaeochannel is truncated by the Lake Eyre Fault and is significantly elevated above the modern Umbum Overflow. This is interpreted as tectonic rearrangement of the main river channel. On the ground there is little of the channel left in-situ as a result of erosion and deflation of the main palaeochannel. Arcuate stone mounds have formed, possibly where cobbles and pebbles formed riffles in the original channel. Erosion and deflation have caused these coarser lags to armour the underlying sediment and they have become topographically inverted. Sands from the palaeochannels appear to have been blown out of the palaeochannel via deflation, forming surrounding sand dunes and sand sheets and leaving claypans behind. The stone armoured mounds are arranged in a distributary pattern across the Neales Fan and appear to diverge in accordance with underlying basement features, implying that the surface topography has been controlled by basement structure throughout the Pleistocene.

An association of coastal dunefields with modern deltas has been interpreted as the effects of deflation blowing away sediment from the delta/terminal splay complex to supply sand to the coastal dunefields. This same association is also observed at the terminus of each of the palaeo-distributaries where a coastal dunefield is located north of the inferred locations of palaeo-deltas. Additionally, the coastline at each of these locations is scalloped in the planform of a delta/TSC of similar size to those observed in the modern system.