Surficial Geology

Explanatory notes for the 1:100 000 scale environmental map of the Tomkinson Ranges, Western Musgrave Block, central Australia

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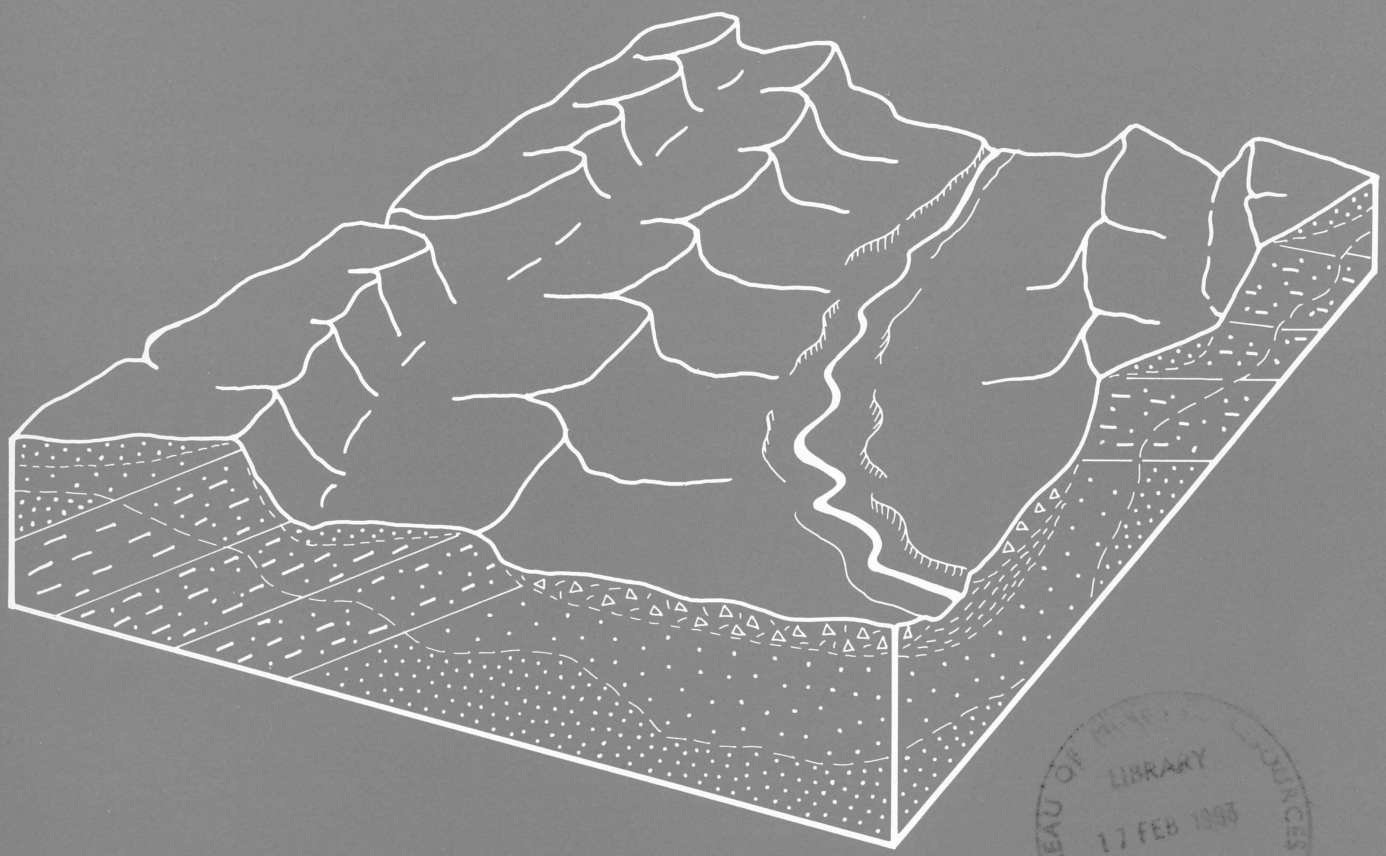

Record 1992/34
by Erwin H J Feeken
edited by A Y Glikson

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4

Based on contract environmental mapping conducted for the National Geoscience Mapping Accord Musgrave project

Record 1992/34
by Erwin H J Feeken
edited by A Y Glikson

Minerals and Land Use Program

DEPARTMENT OF PRIMARY INDUSTRIES AND ENERGY

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(formerly BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS)

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ISSN 0811–062X
ISBN 0 642 18002 4

SUMMARY

Detailed field mapping of Quaternary surface deposits and vegetation habitats has been conducted in the Tomkinson Ranges, western Musgrave Block, central Australia, to prepare a 1:100 000 environmental map. The mapping included interpretation of 1:20 000 colour aerial photography and remotely sensed imagery, including Thematic Mapper and Geoscan Mark-I. Close correlations are observed between surficial deposits/habitat types and the remotely sensed imagery. The mapping allows classification of morphological and surface units in terms of 16 types: playa plains, floodplain, floodplain with insitu gravel, alluvial plain, alluvial plain with insitu gravel, alluvial fan, ancient channel, sandplain, dunes, pediments, colluvial fans and scree, ferricrete, calcrete, silcrete, undifferentiated duricrust and undifferentiated bedrock. Vegetation habitats/associations are classified into 26 types. Grassland (perennial or annual) include 8 types. Shrublands (Chenopodiaceae, Melaleuca, desert shrubs and trees, Acacia-dominated mixed trees and shrubs and Eucalypts) include 9 types. Woodlands (Hakeas, Cypress, Acacias) include 7 types, and barren hill slopes two types. Important correlations are observed between vegetation, surface deposits and bedrock types. Due to general southward tilting of the terrain, a step-wise topographical decline and preferential orientation of drainage take place in this direction. Relics of deeply lateritized land surface occur in several areas, capping some of the ridges and forming fossil valleys, where lateritic nickel deposits are hosted. Dune patterns are controlled by prevailing wind directions and are markedly affected by ridge and valley patterns which control their dynamic movement. Observations of the flora and fauna in the area suggest serious environmental degradation due mainly to feral animals and over-hunting.

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ENCLOSURE: 1:100 000 SCALE MAP OF SURFACE DEPOSITS AND VEGETATION, TOMKINSON RANGES, WESTERN AUSTRALIA/ SOUTH AUSTRALIA

I. INTRODUCTION

1. Geographic position, habitation and climate

This report, accompanying the Tomkinson Ranges 1:100 000 scale environment map (enclosure), presents the results of field mapping of surface deposits and vegetation habitats (Figs. 1-3). A major aim of this survey is to establish the relationships between the land forms, surface deposits and vegetation in this environment. The Tomkinson Ranges straddle the Western Australia-South Australia border and the main mapping area centres on longitude 129°00'E (the border between W.A. and S.A.), and for the most part between latitudes 26°00' and 26°23'S. The area includes the bulk of the bedrock outcrops within the Bell Rock and Davies 1:100 000 Sheet areas, as well as a small part of the Bates 1:100 000 Sheet area. The area measures about 3250 square kilometres comprising a block about 80 km in longitude and 40 km in latitude.

The Tomkinson Ranges region includes three permanent Aboriginal settlements, including Wingellina (Irrunytju; average estimated population of 100), Pipalyatjara (formerly Mount Davies; average estimated population of 150) and Kalka (population of less than 30). Several outstations and bores, occasionally visited by Aboriginal people from the main communities, exist in the area. The region includes a good network of graded dry weather tracks, mostly suitable for conventional drive vehicles. Chief access roads are from Amata in the east and Giles weather station in the north (Gun Barrel Highway) and from Warburton in the west. Each of the communities mentioned above possesses a well maintained landing ground.

Median annual rainfall lies between 150 and 200 mm, with an average of 20 rainy days per year, principally during the summer months. The average daily range of summer temperatures is 21°C to 36°C and of winter temperatures 3°C to 18°C. Day time humidity ranges from about 25% in summer to about 35% in winter. Night time humidity in winter may reach 50%. Average annual moisture evaporation is about 3500 mm - among the highest on the continent. Excepting a few soaks or springs in some creek beds within the ranges, no permanent surface water exists in the area. The Aboriginal communities obtain their water from bores, some of which contain high concentrations of nitrate and iron.

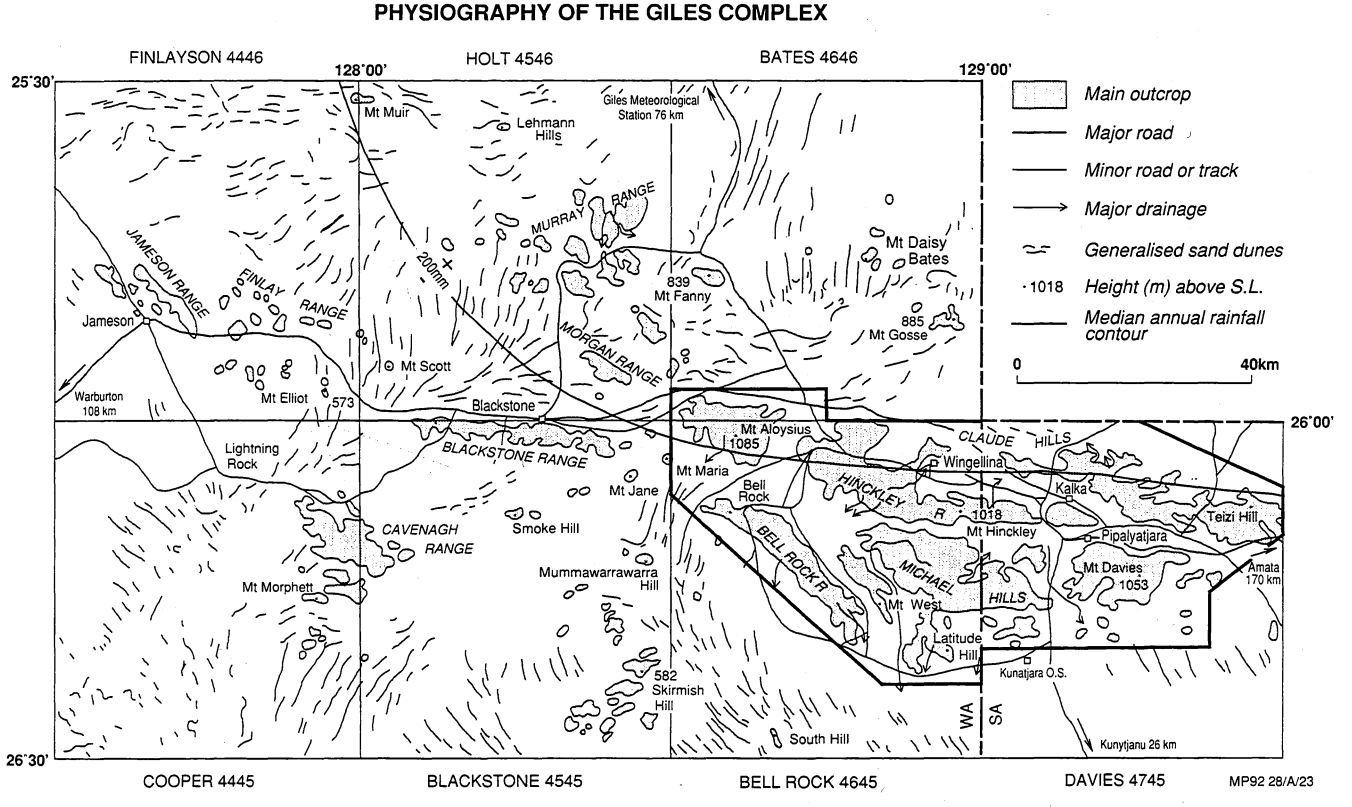


Fig. 1 - Location and principal morphological features of the Tomkinson Ranges, Western Australia and South Australia

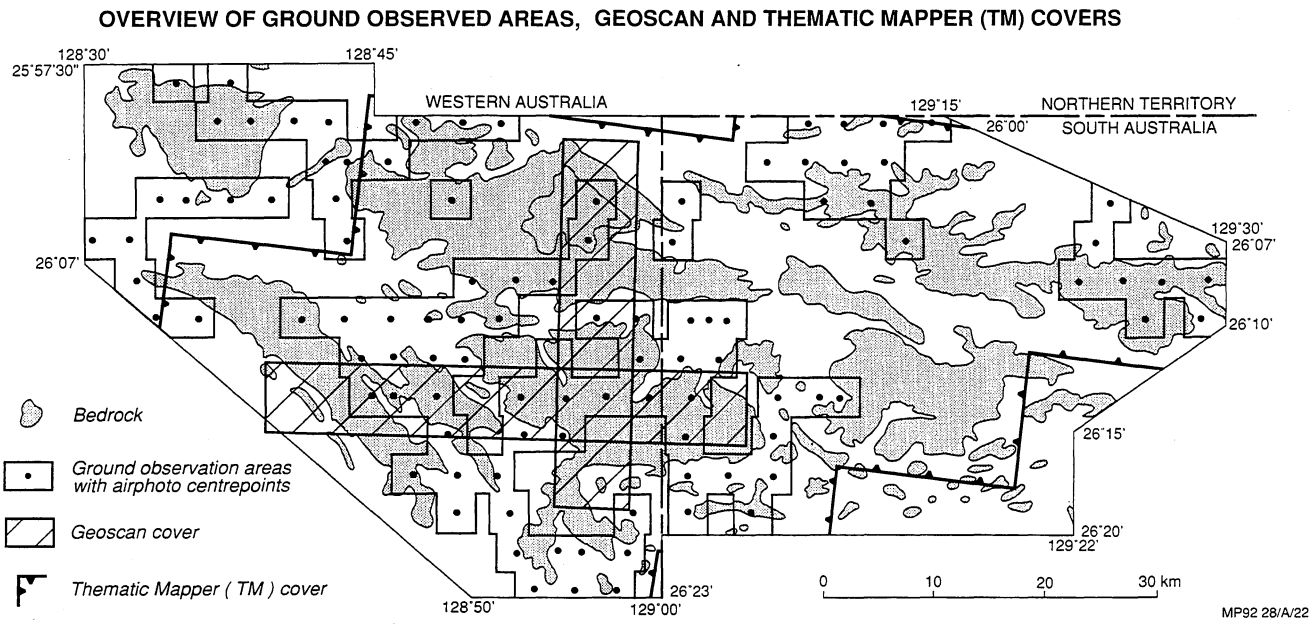


Fig. 2 - Coverage of ground observations and remotely sensed data, including Thematic Mapper and Geoscan I data.

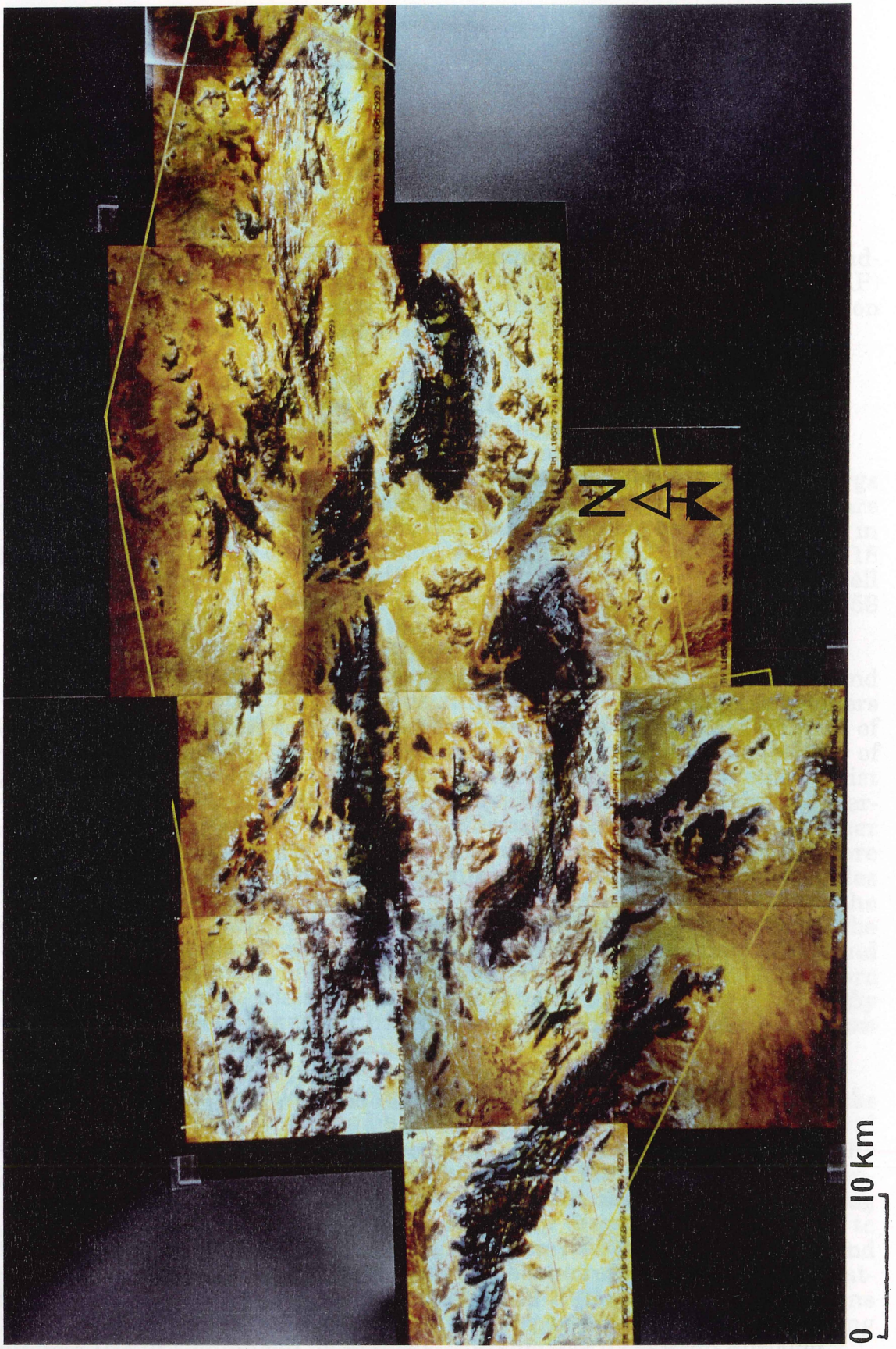


Fig. 3 - Thematic mapper imagery mosaic of the Tomkinson Ranges

2. Early geographic investigations

In 1873 Ernest Giles and Williams C. Gosse, in separate exploratory parties, traversed the region south of the Hinckley Range. In 1874 John Forrest traversed the country on his journey from Perth to the Overland Telegraph line. In 1895/96 S.G. Hubbe travelled south of the Hinckley Range in search of a stock route to the west. In 1901 R.T. Maurice, exploring for the South Australian Department of Mines a route from Fowlers Bay to the Rawlinson Range, passed through the Tomkinson Ranges. In 1903, L.A. Wells was despatched by the same Department on a prospecting journey to the northwest of South Australia, which included the Tomkinson Ranges. In 1907 Frank Hann carried out investigations in the southern Tomkinson Ranges.

3. Previous environmental studies

Daniels (1974), in his introduction to his Bulletin on the geology of the Blackstone Region, has provided substantial information on the flora and fauna of the Tomkinson Ranges. Laut (1977) reported on the Tomkinson Ranges in his report on Environments of South Australia for the Division of Land Use Research of the CSIRO. Laws (Geological Survey of Western Australia) provided further information in a hydrogeological report for Aboriginal communities in the Blackstone region. The Southwestern Mining Company (unpublished reports, Mines Department, Western Australia) added some environmental information based on regional mapping and prospecting for lateritic nickel near Wingellina.

4. Methods of investigation

Field observations of surface deposits and vegetation were conducted during the winters of 1987, 1988 and 1990. The area is covered by 1:20 000 colour aerial photography. The ground observations and aerial photography were supplemented by remotely sensed imagery, using Geoscan mark-I imagery in bands 9:4:1, 6/8:6/9:5/4, 6/8:6/9:11/10, and 10:11:12 and Thematic Mapper (TM) imagery in the 7:4:1 bands and other bands studied in collaboration with the BMR remote sensing group (C. Simpson, pers. comm.). The coverage of remote sensed data is indicated in Fig. 2 and a TM imagery in RGB 7:4:1 shown in Fig. 3. Correlations between remotely sensed data, surface deposits and vegetation habitats are presented in Table 1. Surface deposits have been systematically sampled, including 120 soil and duricrust samples. A similar number of plant specimens has been collected and photographed for identification purposes. Data compilations were conducted on aerial photo scale overlays and were subsequently reduced to 1:100 000 map

scale (see enclosed map). Unit symbolization for surface deposits and landforms has been adopted from the BMR Regolith Terrain Mapping (RTMAP) database. A provisional numbering system has been applied in conjunction with vegetation classification and mapping.

II. LANDFORMS

The Tomkinson Ranges constitute a series of ridges and inselbergs occupying about 40 percent of the map area. In most parts the outcrops are strongly dissected, reaching elevations around 1000 metre above sea level in the Hinckley Range (1014 m), Mount Davies (1053 m), Ewarara hills (1018 m), Mount Kalka (1009 m), Teizi hills (871 m), Mount Aloysius (982 m), Bell Rock Range (874 m), Michael Hills (838 m) and the Mount West massif (858 m). Duricrusts may form low rises above valley floors and plains.

Ridges consisting of gabbro or pyroxenite display jagged skylines and may contain prominent rock piles consisting of slumped subangular boulders several metres across with little soil or vegetation in-between. Examples of such boulder piles are common in the Bell Rock Range, consisting largely of gabbro, and Mount Kalka and Ewarara intrusion, where the slumps consist mainly of pyroxenite. It is likely that this feature results where the weathering rate of fresh resistant lithologies is slower than that of removal of finer grained inter-boulder material. Where weathering of the gabbro is more advanced the rocks display onion-like exfoliation features. No boulder piles are developed in basic granulites which result from recrystallization of the gabbro, i.e. in the western Hinckley Range and in the Wingellina Hills. The basic granulites are, as a rule, less resistant to erosion than the gabbro, and form more subdued morphological features. Basic dykes which cut gabbro outcrops are often less resistant and may thus form local depressions. By contrast, where basic dykes cut basic granulites they stand out as narrow ridges, as is common in the Wingellina Hills.

Morphological units consisting of felsic metamorphic and igneous rocks display more rounded or turtle back-like morphology, including low oval domes of granite gneiss in the Champ-de-Mars depression between the Hinckley Range and Michael Hills. These features result from joint-controlled deep weathering of the granites. Felsic granulite outcrops, including quartz-rich metasedimentary units, commonly display well preserved to palimpsest sedimentary bedding, with good examples in Mount Aloysius and the Ewarara-Teizi range. Basic dyke swarms which intrude felsic rock outcrops may stand out in places as narrow knife-like ridges. Granitic veins which intrude basic granulite are commonly more resistant to weathering than the latter, standing out as light coloured bouldery ridges.

The intermontane valleys and intersecting plains in the Tomkinson Ranges show a general decline in elevation toward the southwest. This fall is expressed by a southward stepping decline from a level of about 700 metres above sea level in the northeast, i.e. north of the Ewarara and Teizi Hills ridges, to about 550 metres in the south and southwest, i.e. south of Michael Hills - each step involving a fall of about 50 metres.

Dune fields within the mapped area are of limited extent. Individual dunes average a height of 10 metres. Several types can be identified: *network dunes* occur in the valley between Mount Aloysius and the western part of the Hinckley Range. They gradually change to *broadcrested linear dunes*, some chain-forming, in the plains southwest of Mount Aloysius and northwest of Bell Rock Range, where they trend south and finally southeast. The latter trend conforms to the general trend seen south of the Tomkinson-Mann ranges. Another set of dunes within the map area lies north of a line from Wingellina Hills to Claude Hills and Teizi Hill. The form and occurrence of these dunes are irregular and they are not closely spaced enough to constitute a network. South of Mount Davies, at the southern margin of the map area, are the northern limits of narrow, *single-crested dunes*, which stretch out southeasterly, often measuring several kilometres in length. A fifth type of dune occurs in groups or as isolated dunes which mostly fringe the northern margins of the outcrops, for example on the westernmost end of Hinckley Range, Wandu Hill and north and south of Mount Davies. These dunes coincide with isolated inselberg outcrops and form in conjunction with a wind shadow effect.

Drainage patterns, well defined within ridge areas, become disoriented and rapidly lost once they enter the plains. The catchment areas of southward-directed drainage are larger than of northward-directed drainage areas, a pattern clearly related to the general southward decline in plain elevation. Consequently, northward directed streams are short, while the longest southward running stream beds - Carruthers Creek and Pidingadinga Creek - are a little over 25 kilometres long and terminate in large floodplains. Intense occasional rainfalls resulted in high level debris along the creeks. The level of flood waters in creeks is indicated by high level vegetation debris which can be caught above creek beds (Fig. 13).

III. DISTRIBUTION OF SURFACE DEPOSITS

Major elevated morphological units in the Tomkinson Ranges consist of basic and to a lesser extent ultrabasic rock, including the Hinckley Range, Bell Rock Range, Mount Kalka, Mount Davies, Michael Hills and the southern part of the Mount West massif. Other elevated units consist of felsic granulites and granitic gneiss, including Mount Aloysius, Mt West, Ewarara hills and numerous scattered outcrops, charted by previous geological maps, including the Scott and Cooper 1:250 000 Sheets (Daniels, 1974) and the Davies 1: 63 360 Sheet (Thomson, 1964). In the following the distribution of some of the surface deposits associated with the ranges is outlined:

Horizons of **calcrete** are found predominantly to the north and south of the Hinckley Range, south of Bell Rock Range, south of Latitude Hill and between the eastern part of Michael Hills and Mount Davies. Calcrete is generally absent around the Mount Aloysius massif. Only very minor outcrops occur to the east of Mount Kalka. Thus, the distribution of calcrete largely reflects an association with outcrops of basic and ultrabasic units of the Giles Complex.

Other types of **duricrust** are relatively rare, although some appreciable fericrete outcrops occur to the north, east and west of Wingellina and along the northern base of Mount Kalka. Silcrete crops out in an area four kilometres east of Wingellina but the remaining silcrete occurs in the southern part of the region as thin interbeds in calcrete.

Colluvial deposits are dominant along the southeastern margin of the Hinckley Range and around the entire base comprising the Michael Hills, including the southern extension made up of Latitude Hill and surrounding outcrops. Elsewhere, notably at the base of the Mount Davies block and large parts of Ewarara-Teizi range, occurrences of colluvium are more isolated. Pediments are observed mainly in association with colluvium and to a lesser extent are interspersed with alluvial fans, jutting out into the plains. As with colluvium, pediments are not common around Mount Davies and Ewarara-Teizi range.

Plains and valleys are covered by mainly lithic materials, grading from gravels in parts of the flood plains and alluvial plains south of Michael Hills and coarse sands in alluvial fans to clayey red to red-brown soils in the centre of alluvial plains. Sandplains, including dunes, are widespread in the northwest, north and northeast of the map area, as well as along the southern margin. The materials of the plains and dunes include coarse to medium-grained red-brown sands, which tend to become quartz-rich in the west, and coarse to medium-grained brown lithic sands in the east. Some dunes, particularly those near the northeastern limit of the Hinckley Range, contain interbeds of fine magnetite grains and flakes (Fig. 8).

IV. VEGETATION

With some irregularities plant growth in the Tomkinson Ranges can be correlated with surface deposits. The floral habitat is dominated by mulga, spinifex and annual and perennial grasses. Mulga can occur on plains, outcrops or among dunes, with or without association with other growth. A reciprocal relationship is seen between mulga and spinifex, and mulga decreases or is totally absent where heavy spinifex growth occurs. Mulga has died back extensively in the near past, a decline not obviously correlated with burning or with the rabbit population. An example is the region south of the Michael Hills from Purnawarra bore eastward, where over 70% of the mulga has died from lack of moisture and/or disease. Very little regeneration of the mulga is evident.

Spinifex tussocks dominate on basic and ultrabasic rock outcrops, but are quite common on some felsic terrains, for example Mount West, and in plains. Bunch grasses dominate on the plains and are also important on felsic granulite and granitic outcrops. Corkwood trees (of the Hakea family, Fig. 12) are locally prominent and often occupy the margins of outcrops, including pediments and alluvial fans. Other prominent plant growth include two species of Grevillea in dune fields on or near the crest of dunes, often the very dense interdunal desert heath (Thryptomene), and species of native fuchsia and cassias.

V. SURFACE DEPOSITS AND VEGETATION MAP UNITS

Sixteen types of surface deposit/landform units were identified in the Tomkinson Ranges:

Ap - Playa plain (claypan)
Aa1 - Alluvial plain
Aa2 - Alluvial plain with in-situ gravel
Aa3 - Flood plain
Aa4 - Flood plain with in-situ gravel
Af - Alluvial fan
Ai - Ancient channel
Op - Sand plain
Od - Dunes
Ce - Pediment
Cf - Colluvial fan, scree
Xe1 - Ferricrete
Xe2 - Calcrete
Xe3 - Silcrete
Xe4 - Duricrust (undifferentiated)
B - Bedrock (undifferentiated)

Mappable vegetation types are divided into 11 plant communities, and these are subdivided into 26 plant distribution units. These units have been numbered in conjunction with the 1:100 000 scale map, as follows:

A. Grasslands

Perennial or annual grassland

1. Treeless or near-treeless bunch grassland, occasional shrubs, rare herbs.
2. Bunch grassland with scattered mulga (A. aneura) and/or corkwood (Hakea), occasional bloodwoods (E. terminalis), rare weeping pittosporum (P. phylliraeoides), shrubs, herbs.
3. Bunch grassland with groves of undifferentiated herbs and low shrubs with or without isolated trees.

Hummock grassland

4. Mainly hard spinifex (Triodia basedowii), porcupine grass (T. irritans) with occasional areas of shrubs; scattered mallee and/or mulga; native fig (Ficus platypoda); rare pittosporum.
5. Dominating hard spinifex, some porcupine grass, few shrubs, rare native fig.
6. Dominating soft spinifex (Triodia pungens)
7. Dominating giant grey spinifex (Triodia longiceps).
8. Undifferentiated spinifex (Triodia).

B. Shrublands

Chenopodiaceae

9. Old man saltbush (Atriplex numularia)

Melaluca

10. Teatree (Melaleuca glomerata)

Desert shrubs and trees

11. Exclusively desert heath (Thryptomene)
12. Dominating desert heath, grevilleas, cassias, mallee, acacias; isolated desert kurrajongs (Brachychiton gregorii), desert oaks (Allocasuarina decaisneana), mulga, soft spinifex.

Acacia-dominated mixed trees and shrubs

13. Dense mulga, with or without understorey.
14. Open to medium woodland dominated by mulga, with mixed understorey including acacia shrubs, native fuchsia, cassia, spinifex.
15. Dominating shrubs including acacia, native fuchsia, cassia.

Eucalypts

16. Giant mallee (E. oleosa), other rare mallee species.
17. Blue mallee (E. gamophylla), other rare hillslope species.

C. Woodlands

18. River red gums (E. camaldulensis).
19. Bloodwood trees (E. terminalis).

Hakeas

20. Intermixed corkwood (Fig. 12) and bloodwood trees.
21. Long-leafed and fork-leafed corkwood trees (Hakea subera and Hakea eyreana, respectively)

Cypress

22. White cypress pine (Callitris glaucophylla)

Acacias

23. Gidgee (A. pruinocarpa or cambagei).
24. Gidgee; mulga and/or corkwoods

D. Barren hill slopes

25. Few trees, mainly mulga; rare weeping pittosporum, native fig; shrubs, sparse annual grasses and forbs.
26. Devoid of trees, few shrubs, sparse grasses.

E. Surface deposits and vegetation units

Ap - PLAYAS are generally up to a few hundred metres across, the largest playa of 5x1 km ocurring in the Champ de Mars valley between Hinckley Range and Michael Hills. Sparse gravel litter occurs over some clay pans.

The claypans are the ultimate destination of high floods, spilling over from occasionally overfilled floodplains. Most have deep honeycomb crack patterns when dry and are bare of vegetation. The numerous small claypans in the overflow areas of some streams, notably near the banks of Carruthers Creek, show minor cracking (Figs 4, 5). The pans are dish shaped and rise from their centres to the rims by about 50 centimetres and are also devoid of vegetation. Inter-pan flats are covered by old man saltbush (Atriplex nummularia).

Aa1 - ALLUVIAL PLAINS are composed of sand, silt and clay, and red loam in places. Alluvial plain levels are intermediate between higher alluvial fans and lower flood plains. South and north of the Bell Rock Range (Fig. 6) and around Wingellina alluvial deposits have filled the ancient drainage, covering calcrete. Near the southeastern corner of the study area, calcrete areas have been submerged by alluvial deposits; faint traces of old drainage patterns can still be detected nearby.

Aa2 - ALLUVIAL PLAINS WITH IN SITU GRAVEL, in addition to sand, silt and clay, carry exposed gravels. They have been mapped out separately because of their prominence in one locality, i.e. on the east side of the floodplain southeast of Sphinx Hill. Other localities have only sporadic patches of such gravels.

The vegetation cover of alluvial plains is similar to that of floodplains, namely grassy and treeless in places, medium to dense mulga mainly on red loams, with occasional thickets of shrubs, e.g. native fuchsia, cassia and acacia. Alluvial plains attract more corkwoods and more spinifex in comparison to floodplains. Small stands of bloodwoods appear in sheltered positions and river gums occur in and along stream beds.

Aa3 - FLOODPLAINS contain fine sand, silt and clay. Some plains, particularly south of Anumarrapirti (south of Bell Rock Range) also contains magnetic flakes. Extensive floodplains occur south of some ranges, namely at the eastern part of Champ-de-Mars valley (south of the eastern Hinckley Range) and to the south of Bell Rock Range. Only minor floodplains exist within northerly flowing drainage.

Aa4 - FLOODPLAINS WITH IN SITU GRAVEL occur south of Michael Hills and southeast of Sphinx Hill.

Floodplains of Aa3 and Aa4 type are often grassy and treeless. Some floodplains carry scattered to medium density mulga and, in places, scattered corkwoods with or without an understorey of shrubs, such as native fuchsia and cassia, as well as spinifex. Mulga, often dense, and various other acacias in groves, are common in the red soil areas of floodplains. Bloodwood trees and river red gums are occasionally seen in sheltered areas.

Af - ALLUVIAL FANS. Numerous small, unconnected alluvial fans occur at the mouths of northern flowing streams, consisting of coarse sand to silt. Due to the general rise in plain elevation northward, the extent of these fans is limited, as is the development of floodplains. Soutward-directed alluvial fans are more extensive, allowing the formation of some aprons. Examples can be seen on the southern margin of Teizi Hills and Hinckley Range.

Alluvial fans are the main areas for corkwood trees of two species - the longleafed and the forkleafed. They also accommodate some of the rare 'giant grey spinifex' (Triodia longiceps). Alluvial fans are also home to mulga, bloodwoods and various shrubs.

Ai - ANCIENT CHANNEL. The only ancient channel observed is that of the former bed of Carruthers Creek west of Sphinx Hill, consisting of coarse sand to clay. As the channel was raised by alluvial deposits from the Mount West massif and Michael Hills, southeastward-oriented sheet floods resulted in convergence of floodplains in this direction. The mapped ancient channel continues south to the edge of the mapped area.

Vegetation in the ancient channel is sparse, consisting of scattered mulga and corkwoods, as in the surrounding alluvial plain. The channel is, however, marked by occasional clumps of low shrubs.

Op - SANDPLAINS, including fields of longitudinal and other dunes cover large areas. The main body of dunes stretches from the 3-State Surveyors General Corner eastward and to the north of the Ewarara-Teizi range line. Another stretch of dunes lies between the western Hinckley Range, Mount Aloysius and Bell Rock Range. The remaining areas are mainly sand plains, some with broadly circular and disoriented sand mounts adjacent to or superposed on rock outcrops. The latter are classified separately as 'Od'.

Sandplains and dunes consist of coarse to medium grained red-brown sand. Some areas contain fine magnetite sand. Examples of such occurrences are around the north and southeast of Bell Rock Range.

Sandplains display a wide variety of vegetation. Where no dunes occur, scattered to open woods are dominated usually by mulga. Some corkwood trees and bloodwoods, and occasionally weeping pittosporum, may also be present. Giant mallee (E. oleosa) and occasionally other mallee may occur in groves. Understorey usually includes acacias, specific native fuchsia varieties, cassia and sometimes indigofera. Soft spinifex (Triodia pungens) commonly spreads among the mulga and mallee. In longitudinal dunes growth is more scattered and desert heath (Thryptomene) and grevilleas are more prominent - the desert heath often stands in dense thickets in interdunal plains while grevilleas including up to three species (desert grevillea, rattlepod grevillea, honey grevillea) range from dune slopes to crests. In spinifex-free depressions, grasses including mainly wind grasses (kerosene) provide sparse ground cover.

Desert kurrajongs and desert oaks are rare in this region. Desert kurrajongs are prominent solitary trees, regularly but widely spaced out among the dunes between Mount Aloysius and Bell rock Range, in the Claude Hills area and northwest of Teizi Hill.

Desert oaks have been seen in isolated groups of up to 10-12 trees in small flats among the dunes northeast of Teizi Hill. The largest group of desert oaks was found north of Claude Hills, just outside the map area. It appears that in this region the southern limit of desert kurrajongs and desert oaks lies along a line from northern Bell Rock Range to north of Wingellina Hills and north Hinckley Range to north of the Ewarara-Teizi range.

Od - DUNES consist of coarse to fine grained red-brown lithic sands, and generally become more quartz-rich westward. They are interbedded in places by thin layers of magnetitic sand (see Appendix A, Fig. 8). The dunes are of semi-circular to irregular outline, often with a concave centre. Distribution is irregular, but the dunes are attached to small bedrock outcrops or stand free in the plains. No directional trend is observed. Some of these dunes are relatively free of vegetation and have penetrated and covered older growth. Dune movement is controlled by both prevailing wind directions, wind deflections related to adjacent ranges and the morphology of intermontane valleys. For example, four kilometres west-northwest from Mount West dunes are shifting from north to south with apparent prevailing westerly winds. By contrast, south of the North Hinckley range dunes are observed to shift westward.

Sparse but varied vegetation, ranging from grasses to mulga, occurs usually around the outer margins of the dunes, with minor and often dead vegetation around the inner rims. Partially buried mulga serves to indicate the current mobility of the sand.

Ce - PEDIMENTS rock surfaces are mostly smooth and are covered by very fine to fine grained sand, often including veneers of pebbles. The pediments abutt against the margins of outcrops. Their areas are not usually large; they are rarely wider than 500 metres and usually share their spaces along outcrop margins with alluvial fans where stream beds enter the plains, or with colluvial deposits which occupy embayments. Only in highly eroded areas, e.g. south of Mount Davies, are the pediments relatively extensive as compared with adjacent bedrock terrains.

Vegetation on pediments is similar to that of alluvial plains, i.e. usually scattered mulga and/or corkwood and occasional bloodwoods and shrubs. Corkwoods are more common than in the open plains. Some spinifex may extend onto pediments from adjacent outcrops of basic and ultrabasic rock.

Cf - COLLUVIUM consists of predominantly colluvial and eluvial valley floor deposits. Some of the main ridges, including the Michael Hills, the Latitude Hill area, the southern portion of the Hinckley Range and Mount Aloysius, include steeply flanked flat floor valleys dominated by colluvium. The deposits contain fine to coarse grained sand, containing gravel and occasional boulders in places. Magnetite flakes and magnetite float are common in colluvium-dominated areas along the northern part of Bell Rock Range and south of Wingellina.

Colluvium supports a variety of vegetation, the following plants being more dominant: Corkwoods are more common than on other surficial deposits, excepting perhaps alluvial fans. Scattered to dense mulga, river red gums along and/or in stream beds and open stands of bloodwoods make up the rest of the woodland flora. Acacias, native fuchsia, cassia, applebush, plumbush and some lesser species in varying proportions are the main understorey shrubs. Three species of spinifex occur: Hard spinifex, extending out from basic and ultrabasic rock outcrops; soft spinifex as the main plains species, and giant grey spinifex, which is rare and restricted to a few colluvial and alluvial fan deposits. Spinifex free areas may carry grasses and sedges in and along some stream beds.

Xe1 - FERRICRETE. The setlement of Wingellina lies in the centre of numerous shallow ferricrete outcrops and gravel. From north round to east, minor ferricrete outcrops within large areas of ferricrete float alternate with basic and ultrabasic rock outcrops. South and west of Wingellina ferricrete boulders and gravel overlies calcrete. Concentrations of ferricrete occur along a six kilometre strip associated with the northern base of Mount Kalka, and include ferricrete gravel overlying bedrock. Another concentration of ferricrete occurs about two kilometres west of Teizi Hill where it is in contact with weathered felsic igneous rocks as well as basic rocks. Other concentrations of ferricrete occur in Claude Hills and the Mount Davies range. Only isolated patches of ironstone gravel occur south of the main ranges. Small outcrops of ferricrete and ferruginous gravel occur in valleys and plains, for example west of Latitude Hill.

The vegeation associated with ferricrete consists of occasionally dense mulga, giant mallee groves and a variety of other shrubs, spinifex and grasses. The acacia shrub 'dead finish' (A. tetragonophylla) is strongly represented.

Xe2 - CALCRETE is a prominent surficial deposit in the Tomkinson Ranges. The calcrete includes solid outcrops and weathered calcareous cobbles, pebbles and nodules, often covered by calcareous sands. In places minor fericrete or silcrete may be included. One of the more extensive areas is situated in the plains between the southwestern margin of the Hinckley Range and the Bell Rock Range. The area includes a prominent drain active following heavy rains, and appears to be continuous beneath alluvium with the Carruthers Creek area east of Mount West and with small calcrete occurrences in the Champ de Mars valley. Calcrete occurs also in the plain near Wingellina, where it is mostly covered by alluvium. A large mass of calcrete is centred south of Wandu Hill along Pidingadinga Creek (Fig. 11). The west bank of a tributary of this creek exposes the thickest section of calcrete observed in the area, measuring three metres from the stream bed to the plain surface. Calcrete in this area includes narrow interbeds of silcrete. Large tracts of calcrete occur about 4-5 km southwest of the entire length of the Bell Rock Range. Much of the calcrete contain drainage patterns submerged by alluvial sands. Dissected calcrete outcrops covered by thin veneers of alluvium and calcrete nodules also occur south of Latitude Hill.

Vegetation in areas underlain by calcrete is similar to that above ferricrete. Giant mallee may be prominent and may alternate with mulga. Shrubs such as acacia, including 'dead finish', and native fuchsia are common along with spinifex.

Xe3 - SILCRETE appears as boulders, pebbles and gravel and is exposed as minor interbeds along some stream banks. It consists of amorphous quartz, locally chalcedony and is in places recrystallized. An outcrop of silcrete about 500 metre across crops out about four kilometres east of Wingellina and is mined for chrysoprase. Similar though smaller occurrences are four kilometres southeast of Kalka and north of Purnawarra bore. Silcrete is commonly associated with calcrete. The vegetation cover over silcrete is similar to that on ferricrete and calcrete.

Xe4 - DURICRUST. Areas designated as duricrust occur where the nature of alluvium-covered crust is unclear, although in the majority of instances calcrete can be assumed. Examples are areas north of Bell Rock and near the westernmost extremity of the Hinckley Range. The vegetation cover is the same as over calcrete and ferricrete.

B - BEDROCK constitutes an undivided unit, although references are made in the text below regarding the relationships between surface deposits, vegetation and composition of the bedrock, as follows:

Vegetation occurring on bedrock regardless of composition includes open to dense mulga and gidgees (Acacia pruinocarpa or Acacia cambagei) which grow on ridge slopes. Mulga appears to be denser on lower and steeper slopes, gidgees grow in groups and are rather uncommon. Tea trees tend to grow in upper rocky creek beds above the level of river red gums and bloodwood trees. Native figs grow in rocky crevasses and other sun-sheltered areas. Weeping pittosporum and desert poplars sometimes occur on ridge tops and slopes.

Vegetation associated with felsic igneous and metamorphic rocks include white cyprus pine (Callitris glaucophylla), which grows preferentially below rocky benches away from the mid-day sun and in upper rocky stream beds. Pines are particularly common on exfoliated tors of granite gneiss. Pines are less commonly found over basic rock types and in other situations.

Vegetation associated with basic and ultrabasic rocks is dominated by dense hard spinifex, and often includes blue mallee, which forms bushes spreading openly over entire ridge slopes.

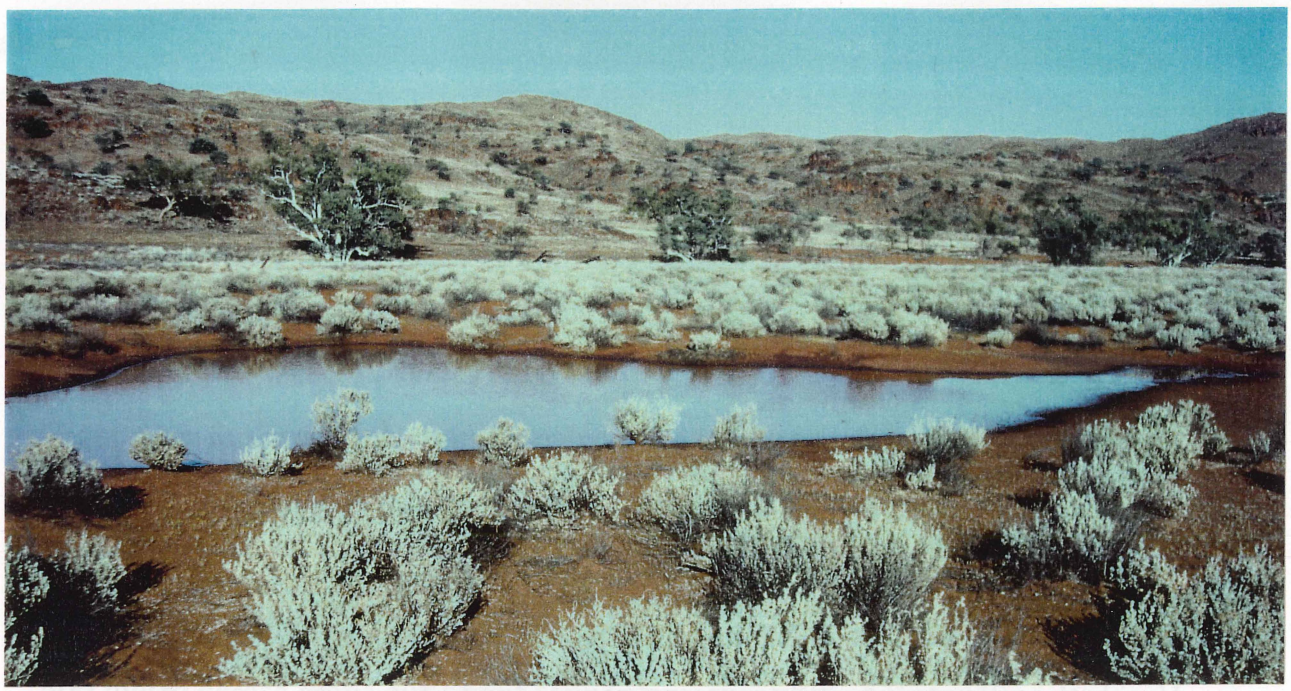


Fig. 4 - Claypans in overflow flats of Carruthers Creek; the creek is delineated by river red gums; the flats are vegetated by old man saltbush.

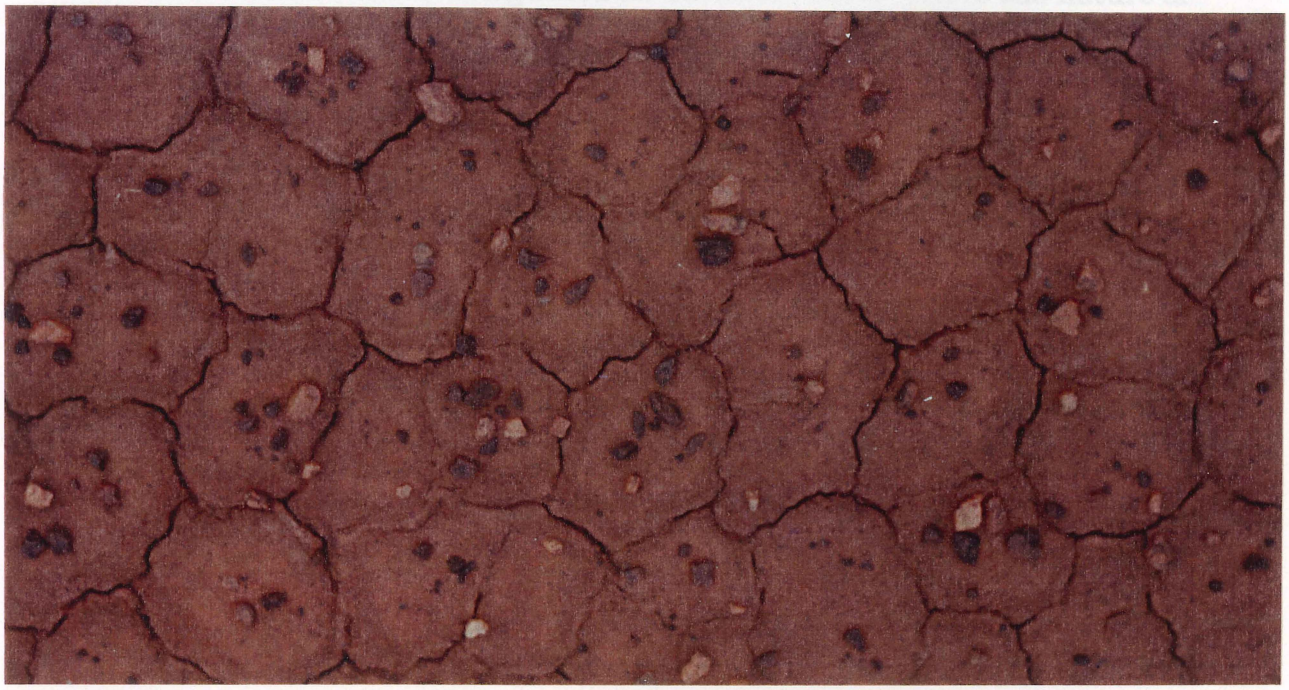


Fig. 5 - Polygonal mud cracks in small claypans associated with Carruthers Creek; note the gravel trapped in the clay pan.

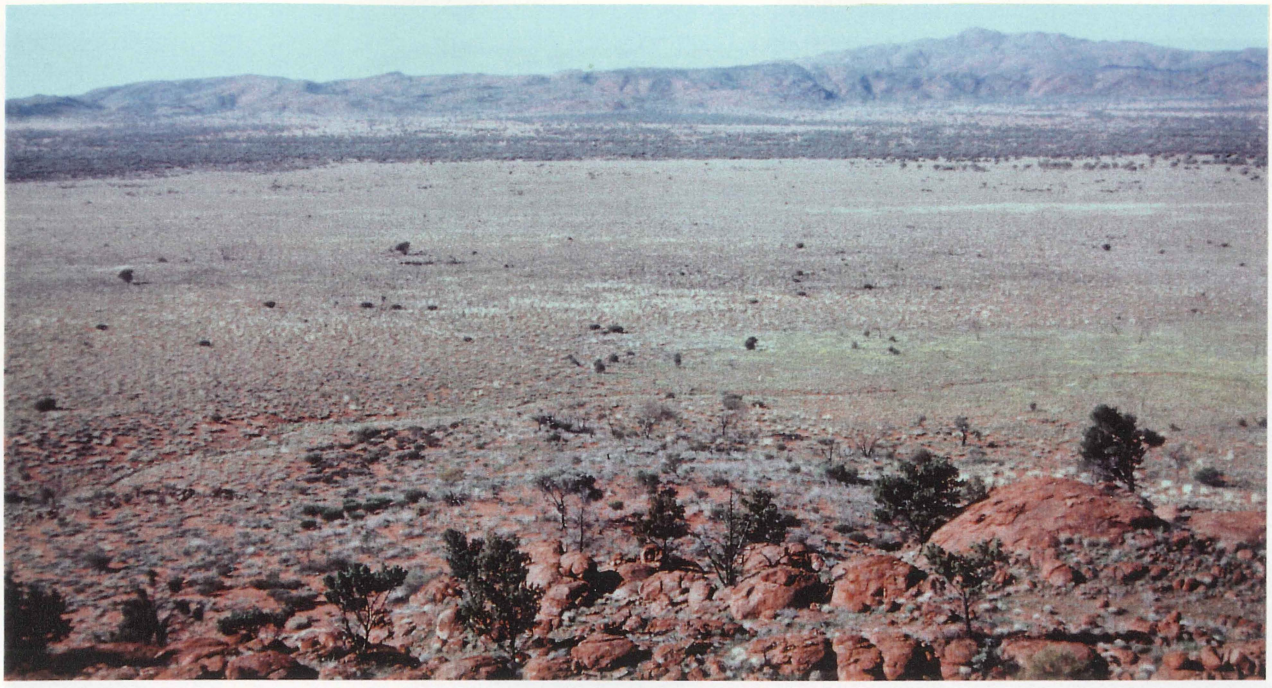


Fig. 6 - A view of Mount Aloysius from the southwest; note the grassy sandplain in the foreground and dense mulga in the distance.

Fig. 7 - A view from the margin of Ewarara range south across Ewarara Creek toward Mount Kalka (Dulgunja Hill). Typical spinifex-covered ultrabasic rocks in the foreground; river gums along Ewarara creek; grassy alluvial plain between the creek and Mount Kalka; note the rock slumps at Mount Kalka, consisting of resistant pyroxenite (left flank of ridge).

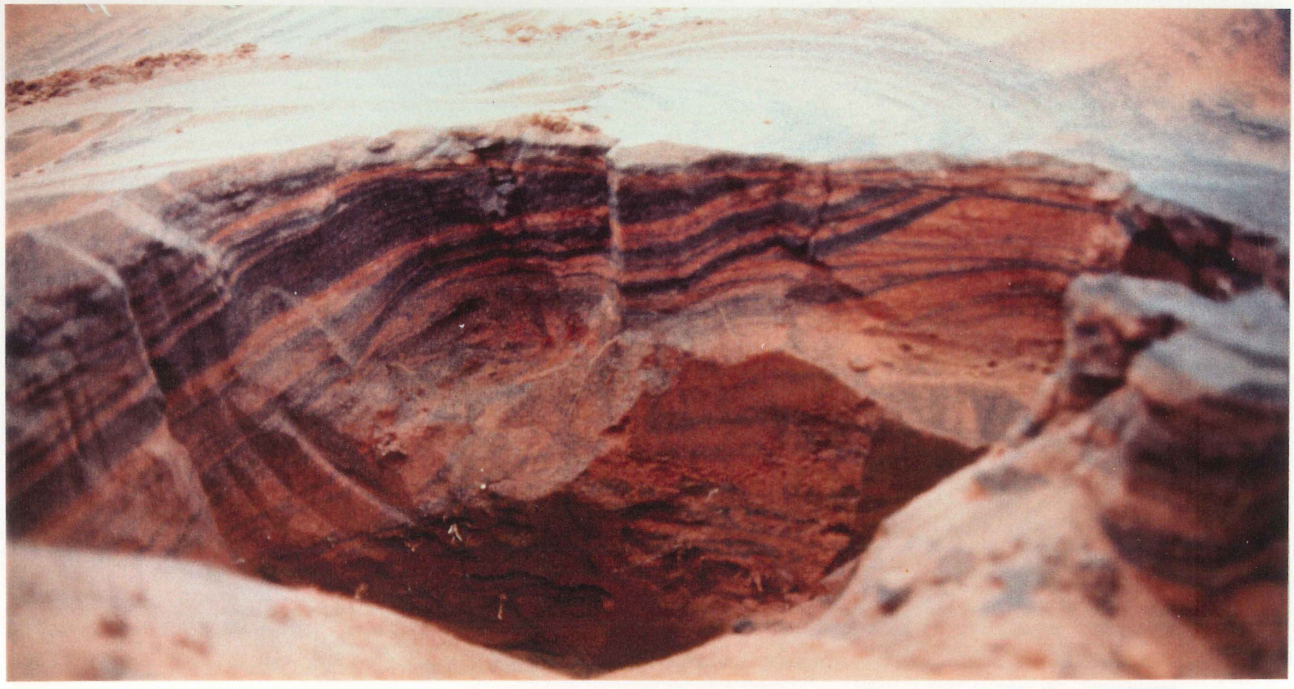


Fig. 8 - Magnetite-rich sand interbeds in a cross-bedded dune northwest of Mount West.

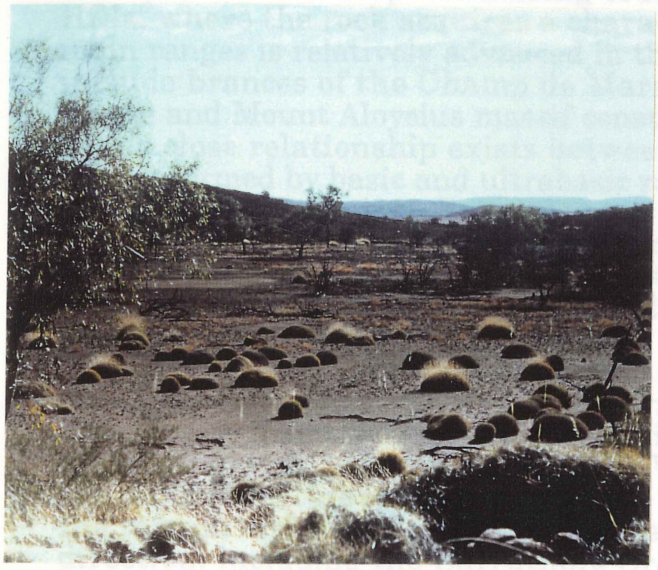
Fig. 9 - A mobile vegetation-free dune near the eastern margin of the North Hinckley Range.

Fig. 10 - Ferricrete duricrust exposed in a "breakaway" scarp about 3 km east of Wingellina close to an abandoned chrysoprase mine.

Fig. 11 - A thick calcrete profile exposed on the bank of a western tributary of Pidingadinga Creek, south of Wandu Hill. The calcrete includes minor silcrete interbands.

12

13



14

15

Fig. 12 - Corkwood trees (centre) and mallee (left) growth over an alluvial fan.

Fig. 13 - Evidence of flooding in a creek issuing from the Bell Rock Range south of Anumarrapirti outstation.

Fig. 14 - Evidence of recent fire in a valley associated with the Bell Rock Range. The grass has burnt out whereas hardier spinifex has survived.

Fig. 15 - Rabbit burrows around dead mulga trees in calcareous soil near Teizi Creek.

VI. INTERPRETATION OF LAND FORMS

The Tomkinson Ranges display a strongly dissected morphology indicating an advanced stage of erosion of an undulating peneplain - relics of which are locally preserved, e.g., as ferricrete at the top of the Mount Davies range and as sporadic deep rock weathering profiles and fossil weathered valleys along the Ewarara-Teizi range, Wingellina Hills and other areas. Well pronounced deep weathering of felsic gneiss is seen south of Claude Hills, where the rock acquires a characteristic red colour. Erosion of the main ranges is relatively advanced in the Michael Hills, where large valleys include brances of the Champ de Mars valley. By contrast, the Bell Rock Range and Mount Aloysius massif constitute relatively intact outcrops. As a rule a close relationship exists between geology and morphology, namely, ranges formed by basic and ultrabasic rocks are separated by valleys underlain by granite gneiss. Examples are the Champ de Mars valley and its extension eastward, separating the Hinckley Range and Mount Kalka in the north from Michael Hills and Mount Davies in the south. Fault escarpments stand out clearly, i.e., Hinckley fault and its branch south of Wingellina Hills, and the Champ de Mars fault delimiting the Michael Hills on the north.

Development of relic inselberg terrains is well pronounced south of the main ranges, namely south of Michael Hills and south of Mount Davies, while fewer inselbergs are seen north of the Wingellina Hills and Ewarara-Teizi range. This feature is clearly related to the southward-stepping elevation of the terrain and development of a more extensive drainage system in this direction, including the Carruthers Creek system. An example of an advanced stage of erosion is south of Mount Davies, where the formerly contiguous bedrock outcrops have been dissected to about fifty isolated inselbergs within the pediplain. The inselbergs are surrounded by relatively wide pediments and colluvial rubble and are in places deeply weathered. Locally small sand dunes are attached to these outcrops which act as wind barriers.

VII. ENVIRONMENTAL IMPACT

No pastoral activity occurs in the Tomkinson Ranges and land use is restricted to sporadic hunting activities by Aboriginal people of the local communities, which includes development of networks of graded tracks and wheel tracks affecting the plain and valley terrains. Abandoned tracks between settlements have locally become linear depressions and erosional gullies, causing local diversion of existing natural drainage. Hunting activities has considerably reduced the native kangaroo and wallabee population. Further, the arrival of feral animals over 100 years ago has become the single most destructive influence vis-a-vis the original natural habitat and wildlife in the region. In particular, rabbit burrows have reached plague proportions, the rabbit concentrating in pediments and calcrete areas but also extensive in mulga-covered red soil alluvial plains and in sandy plains. Extensive destruction of the mulga and shrubs due to rabbits ensues. More recent increases in the size of camel herds has a lesser but still significant effect on the vegetation, affecting mainly the larger bushes and trees such as corkwood, mulga and grevillea.

The effect of fires on the habitat can not be overestimated. In some spinifex-dominated areas at least three stage of regrowth are observed. In some sandy plains extensive elimination of spinifex has occurred, possibly due to disease and/or exhaustion of the nutrients in the soil. Spinifex is ecologically most important in that it is able to retard erosion and thus allow development of soils. Fires have traditionally been lit by Aboriginal people but some occur as the result of lightening. The question whether fires enhance or retard plant growth and soil erosion in the long term remains controversial. Some burnout area experience new growth, particularly of mallee and spinifex. In general, however, it is evident that the Tomkinson Ranges have enjoyed lusher vegetation in the near past - most notable being the extensive tracts of dead mulga, where no fresh regrowth is evident.

Acknowledgements

I thank Andrew Glikson for his supervision of this work during the field seasons in the Tomkinson Ranges and the writing stage. I thank Colin Simpson for his guidance with the application of remotely sensed data and his general interest in the project. I also thank Colin Payne for his general advice and help with terminology of surface deposits units and Alastair Stewart and Stewart Needham for their comments on the manuscript.

Table 1 - A correlation between types of surface deposits and vegetation observed in the field and hue equivalents on Thematic Mapper and Geoscan I imagery for different band and band ratio combinations.

SURFACE DEPOSITS/ VEGETATION	GEOSCAN			THEMATIC MAPPER	REMARKS
	9, 4, 1	6/8, 6/9, 5/4	6/8, 6/9, 11/10	(TM)	
BEDROCK	Light brown to mid grey-brown for felsic rocktypes. Mid blue, mauve, mid to dark purple; grey purple in unburnt spinifex, greenish to green-blue in burnt spinifex for ultramafic rocks	Multitude of hues varying according to rocktype and whether area was burnt. Ranging from off-white through brown and varied greens to blues and reds	White, off-whites yellow, greens and browns, according to rocktype	Predominantly light to dark brown for for felsic rock types. Green-blue-purple greys, purple-blue, blue-green and yellow-green for ultramafic rocktypes	Hues for felsic and ultramafic rock types and fire burns can be more accurately identified
CALCRETE	*Greenish, pinkish, purplish, bluish whites, purplish white (good indicator)	Some unidentifiable to indistinct pinkish, yellowish, greenish hues. Mottled red-browns, and orange-white	Purplish red, red-brown, and pinkish	Constantly white. Heavy mallee cover darkens some areas (good indicator)	*Colour influenced by vegetation, e.g. mallee+ blue
FERRICRETE	Hues variable	Hues variable	Hues variable	Hues variable red-brown	Inconclusive
PEDIMENT	Light brown-yellow mottled, deep blue, aqua tinge over colour of plain	Whitish, yellow-green, khaki. Much is not identifiable	Blue & green mixed. Some are not distinguishable from plains	Pink-pale brown, orange to pink, cream to brownish, pale purple, light orange	
ALLUVIAL FAN	White, pale to distinct pink, pale blue, greenish, dark blue-purple	Deep blue, but most areas indistinct or not identifiable	Yellowish (1 example only)	Mostly distinct pink, some white or off-white	
ALLUVIAL PLAIN	White-yellow, yellow/white mottled dominant. Greenish yellow-white with mulga/cork cover. Also yellow-brown, yellow-pink, pale green-orange	Deep purple-blue dominant in treeless areas. Brownish mottled in mulga/cork cover. Also khaki, mauve brown, deep green to turquoise. Grey-blue, black	Deep aqua in treeless areas is donimant, also vivid blue. Mottled brown or blue-black in mulga/cork cover	Predominantly all shades of yellow, also brownish	
FLOOD PLAIN	Whitish in lowest areas, blending into yellow-pale green. Turquoise,	Greenish brown and blue to red-brown, dark green, mottled purple	No observation	Pale to greenish yellow, deep to brownish yellow, cream. Brown in scree* areas;	*See under SCREE

SURFACE DEPOSITS/ VEGETATION	GEOSCAN			THEMATIC MAPPER (TM)	REMARKS
	9, 4, 1	6/8, 6/9, 5/4	6/8, 6/9, 11/10		
SANDPLAIN	Yellow with greenish to brownish tinge, pale blue-green	Khaki,greyish blue	Mottled khaki	Light to mid yellow, orange	Few examples only
SCREE (incl. COLLUVIUM	Brown & khaki dominant, yellow specks, pinkish, pale green, blue purple	Whitish, greenish, red-brown, 'blotchy' blue	Whitish (1 example only)	Distinct brown, also pink; blue grey: examples equivalent to bedrock hues	Few examples only
PRINCIPAL DRAINAGE	Greenish, bluish green, turquoise, blue, blue-purple, purple.(Melaleuca cover=turquoise) Blue is indicator for magnetite-bearing sand	Whitish, pinkish, yellowish, pale brown to yellowish, pale green, deep blue, local ground colour (Melaleuca=clean pale yellow	Whitish, pale green, local ground colour	Pink, pale brown, mauve, light purple Pale yellow in some upper reaches, Mauve/purple indicates magnetite in stream beds	Geoscan 9,4,1 and TM are indicators for magnetite-bearing sand in stream beds
CLAYPAN	Mid yellow to pale green, Outline indistinct	Deep blue, mottled mauve	No observation	Pale to deep yellow, Outline not distinct from floodplain	
MULGA	Dark grey	White	White	Intterpretation not reliable	
CORKWOODS	*Greenish when dense	Not identifiable	Not identifiable	Not identifiable	* only 1 example
RIVER RED GUMS & BLOODWOODS	1 example only: Bloodwoods as individual pale green dots, Generally trees are poorly distinguished	Commonly individual yellow dots, Some blurred pink, indistinct red-brown dots, Bloodwoods orange (1 example only)	Individual orange dots for some bloodwoods, Also individual (sometimes blurred) white dots	Not identifiable	
MALLEE	Turquoise, pale blue, purple	Yellow dots	Distinct white dots	Dark patches	Usually on calcrete =whitish base
SPINIFEX	Commonly creates colour change: Ultramafic rocks (purple) to milky purplish tints	Commonly creates colour change: Ultramafic rocks (pink) to pinkish white			Heavy spinifex tends to blurr photo images

Ground observations were made on 20 selected 1:20 000 colour airphotos within remote-sensed images, Geoscan band combinations 9,4,1; 6/8, 6/9, 5/4 and 6/8, 6/9, 11/10 are inluded in this table, The only other available combination, 10,11,12, proved unsuitable, TM covers all of Geoscan cover and has been included for further comparison, TM colour values are closely related to Geoscan 9,4,1.

Table 2 - Summary of the associations between surface deposit units (symbols) and vegetation type units (numbers). For explanation of the symbols and numbers refer to the text.

	1	2	3	4 5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22 26	23 24	25
Ap -	x	x						x															
Aa1/2	x	x					x										x	x					
Aa3/4	x	x										x	x	x			x	x					
Af -		x	x			x												x	x	x			
Ai -		x																					
Op -	x	x	x		x		x			x	x	x	x	x	x			x					
Od -		x					x											x					
Ce -	x	x					x						x	x						x			x
Cf -		x				x	x		x				x					x	x	x		x	
Xe1 -		x										x	x		x								
Xe2 -	x	x	x				x						x	x	x								x
Xe3 -		x																					
Xe4 -	x	x	x				x						x	x	x								x
B -				x	x		x		x			x	x		x	x		x		x	x	x	x

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APPENDIX A - INDEX OF IDENTIFIED PLANTS

** Utilised by Aborigines for food, medicine, or craft*
*** Plant species not positively identified*

BOTANICAL NAMES	COMMON NAMES
Abutilon leucopetalum	Desert lantern flower
Abutilon otocarpum	Desert chinese lantern
*Acacia aneura**	Mulga
*Acacia basedowii***	Basedow's wattle
Acacia dictyophleba	Waxy wattle, sandhill wattle, feather-veined wattle
*Acacia kempeana**	Witchetty bush
*Acacia pruinocarpa or cambagei***	Gidgee, stinking wattle; black gidgee, black wattle
Acacia spondyophylla	Curry wattle, spineleaf wattle
Acacia strongylophylla	Round-leaf wattle
*Acacia tetragonophylla**	Dead finish
*Acacia victoriae**	Acacia bush, Victoria wattle
Allocasuarina decaisneana	Desert oak
Alyogyne pinoniana	Sand hibiscus
*Amphipogon caricinus**	Greybeard grass
Amyema maidenii	Maiden's mistletoe
Amyema miquelii	mistletoe (no specific name)
*Aristida contorta**	Feathertop wire grass, bunched kerosene grass, wind grass
Atriplex nummularia	Old man saltbush
Bothriochloa ewartiana	Desert blue grass
Brachychiton gregorii	Desert kurrajong
Brachycome ciliaris	Variable daisy
Brunonia australis	Blue pincushion
Calandrinia balonensis	Broad-leafed parakeelya
Calandrinia remota	Parakeelya
Callitris glaucophylla	White cypress pine
Calocephalus	Billybuttons
Cassia artemisioides	Silver cassia
*Cassia chatelainiana***	none
*Cassia desolata**	Grey cassia
Cassia helmsii	Blunt-leaf cassia, Helms' cassia
Cassia nemophila	Desert cassia, punty bush
Cassia notabilis	Cockroach bush
Citrullus lanatus	Wild melon
*Codonocarpus cotinifolius**	Desert poplar
Crotalaria cunninghamii	Parrot pea, Cunningham's rattlepod
*Crotalaria eremaea**	Desert rattlepod, bluebush pea
Cyperus	sedge
Dicrastylis beveridgei	none

*Dodonaea viscosa**	Sticky hopbush
Einadia nutans	Climing saltbush
Enchylaena tomentosa	Ruby saltbush
Enteropogon acicularis	Umbrella grass, spidergrass
Eremophila christophori	Desert fuchsia
Eremophila gibsonii	Gibson's desert fuchsia
*Eremophila glabra***	Black fuchsia
*Eremophila latrobii**	Native fuchsia, Latrobe's desert fuchsia
*Eremophila neglecta or latrobii***	
Eremophila willsii	Sandhill native fuchsia, Will's desert fuchsia
*Eremophila***	type E, not further identified
*Eremophila alternifolia or E. freelingii***,*	Scented emu bush or rock fuchsia bush
Erodium cygnorum	Storkbill, blue crowfoot
*Eucalyptus camaldulensis**	River red gum
Eucalyptus gamophylla	Blue mallee
Eucalyptus oleosa	Giant mallee
*Eucalyptus terminalis**	Bloodwood tree
*Euphorbia drummondii**	Caustic weed, red soldier
*Ficus platypoda**	Native fig
Gnephosis skirrophora	none
Goodenia heterochila	Serrated goodenia
*Gossypium sturtianum**	Sturt's desert rose
*Grevillea eriostachya**	Honey grevillea
*Grevillea juncifolia**	Desert grevillea
*Grevillea stenobotrya**	Rattlepod grevillea
Gyrostemon ramulosus	Camel poison bush
*Hakea eyreana**	Fork-leafed corkwood
*Hakea subera**	Long-leafed corkwood
Halgania erecta	none
Helichrysum bracteatum	Golden everlasting
Helichrysum cassinianum	Pink everlasting
Helichrysum davenportii	Davenport daisy
Helipterum floribundum	White paper daisy
Helipterum pterochaetum	Perennial sunray
Helipterum tietkensii	Tietkens' daisy
Hibiscus solanifolius	Tomato-leafed hibiscus
Indigofera basedowii	Showy indigo, Basedow's indigo
Indigofera leucotricha	White indigo
Indigofera georgii	George's indigo
Keraudrenia integrifolia	none
*Leichhardtia australis**	Bush banana, native pear, doubah
Leptosema chambersii	Chambers leptosema, upside-down plant
Maireana campanulata	Bluebush
*Marsilea exarata**	Nardoo

Melaleuca dissitiflora	Paperbark
*Melaleuca glomerata**	Inland teatree
Minuria leptophylla	Minnie daisy
Morgania floribunda	Blue rod
Myoporum acuminatum	Desert or western boobialla, native myrtle
Myrio rudallii	Small poached egg daisy
Newcastelia	none
*Nicotiana excelsior**	Native tobacco
Olearia stuartii	Daisy bush
Olearia subspicata	Spiked daisy bush
*Pandorea doratoxylon**	Spearbush
Petalostylis cassioides	Butterfly bush
*Pittosporum phylliraeoides**	Weeping pittosporum
*Prostanthera striatiflora**	Striped mintbush
*Psoralea***	Native verbine
Pterocaulon sphacelatum	Applebush
Ptilotus exaltus	Pink mulla mulla
Ptilotus helipteroides	Hairy mulla mulla
Ptilotus macrocephalus	Large green pussytail
Ptilotus obovatus	Silvertails
Ptilotus polystachyus	Longtails
Rhagodia spinescens	Thorny saltbush
Salsola kali	Roli-poli, buckbush, tumbleweed
*Santalum lanceolatum**	Plum bush
*Sarcostemma australe**	Caustic vine
Scaevola ovalifolia	Fanflower
Sclerolaena bicornis	Goathead burr
Sclerolaena birchii	Galvanised burr
Sclerolaena crenata	Prickle bush
Senecio gregorii	Annual yellowtop
Senecio magnificus	Perennial yellowtop, tall yellowtop, camel weed
Solanum quadriloculatum	Wild tomato
*Solanum petrophyllum***	Wild tomato
Stemodia viscosa	Blue rod
Swainsona burkei	Burke's swainsona
Swainsona microphylla or *S. flavicarinata***	Poison pea or yellow-keeled pea
Themada australis	Kangaroo grass
*Thryptomene maisonneuvii**	Desert heath myrtle
Trachymene glauciflora	Wild parsnip
Trianthema triquetra	Red spinach
Tribulus	a prostrate herb
Trichodesma zeylanicum	Cattlebush
Triodia basedowii	Lobed spinifex, hard spinifex
Triodia irritans	Porcupine grass
Triodia longiceps	Giant grey spinifex, buck spinifex

*Triodia pungens**	Gummy spinifex, soft spinifex
Wahlenbergia	Bluebell
Waitzia acuminata	Orange immortelle

APPENDIX B - SOIL AND DURICRUST SAMPLES

Samples have been taken for identification of surface deposits. They are plotted on the accompanying map and listed according to airphoto runs and numbers, and sample numbers e.g. 22/036/2 : Run 22, photo no. 036, sample no. 2 of photo 036.

A. Soil samples

22/036/2	25/137/5	27/104/2	29/167/2	30/185/1	32/061/1
042/4	141/1	104/5	172/1	191/1	061/2
046/1	141/2	104/7	172/2	195/1	061/3
064/1	141/3	28/110/4	174/1	197/1	061/4
24/118/2	146/1	133/1	176/2	203/2	063/1
139/1	150/1	134/1	180/1	203/4	063/5
25/118/1	150/2	134/2	180/2	31/022/1	063/6
118/2	26/008/1	134/3	180/3	022/2	065/1
118/3	027/1	137/1	180/4	029/1	33/107/1
118/4	031/2	139/1	184/1	029/2	109/2
118/5	052/1	139/3	184/2	033/1	109/3
120/1	27/056/1A	139/4	184/3	033/2	113/2
120/2	056/2	143/1	184/4	033/3	34/126/2
125/1	071/2	145/1	184/5	033/5	126/3
125/2	073/1	145/2	186/1	32/050/1	128/3
137/1	102/2	145/3	186/2	050/2	128/4
137/2	102/5	151/2	186/3	050/3	128/5
137/4	104/1	29/167/1	188/1	050/4	

B. Ferricrete samples

22/064/3	24/118/1	27/104/3	28/158/1	29/176/1	34/126/1

C. Calcrete samples

22/038/3	24/122/1	26/031/1	27/104/4	30/203/1	31/018/1
33/111/1					

SURFACE DEPOSITS AND VEGETATION, TOMKINSON RANGES

WESTERN AUSTRALIA / SOUTH AUSTRALIA

by E.H.J. FEEKEN

EXPLANATION OF THE MAP

Surface Deposits and Vegetation on this map are identified from aerial photographs, Thematic Mapper and Geoscan images, and ground observation, and are expressed as Landform/Regolith units as prescribed by AGSO. In addition, the map shows major vegetation types which are grouped into Plant Communities adopted by the Australian Systematic Botany Society.
The dual-level map is a pilot study of surface deposits/landforms with superimposed vegetation types. The composition of these features allows identification of relationships between soils/landforms and vegetation types. As such it provides a basic view of the environment of a portion of arid Australia with rainfall less than 200 mm per annum

VEGETATION TYPES AND RELATED LANDFORMS

	PLANT COMMUNITIES		PLANT DISTRIBUTION	PLANT ENVIRONMENT
GRASSLANDS	Perennial or annual grasslands	1	Treeless or almost treeless, bunch grasslands, occasional shrubs, rare herbs	
		2	Bunch grasslands with scattered mulga (A. aneura) and/or corkwood (Hakea), occasional bloodwoods (E.terminalis), rare weeping Pittosporum (P. phylliraeoides) ; shrubs, herbs	Alluvial plains, sandplains
		3	Bunch grasslands with groves of undifferentiated herbs and low shrubs with or without isolated trees	Plains, calcrete
	Hummock grasslands	4	Mainly hard spinifex (Triodia basedowii), porcupine grass (T. irritans), with occasional areas of shrubs; scattered mallee and/or mulga; native fig (Ficus platypoda); rare pittosporum ( )	Predominantly on ultramafic outcrops, rare on felsic outcrops or colluvial plains
		5	Dominating hard spinifex, some porcupine grass, few shrubs, rare native fig	
		6	Dominating soft spinifex (Triodia pungens)	Dominant on interdunal sandplains; also in broad rocky valleys
		7	Dominating giant grey spinifex (Triodia longiceps)	Occurrence rare– on colluvial and alluvial fan/ calcrete
		8	Undifferentiated spinifex (Triodia)	Mainly on alluvial plains and sandplains
SHRUBLANDS	Chenopodiaceae	9	Old man saltbush (Atriplex nummularia)	Dominating some river flats
	Melaleuca	10	Teatrees (Melaleuca glomerata)	In rocky stream beds usually within confines of outcrops
	Desert shrubs and trees	11	Exclusively desert heath (Thryptomene)	Dune fields
		12	Dominating desert heath, grevilleas, cassias, mallee, acacias; isolated desert kurrajongs (Brachychiton gregorii), desert oaks (Allocasuarina decaisneana), mulga, soft spinifex	
	Acacia–dominated mixed trees and shrubs	13	Dense mulga, with or without understorey	Predominantly on red soil floodplains and sandplains; also on outcrops of bedrock and duricrusts
		14	Open to medium woodland dominated by mulga, with mixed understorey including acacia shrubs, native fuchsia, cassia, spinifex	
		15	Dominated by shrubs including acacia, native fuchsia, cassia	
WOODLANDS	Eucalypts	16	Giant mallee (E. oleosa), and rare other mallee species	Dominant on calcrete, ferricrete; also on interdunal plains
		17	Blue mallee (E. gamophylla), and rare other hillslope species	Commonly open spread on hillslopes of mainly ultramafic rocktype
		18	River red gums (E. camaldulensis)	In and along stream beds
		19	Bloodwood trees (E. terminalis)	Along some stream beds; on all types of plains, usually near outcrops
	Hakeas	20	Intermixed corks and bloodwoods	Predominantly on alluvial fans and colluvium
		21	Long–leafed and fork–leafed corkwoods (Hakea suberea and H. eyreana respectively)	
	Cypress	22	White cypress pine (Callitris glaucophylla)	Hillslopes and rocky gullies, mainly of felsic rocks
	Acacias	23	Gidgee (Acacia pruinocarpa or cambagei)	Usually restricted to hillslopes and shallow rocky gullies
		24	Gidgee; mulga and/or corks	
BARREN HILL SLOPES	Mixed types	25	Few trees, mainly mulga; rare weeping Pittosporum ( ); native fig ( ); shrubs, sparse annual grasses and forbs	
		26	Devoid of trees, few shrubs, sparse grasses	

Vegetation type boundary

13 Vegetation type identification number

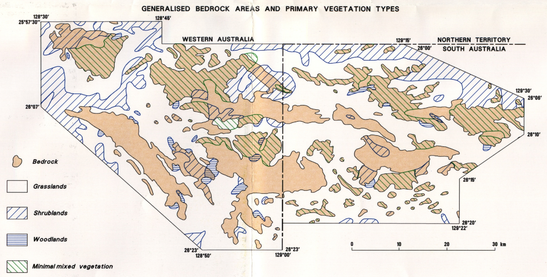
Symbols indicate observed localities of prominent species:
- Desert kurrajong (Brachychiton gregorii)
- Desert oak (Allocasuarina decaisneana)
- Native fig (Ficus platypoda)
- Weeping pittosporum (Pittosporum phylliraeoides)

SURFACE DEPOSITS AND LANDFORMS

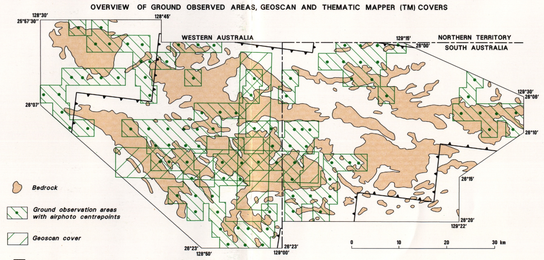
DEPOSIT		LANDFORM
Ap	Greasy or gritty clay; silt; claypan	Floodplain, alluvial plain, sandplain
Ap$_s$	Sand, silt, clay	Floodplain
Ap$_g$	Gravel; sand, silt, clay	Floodplain
Ah	Silt, clay, sand; red loam	Alluvial plain
Ah$_s$	Gravel; silt, clay, sand	Alluvial plain
At	Coarse to fine sand, silt	Alluvial fan
Ai	Grading from coarse sand to clay	Ancient channel
Dp	Coarse to medium sand, often with magnetite grains	Sandplain, and predominantly longitudinal dune fields
Dd	Coarse to fine sand, often with fine magnetite grains	Isolated, more or less circular dunes in the sandplains, or dunes attached to minor well–weathered outcrop
Cs	Very fine to fine sand, gravelly in places	Pediment
Cf	Fine to coarse sand, at times rich in magnetite, gravelly to pebbly in places; occasional ferruginous rubble with magnetite grains	Predominantly colluvial and eluvial valley floor deposits
Xr$_1$	Ferricrete outcrops, minor calcrete interbeds, weathered ferruginous gravel, minor mottled zone, magnetitic gravel in places	Near margins of ultramafic rock, forming low rises
Xr$_2$	Calcrete, minor ferricrete; weathered calcrete cobbles, pebbles and gravels; minor silcrete interbeds	Forming very low rises in plains, also flanking some major stream beds
Xr$_3$	Silcrete outcrops, boulders, pebbles and gravels	Occurring in association with calcrete, ferricrete
Xr$_4$	Undifferentiated duricrust	See Xr$_1$, Xr$_2$, Xr$_3$
	Undifferentiated bedrock	Low ranges, often abrupt, and inselbergs, intersected by plains

- Major rockpile
- Scarp
- Dyke
- Sand dunes
- Stream channel; arrow marks limit of traceability. (Watercourses on this sheet are mainly dry)
- Landing ground
- Bore with windpump
- Building
- Mine or open cut, abandoned (Cb–Chrysoprase)
- Road
- Vehicle track
- 2500021 Sample locality for duricrust or soil
- Trigonometrical station
- 679 Elevation ASL

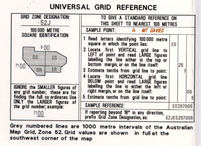
GENERALISED BEDROCK AREAS AND PRIMARY VEGETATION TYPES



OVERVIEW OF GROUND OBSERVED AREAS, GEOSCAN AND THEMATIC MAPPER (TM) COVERS



UNIVERSAL GRID REFERENCE



Grey numbered lines are 1000 metre intervals of the Australian Map Grid, Zone 52. Grid values are shown in full at the southwest corner of the map

SCALE 1:100 000

1 0 1 2 3 4 5 6 7 8 9 10 Kilometres

UNIVERSAL TRANSVERSE MERCATOR PROJECTION, AUSTRALIAN MAP GRID, ZONE 52
LATITUDE OF ORIGIN : 0°, LONGITUDE OF ORIGIN : 129°

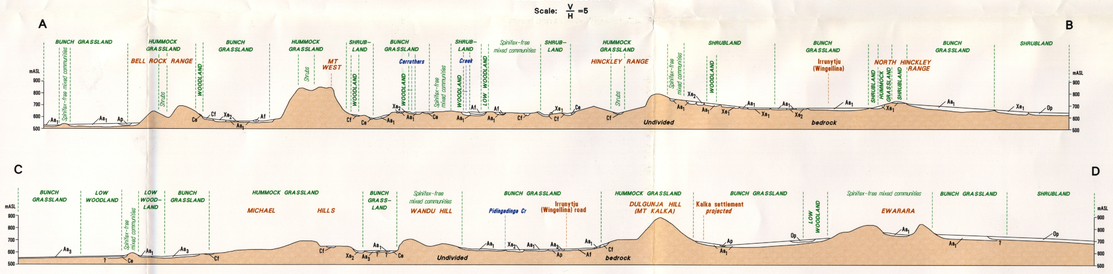
INDEX TO 1:100000 MAPS

1:250000 maps shown in blue

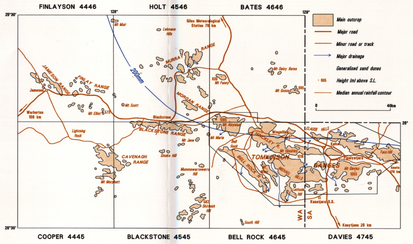
DICKINSON 4447	TOMKARORO 4547	DESERAD 4647	POTTERY 4747	PETTERMANN 4847	OLIA CHARN 4947
SCOTT				PETTERMANN RANGES	
FINLAYSON 4446	SG52-6 HOLT 4546	BATES 4646	COCKBURN 4746	SG52-7 DAVIES 4746	BUTLER DOME 4846
COOPER 4445	BLACK-STONE 4545	BELL ROCK 4645	DAVIES 4745	WARK 4445	HANKINS KNOLL 4945
	COOPER			MANN	
LIVESEY 4444	SG52-10 YINES 4544	AGNES 4644	MOULDEN 4744	SG52-11 MANGA 4844	TIETKENS 4944

SCHEMATIC SECTIONS

Scale: V/H = 5

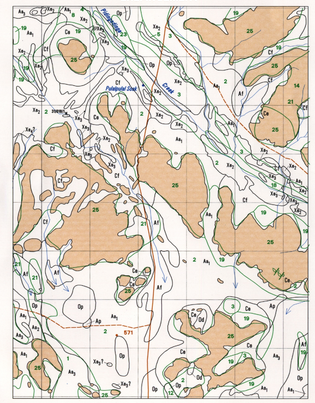


PHYSIOGRAPHY OF THE GILES COMPLEX



MAP LOCALITY

ENLARGEMENT



SEE ENLARGEMENT

Surface deposits, landform, and vegetation data compiled 1990–1991 for the Australian Geological Survey Organisation by E.Feeken, geo–cartographic consultant

Cartography by D.Dlugosz, J.Stirzaker, AGSO
Compiled and produced by Cartographic Services Unit, BMR using Intergraph graphics applications.
Printed by Land Information Centre, Bathurst, NSW

Topographic information on this map has been derived from digital data supplied by the Australian Surveying and Land Information Group, Department of Administrative Services, Canberra, Australia.

Published by the Australian Geological Survey Organisation, Department of Primary Industries and Energy, Canberra, Australia, issued under the authority of the Minister for Primary Industries and Energy.

It is recommended that this map be referred to as:
Feeken, E.H.J., 1992– *Surface Deposits and Vegetation, Tomkinson Ranges* (1 : 100 000 scale map). Australian Geological Survey Organisation, Canberra, Australia

This map is accompanied by a text publication:
E.H.J. Feeken, 1992
Notes on the 1 : 100 000 environmental map of the Tomkinson Ranges, Western Musgrave Block,Central Australia. Australian Geological Survey Organisation, Canberra, Australia, *Record* 1992/34

DIGITAL DATA

The digital data for this map were compiled on the AGSO Intergraph System and, in some circumstances, may be suitable for transfer to other digital systems.
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PRELIMINARY EDITION
DECEMBER 1992

SURFACE DEPOSITS AND VEGETATION, TOMKINSON RANGES