BATHURST AND FORBES 1:250 000 MAP SHEETS, NEW SOUTH WALES

R.A. Chan

CRC LEME, Geoscience Australia, PO Box 378, Canberra, ACT 2601
Roslyn.Chan@ga.gov.au

INTRODUCTION

Regional regolith–landform mapping and modelling of the BATHURST (SI55-08) and FORBES (SI55-07) 1:250 000 map sheets were carried out by CRC LEME in collaboration with the National Geoscience Mapping Accord (Chan *et al*., 1995a,b; Gibson and Chan, 1999a). Regolith–landform maps at the 1:100 000 scale were also produced for the BATHURST 1:250 000 sheet; these maps being BATHURST (Chan and Kamprad, 1995), ORANGE (Chan and Fleming, 1995a), MOLONG (Chan and Fleming, 1995b), COWRA (Chan and Goldrick, 1995), BLAYNEY (Chan, 1995) and OBERON (Hazell and Chan, 1995). Explanatory notes have been published for the BATHURST and FORBES 1:250 000 regolith–landform maps only (Chan, 1998; Gibson and Chan, 2000).

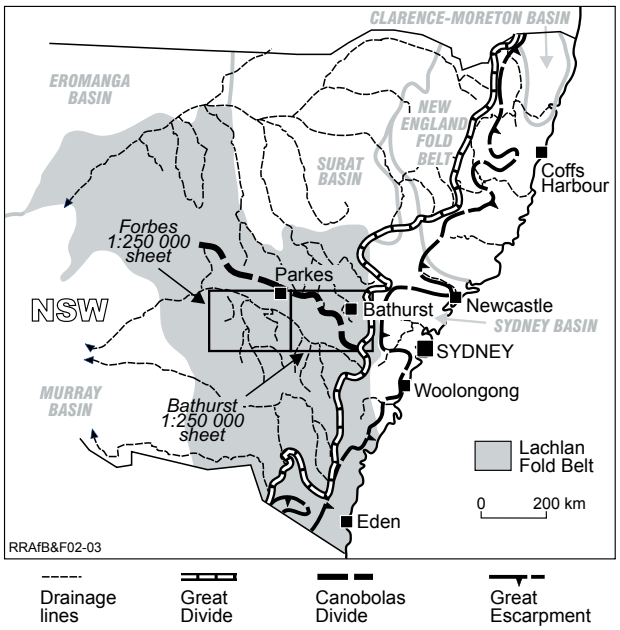

Figure 1. Location of the BATHURST–FORBES region.

PHYSICAL SETTING

Geology

The BATHURST–FORBES region in central-east New South Wales extends from the western margin of the Permian–Triassic Sydney Basin in the east, to the centre of the Palaeozoic Lachlan Fold Belt in the west (Figure 1). Outliers of the Jurassic–Cretaceous Surat Basin occur in the north of the region. Ordovician to Devonian sedimentary and volcanic rocks of the Lachlan Fold Belt are regionally metamorphosed to a low grade in FORBES but increase in metamorphic grade to the east across BATHURST. The Lachlan Fold Belt rocks have a predominant north to northwest structural trend, owing to folding and thrusting during the Palaeozoic, with some re-activation thereafter. This structural trend is interrupted in BATHURST–FORBES by Silurian, Devonian and Carboniferous intrusions. Cenozoic sediments are common in the southwest of BATHURST and over large areas of FORBES, especially towards the west.

Geomorphology

The Great Divide on the eastern edge of BATHURST separates the coastal drainage to the east from the inland drainage to the west. The Canobolas Divide runs northwest across BATHURST and separates the inland drainage of the Macquarie–Darling River system over northeast BATHURST from the Lachlan River system over southwest BATHURST and FORBES. High elevation (600–1400 m) terrain of the Eastern Highlands in eastern BATHURST ranges from plateaux with preserved regolith profiles, to mountains (>300 m relief) with minimal regolith. Lower elevation (300–600 m ASL) low hills (30–90 m relief) and hills (90–300 m relief) of saprolite and saprock with local foot-slope and depositional plain sediments predominate in western BATHURST and eastern FORBES. This hilly terrain grades to long colluvial slopes and extensive depositional plains (200–300 m ASL; <9 m relief) with buried palaeovalleys associated with the Lachlan River and its tributaries over much of central and western FORBES. Strike-ridges and saprolite rises (9–30 m relief), commonly draped with a mantle of colluvial, aeolian and alluvial (modern and ancient) sediments, interrupt this low relief and low elevation terrain.

Climate and Vegetation

Climate within the BATHURST–FORBES region varies from cool temperate in the east with occasional snow at high elevations (above 1000 m) to warm temperate in the west (summer mean daily maxima 31–33^{o}C; average annual rainfall 450 mm). The land is primarily used for agriculture, but there are significant areas of National Parks, State Forests and Nature Reserves over BATHURST and eastern FORBES. Native vegetation ranges from sclerophyll forest and savannah woodland in the east of the BATHURST–FORBES region to shrub and tall woodland in the west of the region. The native vegetation has been cleared from most slopes and plains within central and western FORBES, except for in steep and rocky areas.

REGOLITH–LANDFORM RELATIONSHIPS

Highlands

The term ‘highlands’ informally refers to the Eastern Highlands, which includes both high and low relief landforms at a relatively high elevation (generally 500–1400 m ASL) within most of BATHURST and the eastern part of FORBES. Regolith–landform provinces comprising regolith–landform associations with characteristic toposequences have been established for BATHURST (Chan, 1998).

The Sydney Regolith–landform Province on the northeastern border of BATHURST relates to the Sydney Basin and comprises moderately weathered rises and slightly weathered bedrock mesas with lithologically defined benches. Mesas on the Great Divide are interpreted as remnants of a dissected and warped ancient land surface.

The Lachlan Tablelands Regolith–landform Province encompasses the Eastern Highlands region of the Lachlan Fold Belt. A central arcuate zone of saprolite, transgressing a variety of bedrock types and reaching up to 20 m in thickness, trends northwesterly astride the Canobolas Divide across BATHURST. The saprolite zone forms a northwesterly sloping plateau composed mainly of rises to low hills, and a smaller area of residual regolith on high level plains in the southeast. Erosional scarps commonly define the perimeter of the plateau, with a series of step-down scarps in the west and south of BATHURST possibly resulting from periodic tectonic adjustments of Mount Canobolas.

Alluvial sediments are preserved on the plateau in the northwest of BATHURST as erosional rises at about 600 m ASL, and also on lower elevation (300 m ASL) plateau remnants west of Parkes in FORBES. The sediments are remnants of the Jurassic Surat Basin that covered the northern Lachlan Fold Belt and infilled a topography more rugged than that of the present day (Gibson and Chan, 1999b). Alluvial sediments also occur as residual rises on the plateau close to the Canobolas Divide in the central to southern part of BATHURST.

Scattered plateau remnants atop rugged hilly to mountainous terrain underlain by fresh to slightly weathered bedrock occur on either side of the central arcuate plateau. The plateau remnants are interpreted to have formed an undulating ancient landsurface prior to stream incision. In the northeast of BATHURST, the Macquarie and Turon rivers have incised the palaeosurface by up to 500 m, and in the south of BATHURST the Abercrombie River has incised the palaeosurface by a similar amount. The average relief of the plateau remnants ranges from 9 to 90 m, with moderately weathered to slightly weathered bedrock forming rises to low hills. Remnant deep soils occur on the top of some plateaux.

A few remnant plateaux occur along the margin of BATHURST with FORBES. Low hills and hills composed of saprock in eastern FORBES largely reflect the bedrock form of Devonian igneous intrusions and folded sedimentary rocks. The Bathurst Granite has been preferentially weathered and eroded by the headwaters of the Macquarie River to form a west–northwest aligned erosion basin in the central to eastern part of BATHURST. The lowest part of the basin is 300–500 m below the rim of the plateau surface, which in part forms a metamorphic aureole. Colluvial, granite-derived sediments occur along the eastern margin of the drainage basin, and alluvial deposits and terraces are associated with the past and present course of the meandering Macquarie River. The low base-level of the Bathurst Granite erosion basin has been propagated to the south through incision by headwater tributaries of the Macquarie River. This has resulted in the development of low hills and hills composed of moderately weathered Palaeozoic bedrock, and the topographic inversion of Tertiary lava flows.

The Tertiary Lava Regolith–landform Province transgresses the other provinces in BATHURST and relates to remnants of three episodes of Tertiary volcanism; Late Eocene, Early Miocene and Middle Miocene. The eroded core of the Middle Miocene Mount Canobolas compound shield volcano in central BATHURST has many peaks, plugs and domes and some remnant cone ramparts. Radiating trachytic to basaltic lava flows and basalt lava plains surround Mount Canobolas, with one flow being buried beneath 60 m of alluvium in Mandagery Creek in eastern FORBES. Remnants of variably weathered, topographically inverted basalt flows from the Middle Miocene Mount Canobolas volcano as well as Late Eocene and Early Miocene volcanism are widespread across BATHURST. Multiple lava flows within valleys and twin lateral streams occur in southeast BATHURST.

Lowlands

The term ‘lowlands’ informally refers to the Western Slopes and Plains, which are generally below 600 m ASL and occur within the western part of BATHURST and most of FORBES.

The Lachlan Western Slopes Regolith–landform Province in western BATHURST typifies the regolith–landform associations in the lowlands of the region. Foothills (rises to low relief hills), and slopes and pediments border the Highlands and give way to erosional plains, and alluvial plains associated with the Lachlan River and its tributaries. Scarps locally form the boundary between Highlands and Lowlands and mark the present extent of coalescing slope retreat. Colluvial sediments on lower slopes commonly overlie moderately to highly weathered bedrock. Erosional plains commonly have a veneer of sheetwash colluvium, locally mantled by lag. For example, the Ungarie Granite in southwest FORBES has a lag of mottled granite. Palaeovalleys within this granite contain alluvial deposits with detrital maghemite, which are overlain and masked by colluvial and aeolian sediments (see Gibson *et al*., this volume). Many other palaeovalleys are likely to occur in this terrain.

Much of FORBES comprises alluvial plains and floodplains associated with the Lachlan River and its tributaries. The alluvial plains overlie up to 120 m of alluvial, colluvial, lacustrine and aeolian sediments that bury a north-trending ridge and swale topography of variably weathered bedrock of the Lachlan Fold Belt. Palaeochannel sediments are also present within the basin-fill (see Gibson *et al*., this volume). The ancient Lachlan River was superimposed across the buried Lachlan Fold Belt structure and deviates from its present course. Aeolian sediments occur as sand dunes, sand wedges and source bordering sand scattered across FORBES, and are also likely to have been incorporated into much of the regolith in both the lowlands and uplands areas of BATHURST and FORBES (for example, see Scott, this volume).

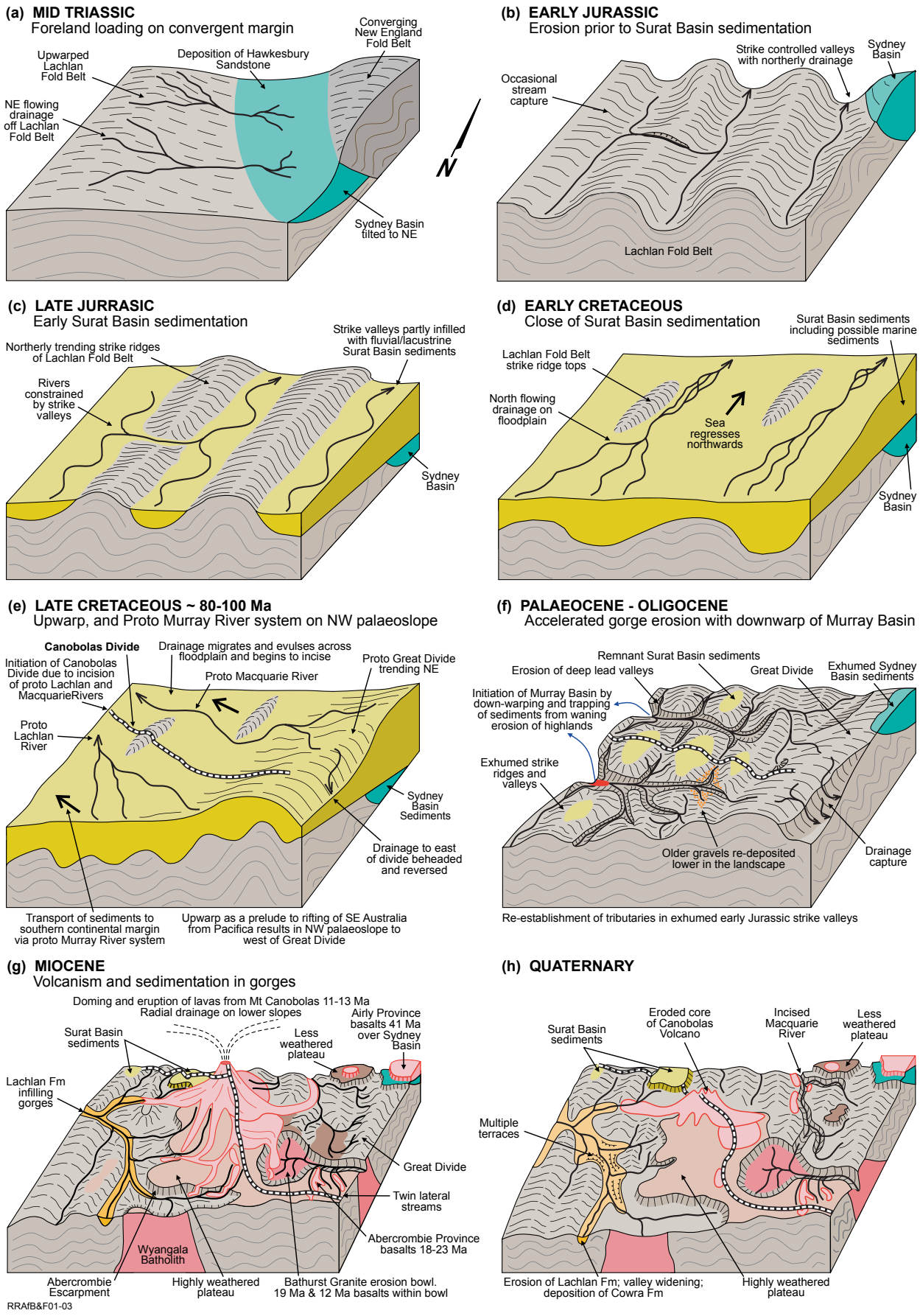

Figure 2. Drainage evolution in the BATHURST–FORBES region.

REGOLITH AND LANDFORM EVOLUTION

Alluvial deposits, both buried (palaeo-Lachlan River alluvium) and topographically inverted (eroded sediments in vicinity of Canobolas Divide), have been dated by palynology (Martin, 1991; Gibson and Chan, 1999b). Ferruginised regolith produced by weathering has been dated by palaeomagnetism at the Northparkes Mine immediately to the north of FORBES (Pillans *et al*., 1999). Apatite fission track thermochronology has been used to interpret major deposition and erosion events in BATHURST and FORBES (O'Sullivan *et al.*, 1995, 2000). Vitrinite reflectance data indicates missing sedimentary sequences (Branagan, 1983; Raza *et al*., 1995; Gibson and Chan, 1999b).

An outline of the regolith and landform evolution of BATHURST–FORBES region is provided below. Further details are provided by Chan (1998, 1999) and Gibson and Chan (1999b,c; 2000).

1. *Late Devonian*. Deposition of Hervey Group fluvial to possibly deltaic sediments.

2. *Carboniferous to Middle Permian*. Regional open folding and re-activation of faults during the Kanimblan Orogeny; high level emplacement of Bathurst Batholith; development of ferruginous mottles in saprolite at Northparkes; 3.5 km thick sediment pile buries Northparkes region (not recorded over Bathurst Batholith).

3. *Late Permian to Early Triassic*. Vigorous erosion of sediment pile at Northparkes region, perhaps due to the Hunter-Bowen Orogeny, and deposition in Gunnedah and Sydney basins.

4. *Mid Triassic*. Northeasterly drainage erodes Hervey Group quartzose sedimentary rocks in the northern part of the Lachlan Fold Belt and deposits sediments as Hawkesbury Sandstone in the Sydney Basin (Figure 2a).

5. *Early to Middle Jurassic*. Northerly drainage in strike valleys, perhaps draining via the Clarence–Morton Basin (Figure 2b).

6. *Late Jurassic to Early Cretaceous*. Burial of structural valleys by fluvial Surat Basin sediments transported from south (0.5 to 1 km thick sediment pile over Northparkes region and FORBES, to several kilometres thick over BATHURST). Sediments probably covered much of north Lachlan Fold Belt and Sydney Basin (no sediments preserved, but vitrinite reflectance data indicates missing section). Sediments over present highlands in BATHURST deposited in tectonic downwarp parallel to a west-subducting convergent margin. Dendritic meandering or braided drainage to north on low gradient depositional plain (Figure 2c,d).

7. *Late Cretaceous*. Cessation of convergence at 95 Ma resulted in rebound and uplift of the plate margin, forming the proto Great Divide and consequent beheading and reversal of drainage; evulsion of drainage across Surat Basin plain from N to NW–WNW normal to upwarp; incision of sediments to form proto Canobolas Divide; erosion of cover over BATHURST causes further deposition after 95 Ma over FORBES (Figure 2e).

8. *Palaeocene to Oligocene*. Downwarp of Murray Basin in Palaeocene and entrapment of sediments from waning erosion in highlands; accelerated gorge erosion due to lowered base-level in Murray Basin; superimposition and entrenchment of drainage onto exhumed Lachlan Fold Belt rocks with some tributaries re-incising into palaeo-strike valleys; headward erosion and scarp retreat on both sides of the Great Divide, and capture of northwest drainage to west of Great Divide towards the southeast to east of the Divide; weathering of exhumed unconformity beneath Surat Basin sediments; Airly Province volcanism (41 Ma); initial deposition of sediments in the lower Lachlan River palaeovalley as an extension of Murray Basin sedimentation (Figure 2f).

9. *Miocene to Pliocene*. Abercrombie Province volcanism (23–18 Ma); incision of unconformity surface and partial erosion of Bathurst Granite; Canobolas Province volcanism (13–11 Ma) with doming of Mt Canobolas and radial lava flows and lava plains burying Miocene topography and re-arranging drainage; deposition of Lachlan Formation in palaeovalley of the Lachlan River and its tributaries induced by climate change; erosion of Lachlan Formation and valley widening; relief inversion of lava flows; local drainage modification and new scarp retreat waves probably due to tectonic reactivation (Figure 2g).

10. *Quaternary*. Continued incision of palaeosurface by Lachlan and Macquarie rivers and their tributaries, and formation of Bathurst Granite drainage basin and consequent local drainage capture around perimeter; exhumation of pre-lava topography; deposition of Cowra and Belubula formations in valleys of the Lachlan and Belubula rivers, respectively; continued in-filling of present Lachlan valley and low gradient tributary catchments by slope wash; formation of terraces on broad floodplain with meandering river; aeolian dust incorporated into regolith as parna, and local aeolian sand deposition as dunes, wedges and source bordering sand in west; continued weathering and scarp retreat (Figure 2h).

REFERENCES

Branagan, D.F., 1983. The Sydney Basin and its vanished sequence. Journal of Geological Society of Australia, 30: 75-84.

Chan, R.A., 1995. Blayney regolith–landforms, New South Wales. Preliminary Edition map. 1:100 000 regolith–landform series, Sheet 8730. Australian Geological Survey Organisation (Geoscience Australia)/National Geoscience Mapping Accord, Canberra.

Chan, R.A., 1998. Bathurst regolith–landforms. In*:* J.J. Watkins and D.J. Pogson (Compilers). Bathurst, New South Wales. Explanatory notes. 1:250 000 geological series, Sheet SI55-8, 2nd Edition. Geological Survey of New South Wales. pp 311-328.

Chan, R.A., 1999. Palaeodrainage and its significance to mineral exploration in the Bathurst region, NSW. In: G. Taylor and C. Pain (Editors). Proceedings of Regolith '98, New Approaches to an Old Continent. CRC LEME, Perth, Australia. pp 38-54.

Chan, R.A. and Fleming, C., 1995a. Orange regolith–landforms, New South Wales. Preliminary Edition map. 1:100

000 regolith-landform series, Sheet 8731. Australian Geological Survey Organisation (Geoscience Australia)/ National Geoscience Mapping Accord, Canberra.

Chan, R.A. and Fleming, C., 1995b. Molong regolith–landforms, New South Wales. Preliminary Edition map. 1:100 000 regolith-landform series, Sheet 8631. Australian Geological Survey Organisation (Geoscience Australia)/ National Geoscience Mapping Accord, Canberra.

Chan, R.A. and Goldrick, G., 1995. Cowra regolith–landforms, New South Wales. Preliminary Edition map. 1:100 000 regolith-landform series, Sheet 8630. Australian Geological Survey Organisation (Geoscience Australia)/ National Geoscience Mapping Accord, Canberra.

Chan, R.A. and Kamprad, J.K., 1995. Bathurst regolith–landforms, New South Wales. Preliminary Edition map. 1:100 000 regolith-landform series, Sheet 8831. Australian Geological Survey Organisation (Geoscience Australia)/ National Geoscience Mapping Accord, Canberra.

Chan, R.A., Hazell, M.S., Kamprad, J.L., Fleming, C., Goldrick, G. and Jurkowski, I., 1995a. Bathurst regolith–landforms, New South Wales. Preliminary Edition map. 1:250 000 regolith-landform series, Sheet SI55-8. Australian Geological Survey Organisation (Geoscience Australia)/ National Geoscience Mapping Accord, Canberra.

Chan, R.A., Hazell, M.S., Kamprad, J.L., Fleming, C., Goldrick, G. and Jurkowski, I., 1995b. Bathurst landforms, New South Wales. Preliminary Edition map. 1:250 000 regolith-landform series, Sheet SI55-8. Australian Geological Survey Organisation (Geoscience Australia)/National Geoscience Mapping Accord, Canberra.

Gibson, D.L. and Chan, R.A., 1999a. Forbes regolith–landforms, New South Wales. Preliminary Edition map. 1:250 000 regolith-landform series, Sheet SI55-7. CRC LEME, Perth.

Gibson, D.L. and Chan, R.A., 1999b. Aspects of palaeodrainage in the north Lachlan Fold Belt region. In: G. Taylor and C. Pain (Editors). Proceedings of Regolith '98, New Approaches to an Old Continent. CRC LEME, Perth, Australia. pp 23-37.

Gibson, D.L. and Chan, R., 1999c. Regolith and landscape mapping and evolution. In: P. Lyons and D. Wallace (Editors). Field Conference Guide: Geology and metallogenesis of the Parkes – Grenfell – Wyalong – Condobolin region, New South Wales, Forbes 1:250 000 Geological Sheet. Australian Geological Survey Organisation (Geoscience Australia), Canberra. Record 1999/20. pp 24-32.

Gibson, D.L. and Chan, R.A., 2000. Regolith materials and landscape evolution. In*:* P. Lyons, O. Raymond and M. Duggan (Compilers and Editors). Forbes, New South Wales. Explanatory notes. 1:250 000 geological series*,* Sheet SI55-7*,* 2nd Edition. Australian Geological Survey Organisation (Geoscience Australia), Canberra. Record 2000/20. pp 198-201.

Hazell, M.S. and Chan, R.A., 1995. Oberon regolith–landforms, New South Wales. Preliminary Edition map. 1:100 000 regolith-landform series, Sheet 8830. Australian Geological Survey Organisation (Geoscience Australia)/ National Geoscience Mapping Accord, Canberra.

Martin, H.A., 1991. Tertiary stratigraphic palynology and palaeoclimate of the inland river systems in New South Wales. In*:* M.J. Williams, P. De Deckker and A.P. Kershaw (Editors). The Cainozoic in Australia: a re-appraisal of the evidence. Geological Society of Australia. Special Publication 18. pp. 181-194.

O'Sullivan, P.B., Gibson, D.L., Kohn, B.P., Pillans, B. and Pain, C.F., 2000. Long-term landscape evolution of the Northparkes region of the Lachlan Fold Belt, Australia: constraints from fission track and palaeomagnetic data. Journal of Geology, 108: 1-16.

O'Sullivan, P.B., Kohn, B.P., Foster, D.A. and Gleadow, J.W., 1995. Fission track data from the Bathurst Batholith: evidence for rapid mid-Cretaceous uplift and erosion within the eastern highlands of Australia. Australian Journal of Earth Sciences, 42: 597-607.

Pillans, B., Tonui, E.K. and Idnurm M., 1999. Palaeomagnetic dating of weathered regolith. In: G. Taylor and C. Pain (Editors). Proceedings of Regolith '98, New Approaches to an Old Continent. CRC LEME, Perth, Australia. pp 237-242.

Raza, A., Hill, K.C. and Korsch, R.J., 1995. Mid-Cretaceous regional uplift and denudation of the Bowen-Surat basins, Queensland, and its relation to Tasman Sea rifting. In*:* I.L. Follington, J.W. Beeston and L.H. Hamilton (Editors). Bowen Basin Symposium 1995 – 150 years on. Geological Society of Australia. Supplement.