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IMPORTANT GEOLOGICAL LOCALITIES BEYOND THE PERTH REGION
THEIR SIGNIFICANCE AND VALUE,
PROTECTION AND PRESENTATION

by

J.D. Carter, M.B.E., B.Sc.

1987

This report was funded by the Australian Heritage Commission
and prepared for the The Geological Society of Australia
Incorporated, Western Australia Division



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Frontispiece

NORTH POLE STROMATOLITES

J.D. Carter

The stromatolites are about 3500 million years old
and may be the last examples of the oldest stromatolites
remaining at North Pole where these vestiges of early
life have been collected without restraint

WESTERN AUSTRALIA

IMPORTANT GEOLOGICAL LOCALITIES BEYOND THE PERTH REGION

This is the second report produced by the Geological Society of Australia Incorporated, Western Australia Division, on the significance and value, protection and presentation of important geological localities of Western Australia made possible by grants from the National Estate Grants Program of the Australian Heritage Commission under the administration of the Western Australian Heritage Committee.

First report, 1979:

Perth and Southwestern Area

T.C. Lemmon, Consultant.
Geological Monuments Subcommittee
R.D. Gee, Convenor,
W.R. Morgan,
C.R. Elkington.

Second report, 1987:

Localities Beyond the Perth Region

J.D. Carter, Consultant.
Geological Monuments Subcommittee
C.C. Sanders, Convenor,
J.W. Bird,
J.G. Blockley.

SUBCOMMITTEE STATEMENT

This inventory is part of a nation-wide programme to document the major geological monuments around Australia. Already most other States have brought forward compilations of their important geological features, accompanied with recommendations for protection of sites. For Western Australia however, being one-third of the continent, significantly greater resources have had to be invested in the project to accomplish the task.

In particular, the Geological Monuments Subcommittee of the Geological Society of Australia (Western Australian Division) needed financial support, and in this regard we were successful in receiving a useful funding grant from the Australian Heritage Commission. In addition, this aid was helpfully guided by the Western Australian Heritage Committee. We wish to acknowledge and thank both organisations for their support.

However, this comprehensive listing of the major geological localities of Western Australia could not have succeeded without the dedication of Mr. John Carter, our consultant for the project. His time, energy and enthusiasm have enabled the task to be most adequately finalised.

It was the objective of this Report that the major geological features of Western Australia should be documented so that decisions can be made for their conservation and proper use.

The task has taken two years, which is probably no great surprise. Not only was it necessary to research the major geological occurrences and geoscientific reference sites, but also there was a need to visit most of them in the field so as to determine aspects such as uniqueness and accessibility. In consequence, John Carter has developed both a resource book, as well as a detailed compilation of the various sites. The compilation will be made available to the Geological Survey of Western Australia. We believe through this report that the goal we set has been achieved.

It is now up to the geological fraternity on the one hand, and appropriate Government agencies on the other, to ensure ongoing protection of the scientifically valuable geological localities recorded herein.

Colin Sanders	(Convenor, Geological Monuments Subcommittee)
John Blockley	(Member)
John Bird	(Member)

August 1987

PREFACE

The Convenor,
Geological Monuments Subcommittee,
Western Australia Division of the Geological Society of Australia
Incorporated:

I submit a report on important geological localities in Western Australia in country beyond the Perth region discussing among other matters their significance and value, and their protection and potential for public presentation.

Just over 100 localities are described and these are listed in a 'Summary of Recommendations' and separated into the groups 'Country Examined' and 'Country Not Examined'.

The study was seen as an information gathering task and as much country was covered as the budget allowed. In locality dossiers geological descriptions are aimed at non-specialists and recommendations are recorded on aerial photographs rather than maps.

The more valuable elements of Western Australia's geological heritage appear to be -

**Archaean microfossil and stromatolite sites of the Pilbara,
ancient minerals and rocks of Mount Narryer in the Murchison,
and the Devonian reef complexes of the Kimberley.**

There is need to protect the earliest stromatolite localities of the Pilbara which have been collected without restraint. Some of these records of life's beginnings are in danger of being lost.

The public has little opportunity of becoming familiar with the geological heritage of Western Australia and suggestions are made to foster public appreciation of the geology of the State.

Introductory sections are followed by dossiers on geological localities and the report concludes with a discussion on the protection and presentation of geological sites.

J.D. Carter,
Consultant Geologist

28th May 1987

ACKNOWLEDGEMENTS

Assistance from many was received during the study and the consultant expresses his thanks to all.

Information sources held by the Geological Monuments Subcommittee were compiled largely by R.T. Brandt some years ago and provided an effective starting point.

A wide range of experts with special knowledge of the geology of the State was consulted and opinions sought in identifying significant geological localities. K. Grey, R.M. Hocking, J.D. Lewis and Dr. A.M. Thorne of the Geological Survey of Western Australia made valuable contributions and many of their colleagues including G. Beere, J.G. Blockley, Dr. A.E. Cockbain, Dr. T.J. Griffin, Dr. A.H. Hickman, Dr. W.M. Hunter, Dr. A. Mory, Dr. J.S. Myers, Dr. P.E. Playford and I.R. Williams were consulted. Assistance at teaching institutions was obtained from B.J. Ingle, Dr. C.I. Mathison and Dr. S.A. Wilde. At the Western Australian Museum, Dr. A.W.R. Bevan and G.W. Kendrick proposed features and L.V. Bastian of the Government Chemical Laboratories made important suggestions. C.D. Arndt, Dr. R.D. Gee, T.E. Johnston, Dr. R.J. Marston, P.C. Muhling and T. Taylor provided excellent advice.

In the field G.R.W. Baker took me around Del Park and during particularly enjoyable fieldwork in March 1986 Dr. R.C. Horwitz of CSIRO demonstrated many locales of unusual interest near the Ashburton River. Dr. W.K. Witt of the Geological Survey introduced me to the geology of Mount Hunt and other features around Kalgoorlie, and S.L. Lipple showed me geology at Mount Singleton. R. Klok and P.M. Lambert of the Department of Conservation and Land Management considerably took me into four-wheel drive localities along the South Coast.

Dr. P.E. Playford, Director, kindly agreed to the reproduction of Figure 4 derived from the 1974 Annual Report of the Geological Survey of Western Australia.

My thanks are due to the Geological Monuments Subcommittee for their support, and to the Convenor, C.C. Sanders, who managed the administration of the work with care.

More than ordinary gratitude is due to Joy and Adrian Oats of the Ace Typing and Calligraphy Service of Dianella. Joy turned difficult drafts into attractive layouts and Adrian's skills are reflected in the clear Figures produced with favourable economy.

Among others Julia Thom examined the report draft and made helpful suggestions.

I have special thanks for my co-drivers, Nigel Drake and my wife, Rosemary, who spent long days in four-wheel drive vehicles, sometimes in difficult country. Nigel produced many outstanding photographs of features which through limitations of cost could not be included.

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SUMMARY OF RECOMMENDATIONS : GEOLOGICAL SITES AND MONUMENTS

Three concepts explained in the Dossier Explanation (p.6) are incorporated in the Summary:

a classification of Sites and Monuments with classes ranking between I and VI, geological themes - 'Archaean Stratigraphy' for Marble Bar and Chinaman Pools is an example, and 'outline' sites and monuments for which partial recommendations are made.

Geological Monuments and outline monuments identified by asterisks are recommended for listing on the Register of the National Estate.

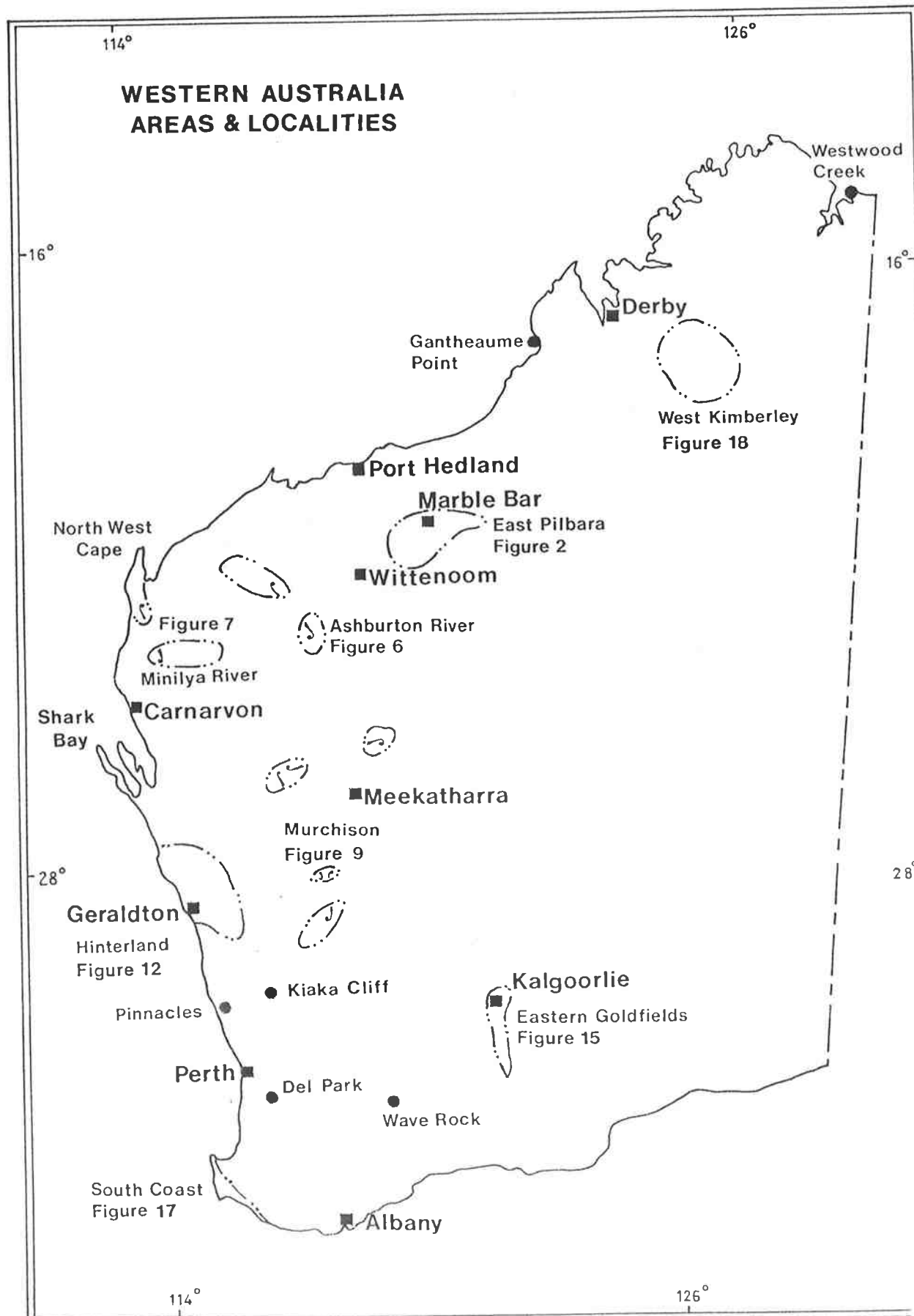


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INTRODUCTION

Aims

Geologists have a duty to gather information on important geological localities and to impart this information to foster public interest in the national geological heritage. In Western Australia this responsibility is even more compelling for here a rich and diverse geological endowment distinguished by localities of universal importance is scattered across an enormous terrain. The study therefore was directed towards:

ascertaining the distribution of fine geological localities beyond the country around Perth examined during a similar survey in 1979,

assessing the significance and value of their features,

recommending fine geological localities for listing in the Register of the National Estate,

considering ways and means of protecting these localities,

and making proposals for the presentation and public use of selected geological localities.

Antecedents

Twenty five years ago the Western Australian Subcommittee of the Australian Academy of Science Committee on National Parks issued a report on 'National Parks and Nature Reserves in Western Australia' and in Chapter 6 'Geological Reserves in Western Australia' contributions of B.E. Balme, P.E. Playford and A.R. Wilson are found. Some 30 geological reserves were proposed and more than half are considered in the present report. Five of the reserves are now incorporated within the National Parks of Kalbarri with the Murchison River Gorge (44)*, Windjana Gorge (81), Tunnel Creek (82), Geikie Gorge (85) and Wolf Creek Crater (93).

* serial number; see 'Summary of Recommendations: Geological Sites and Monuments' (p.(i))

A continuing interest in the geological heritage brought about the setting up of a Geological Sites Committee in the 1970s by the Western Australian Government with aims similar to those just stated. This Committee gathered information on geological localities in many parts of the State and although a lack of funds did not allow its activities to develop, a large number of the localities recommended to the Committee are discussed in this report also.

Perth and Southwestern Area Survey

An important advance was made when the Western Australia Division of the Geological Society of Australia Incorporated received a grant of \$7500 from the National Estate Program of the Australian Heritage Commission in 1978 and this sum, administered by the Western Australian Heritage Committee, provided the means for examining geological localities near Perth and these endeavours bore fruit in 1979 with the report: 'Important Geological Sites in the Perth and Southwestern Area of Western Australia' by T.C. Lemmon, R.D. Gee, W.R. Morgan and C.R. Elkington.

The objectives of the Perth survey were for practical purposes similar to the aims set out in the initial paragraph. The 1979 report is divided into two parts, Part A being a discussion on the 'Identification and Protection of Geological Sites and Monuments' and Part B 'Documentation of Geological Sites and Monuments'. In Part A many subjects relevant to this survey are considered, including:

- Why Protect Geological Sites?
- Identification of Sites and Monuments
- The Nature of Monuments and Sites
- Site Protection Schemes Outside Western Australia
- Land Tenure in Western Australia
- Present Legislation Available for Site Protection
- Non-legislative Methods of Site Protection
- An Approach to Protection

These discussions provide adequate reference sources and apart from the matters of suitable land reservations for important geological localities, and the protection and presentation of sites, the topics are not taken up again.

Geological Sites and Monuments: Definitions

A significant concept developed during the Perth study and applied in this survey is that of Geological Sites and Geological Monuments. These are defined as:

- Sites - those localities which illustrate specific relationships, rock-types or processes, and as such are useful for reference, education or research;
- Monuments - these are sites which have outstanding and unique significance, and contribute to the physical heritage of the country.

The localities now recommended are proposed as Geological Sites and Geological Monuments on the basis of these definitions.

During the Perth investigation 39 sites were identified as having important scientific value and of these, 15 were recommended as Geological Monuments for listing on the Register of the National Estate:

Alkimos Dunes Complex
Armada Road Board Quarry
Armada Shale Quarry
Fairbridge Bluff
Herschell Limestone
Maddington Quarry
Meckering Fault Scarp
MacIntyre Gully

Minim Cove
Molecap Hill
Noondeening Hill
Peppermint Grove Limestone
Point Peron
Rottnest Elevated Platforms
and Notches
Windmill Hill Cutting

IMPORTANT GEOLOGICAL LOCALITIES BEYOND THE PERTH REGION

Background

In January 1985 a sum of \$25,600 was allocated to the Western Australian Division of the Geological Society of Australia Incorporated by the Australian Heritage Commission to complete the survey of geological monuments and sites in Western Australia and in the following June the writer met the Geological Monuments Subcommittee of the Division to discuss ways and means of conducting the survey.

A number of files on recommended geological localities were held by the Subcommittee and these contained lists, and a few summaries and draft descriptions of features. The lists proved to be useful and of the 50 or so localities recorded almost 40 are now recommended as Geological Monuments or Sites. In the files indications were found of the existence of a second accumulation of information on geological localities and eventually this was identified as the file collection of the Geological Sites Committee. This collection holds well-documented recommendations especially for the younger sedimentary basins in the west of the State and many of these are also proposed as Monuments or Sites.

Factors Influencing The Survey

Among the more important factors which influenced the conduct of the survey were:

the poor representation of geology of many parts of the State in inherited lists of localities,

and the curtailment of field examinations; this was due to a slender budget and the size of Western Australia.

Many parts of the State were barely represented or were not represented at all on lists of recommended localities and while obviously it was beyond realism to redress all shortcomings, the Northwest was singled out for improvement for here lie the great Archaean and Proterozoic basins for which the geology of Western Australia is justly famous, and there are sealed roads and distances from Perth are not altogether excessive. Opinions were sought from many geologists and nearly 20 localities were added to Northwest lists. Among other features drawn into the survey were lamproites of West Kimberley and meteorite impact structures to accompany Wolf Creek Crater (93).

Field examinations are necessary for first-hand experience is needed to assess the significance and value of many geological features. Unfortunately field examinations were curtailed by a modest budget and the high cost of getting a co-driver and a properly equipped four-wheel drive into remote areas, and funds were not sufficient to allow a visit to the Devonian reef complexes in the Kimberley and other geology there, and for these features 'outline recommendations' (p.8) are made.

Modern Sedimentary Environments, Caves and Mining Areas

Initial decisions were made not to consider the special topics of modern sedimentary environments, and most caves including those with bone and other fossil deposits. Active mining areas were also excluded apart from Moolyella (3) to avoid obvious complications.

Among the modern sedimentary environments of Western Australia, Shark Bay with Hamelin Pool and its renowned stromatolites is of universal geological importance and is discussed briefly with Other Localities of Geraldton Hinterland on p. 179.

Separate studies are proposed for modern sedimentary environments and caves in the General Recommendations (p. 279).

Nature of Recommendations and Records of the Survey

No legislation exists specifically to protect important geological localities and in the absence of legislative guidelines, the recommendations made are of a preliminary character.

Many of the recommended Geological Sites and Monuments are shown on aerial photographs and prints of these are bound into the report and original photograph pairs are preserved in the Addendum, the Records of the Survey. These aerial photograph pairs allow office-based assessments of recommendations within their geographical and geological settings.

Land tenures are rarely depicted on photographs as tenure is seldom complicated, even in the wheat belt.

Boundaries of recommended areas are tied into prominent fences or natural features where possible and as areas of ground are measured from photographs, these are approximations.

A First-Pass Survey

This 'first-pass' survey is by no means a complete account of fine geological localities beyond the Perth region.

Geological Sites and Monuments: Dossier Explanation

A uniform dossier is used to set out information on localities but it is varied when two or more closely related features are discussed. The method differs in a number of ways from the system employed for the Perth region survey for the dossiers are aimed at the non-specialist; technical terms are suppressed where possible and systematic geological descriptions are kept short since for almost every locality descriptions are available in the literature. The headings shown in the Marble Bar and Chinaman Pools dossier (pp.13-14) are as follows:

1. MARBLE BAR AND CHINAMAN POOLS

STATEMENT OF INTEREST

Location

SIGNIFICANCE and VALUE

GEOLOGICAL NOTE

Reference

TENURE, ACCESS and POSSIBLE THREATS

RECOMMENDATIONS

Protection

Proposal

Presentation

Statement of Interest

This is a brief popular account of the geology of the locality or group of localities, with **Location** latitude and longitude derived from geological map sheets.

Significance and Value

The Subcommittee requested that a system of classifying features should be set up to identify localities of international and national importance and the following method was devised:

Levels of Geological Significance

Class I	International Importance
II	National Importance
III	State Importance
IV	Local Importance

Qualities

V	Public Interest
VI	Historic Importance

Theme

The nature of the principal geological interest, for Marble Bar and Chinaman Pools: 'Archaean Stratigraphy'.

Values

Information Values

Research
Reference
Education

Landscape Values

Outstanding Natural Beauty
Great Landscape Value
Attractive Setting

This example from the dossier of Marble Bar and Chinaman Pools illustrates how the concepts are set out:

Classes II and V : Archaeal Stratigraphy
Reference
Attractive Setting

A number of comments are necessary:

naturally the system is more arbitrary than regulated,

Geological Monuments are assigned 'Geological Significance' Classes I, II or III while Geological Sites draw levels of III and IV,

'Quality' Class V signals a high potential for public presentation,

information values are hierarchal with research implying reference and reference inferring education,

and landscape values of course reflect personal impressions.

Geological Note

This is a brief explanation of such geological background as seems to be warranted and includes the **Reference**.

Tenure, Access and Possible Threats

Tenures and ownership of land and mining tenements change and have done so during the study and whenever recommendations are followed up tenure and ownership (and addresses) should be checked. Many mining tenements prove to be ephemeral and for this reason tenements were not investigated beyond recording their existence or where complex, specifying the relevant Mines Department plan. In dossiers, E represents Exploration Licence, M the Mining Lease and P the Prospecting Licence.

Access instructions should be treated with caution. Access to at least one locality varied during the course of the survey. Distances were measured by odometer and may not be exact. Four-wheel drive (4WD) is used to describe access during good conditions but following rain any track may be 4WD, or not negotiable at all. Aerial photographs are essential navigational aids on leaving main roads. When visiting localities beyond the wheat belt, an experienced co-driver and a properly equipped and provisioned four-wheel drive with radio are needed, and 'out-back' travel precautions must be followed.

Possible Threats in remote areas are difficult to foresee and observations made will need to be re-appraised over the years.

Recommendations

These contain four or five short sections. The first incorporates a recommendation for a **Geological Monument** or a **Geological Site**, or an **outline monument or site** and recommendations with few exceptions are shown on prints of aerial photographs held in the Records of the Survey or are defined in terms of existing Class A and Class C Reserves; Marble Bar and Chinaman Pools is an example of the latter approach (p.14). The qualification **outline** is applied when the geology of a locality clearly warrants site or more usually monument status but no firm recommendation can be made by reason of a lack of information relevant to the survey's needs:

usually a large-scale map is not available (Wittenoom Gorges-12), or geology is too scattered and complex to assess during a brief visit (Mount Singleton-38),

or geology although well-known was not examined (Devonian reef complexes-81 etc.), meteorite craters apart for firm recommendations can be made for these simple structures.

Protection. All geological localities are vulnerable to abuse but those with fragile or rare rocks, rare minerals and fossils are more susceptible to ruin and such localities are assigned a high priority for protection, attracting an extraordinary need for careful use. Other localities should be used with normal care. High priority protection and normal care are considered in the Discussion section (p.271).

Proposal. Where made it concerns usually a need for an illustrated guide or a large-scale geological map.

Presentation. Accessible localities with strong visual appeal or with geology readily appreciated by the non-specialist and which are unlikely to be damaged by increased use are distinguished here. Presentation is also a subject of the Discussion section.

A list of **consultees** terminates the Recommendations.

PART 1 : COUNTRY EXAMINED

Strelley Pool West and Carawine Pool of East Pilbara,
and Jack Hills in the Murchison were not examined
but are considered under Part 1.

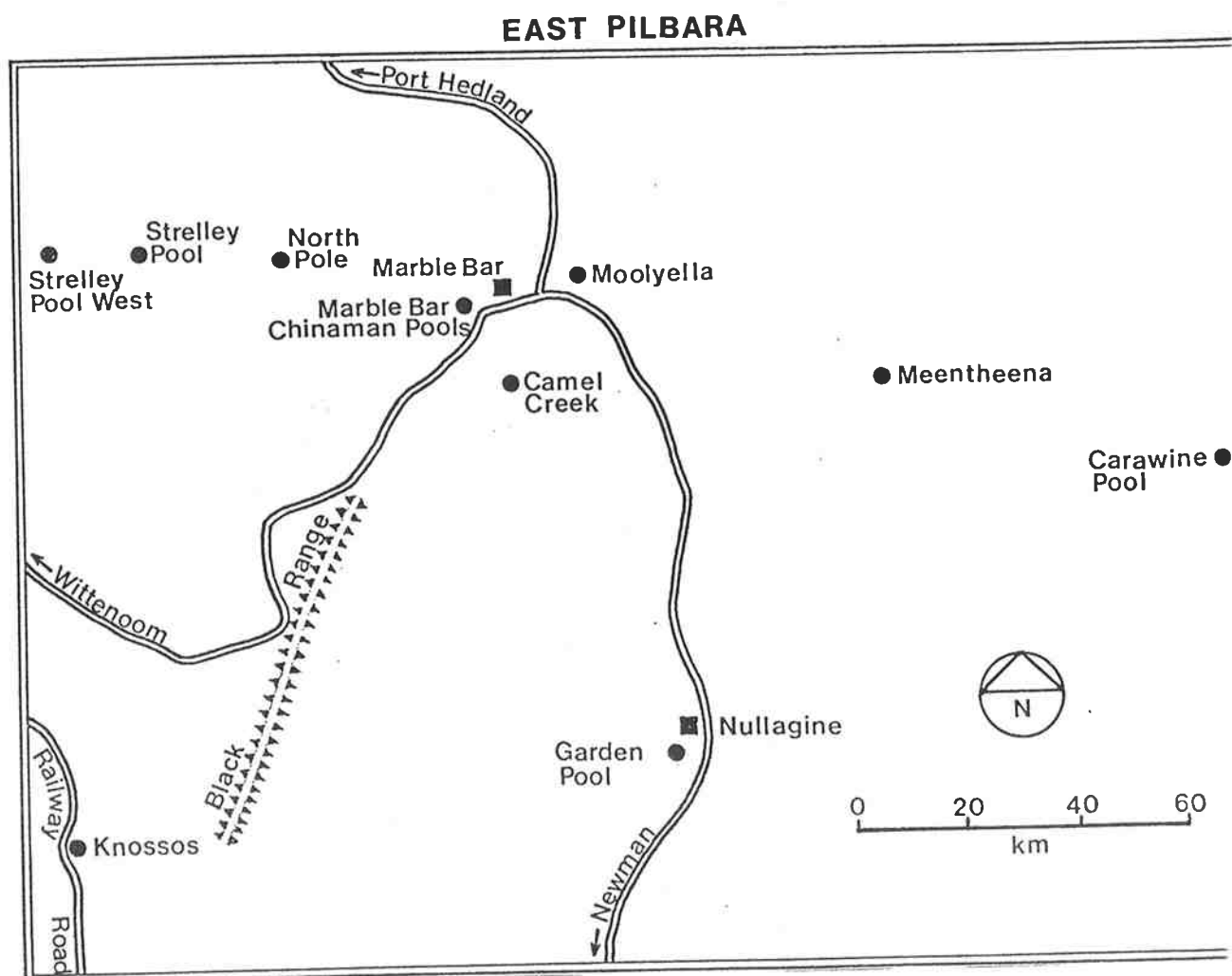


Figure 2

EAST PILBARA

Few localities in East Pilbara were put forward as deserving attention prior to the survey but eight were added, and their locations are shown on Figure 2 and the following recommendations are made:

- | | |
|----------------------------------|------------------|
| 1. Marble Bar and Chinaman Pools | Monument |
| 2. Camel Creek | Monument |
| 3. Moolyella | Site |
| 4. Garden Pool | Monument |
| 5. Black Range | outline monument |
| 6. Carawine Pool | outline monument |

Earliest Life Known On Earth Archaean Microfossils and Stromatolites

- | | |
|-----------------------|------------------|
| 7. North Pole | outline monument |
| 8. Strelley Pool | Monument |
| 9. Strelley Pool West | outline monument |
| 10. Meentheena | Monument |
| 11. Knossos | Monument |

East Pilbara contains one of the world's best exposed portions of the Archaean, the most ancient rocks of Earth's crust. There is no doubt that this geology is under-represented in the study, a weakness which becomes more apparent when one considers that the Pilbara is becoming world famous for its widespread evidence of the origins of life on Earth and that the localities yielding this evidence are subject to indiscriminate collecting.



Plate 1

THE MARBLE BAR

A.H. Hickman

Red and white banded cherts at Marble Bar Pool
are perhaps the best-known of the rock
formations of the Pilbara

1.

MARBLE BAR and CHINAMAN POOLS

STATEMENT OF INTEREST

One of the best-known rock formations of Western Australia, the strikingly beautiful red and white banded cherts crossing the Coongan River at Marble Bar Pool belong to the Archaean Towers Formation, a marker horizon of the Pilbara which although only 0.5 km thick can be traced over great distances. Splendid exposures of pillow basalts accompany the red and white cherts and clear outcrops of grey and white banded cherts and dacitic agglomerate a little downstream at Chinaman Pool complete one of the most distinguished geological sections in the State.

Location: 1:250,000 Geological Series Marble Bar

lat 21 11 S long 119 42 30 E

SIGNIFICANCE and VALUE

Classes II and V : Archaean Stratigraphy
Reference
Attractive Setting

GEOLOGICAL NOTE

Pillow structures establish that this part of the Warrawoona Group faces west and the lowest rock, dacitic agglomerate of the Duffer Formation, outcrops at Chinaman Pool. To the south, towards Marble Bar Pool and beyond, agglomerate is overlain by chert and pillow lava of the Towers Formation, including the Marble Bar Chert Member.

Red and white banded chert, although occurring in a number of localities, is generally uncommon in the Pilbara.

Reference: Hickman, A.H., 1983, Geology of the Pilbara Block and its environs: West. Australia Geol. Survey Bull. 127.

Plates: 1 and 2

TENURE, ACCESS and POSSIBLE THREATS

Class A Reserve No. 24096 'Park and Recreation' vested in the Shire of East Pilbara, incorporates this part of the Coongan River and lies some 4 km southwest of Marble Bar. It is reached from the Wittenoom road where there is a signpost.

The 'Park and Recreation' area is supervised by the Shire and there are no obvious threats.

RECOMMENDATIONS

Class A Reserve No. 24096 of some 97 ha should be deemed a Geological Monument.

- Protection : high priority; use of the Reserve is supervised.
- Proposal : a large-scale map and explanation of the geology is desirable.
- Presentation : notice boards explaining the nature of the cherts and significance of the pillow lavas should enhance public enjoyment of this attractive locale.

The Shire of East Pilbara should be consulted.



Plate 2

MARBLE BAR PILLOW LAVAS

J.D. Carter

Magnificent pillow lavas are overlooked
by many visitors

STATEMENT OF INTEREST

A pristine exposure of columnar rhyolite of the Archaean stands in an elegantly sculpted cliff on the north bank of Camel Creek some 16 km south of Marble Bar. Columnar rhyolite is a rare physiographic feature and this example has exceptional visual appeal.

It was examined by an international geological excursion in 1980.

Location: 1:250,000 Geological Series Marble Bar

lat 21 19 S long 119 46 15 E

SIGNIFICANCE and VALUE

Class III : Archaean Columnar Rhyolite
Education
Attractive Setting

GEOLOGICAL NOTE

Camel Creek columnar rhyolite is part of the Wyman Formation, a thick porphyritic rhyolite unit at the top of the Archaean Warrawoona Group. Columnar jointing is developed in the Wyman Formation at several localities though the best example is at Camel Creek where the columnar cliff face is about 75 m long and some 10 m high.

Reference: Hickman, A.H., 1983, Geology of the Pilbara Block and its environs: West. Australia Geol. Survey Bull. 127.

Plate: 3

TENURE, ACCESS and POSSIBLE THREATS

This part of Camel Creek falls within Pastoral Lease 398/715 of Mr. C.J. Edwards, Limestone Station, P.O. Box 9, Marble Bar, WA 6760, and is covered by mining tenements E 45/351 and P 45/954.

From Marble Bar the Wittenoom road is taken for 12 km before turning south onto the Corunna Downs road which is followed for 6.5 km to Camel Creek. Then turn east onto a track and after 2.6 km find the columnar rhyolite at a minor tributary junction (4WD).

There are possible threats. These unusually shaped and altogether pleasing rhyolite columns could attract indiscriminate collectors, and vandals with paint.

RECOMMENDATIONS

A Geological Monument of approximately 30 ha is recommended as shown on aerial photograph WA 1252 Marble Bar Run 6 No. 5160 (p.17).

Protection : a high priority as this elegant but rather small exposure could be easily despoiled.

Presentation : excellent visual appeal but access is difficult; effective surveillance such as that given Marble Bar and Chinaman Pools would be a pre-requisite for public presentation.

The owners of Pastoral Lease 398/715 and mining tenements, and the Shire of East Pilbara should be consulted.

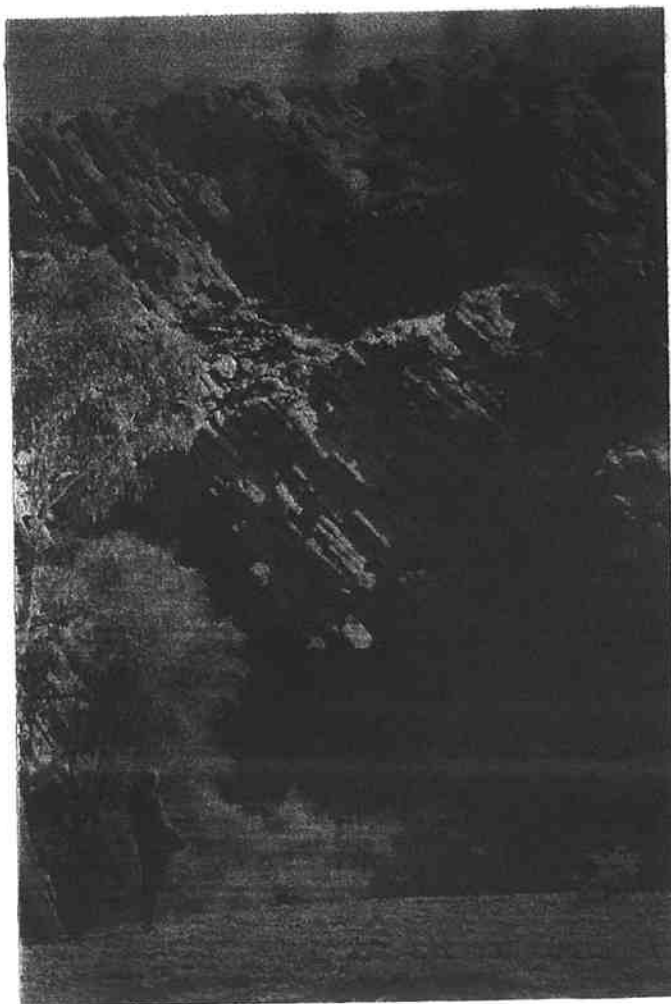


Plate 3

CAMEL CREEK

J.D. Carter

Elegant columnar rhyolite of the Archaean

CAMEL CREEK

MONUMENT

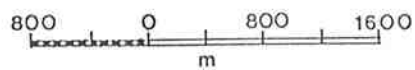
Marble Bar road

Camel Creek

Columnar rhyolite

WA 1252. MARBLE BAR RUN 6 (5126 - 5167) 20,000' 152.56 min 18. 8. 70. PROJ. L12.

5160



STATEMENT OF INTEREST

The intrusive contact between granite of some 3200 m.y. and tin-bearing Moolyella Adamellite (about 2800 m.y.) is seen in a clear but small exposure near tin workings 18 km east of Marble Bar.

This locality is visited by geological excursions.

Location: 1:250,000 Geological Series Marble Bar
lat 21 8 45 S long 119 55 E

SIGNIFICANCE and VALUE

Class III : Intrusive Relationship
Reference

GEOLOGICAL NOTE

Granodiorite of the Mount Edgar Batholith is intruded by Moolyella Adamellite with sharp contact where the older gneissic granitoid contrasts markedly with the more homogeneous, tin-bearing adamellite.

Reference: Blockley, J.G., 1980, Tin deposits of Western Australia with special reference to the associated granites: West. Australia Geol. Survey Mineral Resources Bull. 12.

Plate: 4

TENURE, ACCESS and POSSIBLE THREATS

This locality falls within Class C Reserve No. 7080 'Stopping Place for Travellers and Stock, etc' vested in the Shire of East Pilbara, and is held under mining tenement E 45/345 of Endeavour Resources Ltd. of 31 Ventnor Avenue, West Perth. It lies next to tin workings where operations have ceased temporarily (1986).

From Marble Bar the Nullagine road is taken for 13.4 km to turn left onto the Bamboo road for 2.5 km; then turn right for 2.4 km and cross the dam to find a track running southwards for 2 km (4WD). Aerial photographs showing the contact should be used to locate it.

The contact lies within metres of tin workings and spoil from these could eventually conceal this exposure.

RECOMMENDATIONS

A Geological Site is recommended for a strip 50 m wide for 200 m of the contact zone within the location shown on aerial photograph WA 1253 Marble Bar Run 3 No. 5052 (p.20).

Protection : normal care; this is a useful reference site and Endeavour Resources should be invited to avoid burying it with mine spoil. Cairns could be set up to mark the contact.

Presentation : not suitable; a geological reference site.

Endeavour Resources Ltd. and the Shire of East Pilbara should be consulted.



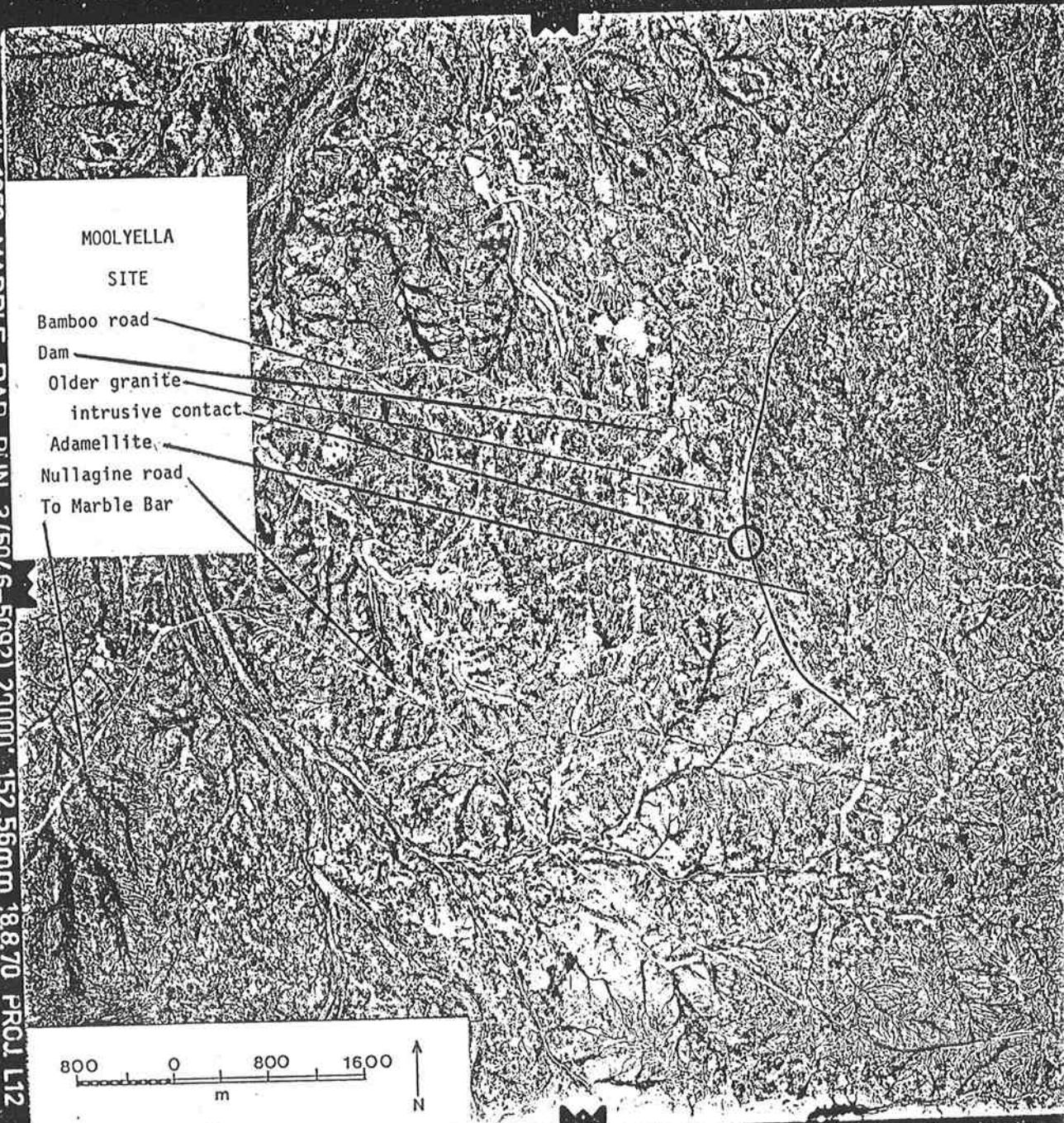
Plate 4

MOOLYELLA

J.D. Carter

Older granitoid of the Mount Edgar Batholith
in the foreground is intruded by Moolyella Adamellite

5052 WA 1253 MARBLE BAR RUN 3 (5046-5092) 20000' 152.56mm 18.870 PROJ L12



4.

GARDEN POOL

STATEMENT OF INTEREST

The angular unconformity in the hill overlooking Garden Pool near Nullagine is of historical importance for it was from this Nullagine River section that A.G. Maitland described in 1905 one of the first of the major unconformities to be recognised in Western Australia. Here steeply inclined schistose rocks of the Archaean Mosquito Creek Formation are overlain by gently dipping conglomerate and sandstone of the Hardey Sandstone, the lowermost formation of the Fortescue Group which is also Archaean in age.

Location: 1:250,000 Geological Series Nullagine
lat 21 55 S long 120 5 E

SIGNIFICANCE and VALUE

Classes III and VI : Archaean Unconformity
Reference
Attractive Setting

GEOLOGICAL NOTE

The conglomerate and sandstone are assigned to the Beatons Creek Conglomerate Member of the Hardey Sandstone (c. 2700 m.y.) and these are lithologically similar to the sandy and shaley metasediments of the Mosquito Creek Formation (c. 3000 m.y.) from which they were derived.

Reference: Maitland, A.G., 1905, Further report on the geological features and mineral resources of the Pilbara Goldfield: West. Australia Geol. Survey Bull. 20.

Plate: 5; Figure: 3

TENURE, ACCESS and POSSIBLE THREATS

Garden Pool lies within Class C Reserve No. 2804 'Common' vested in the Shire of East Pilbara and this portion is held under mining tenement P 46/490.

From Nullagine the Newman road is taken for 1.6 km to the signpost 'Garden Pool 3 km'.

These robust hills are unlikely to be threatened.

RECOMMENDATIONS

The hill on the south side of Garden Pool lying within Class C Reserve No. 2804 'Common' is recommended as a Geological Monument of some 50 ha as shown on aerial photograph WA 1405 Nullagine Run 16 No. 5209 (p.23).

Protection : normal care.

Presentation : a notice board explaining the unconformity could be considered though the feature lacks obvious visual appeal.

The owner of the mining tenement and Shire of East Pilbara should be consulted.



Plate 5

GARDEN POOL

J.D. Carter

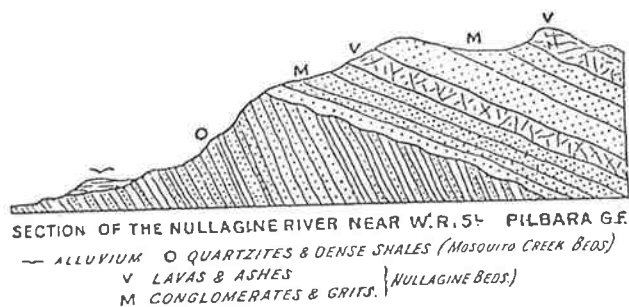
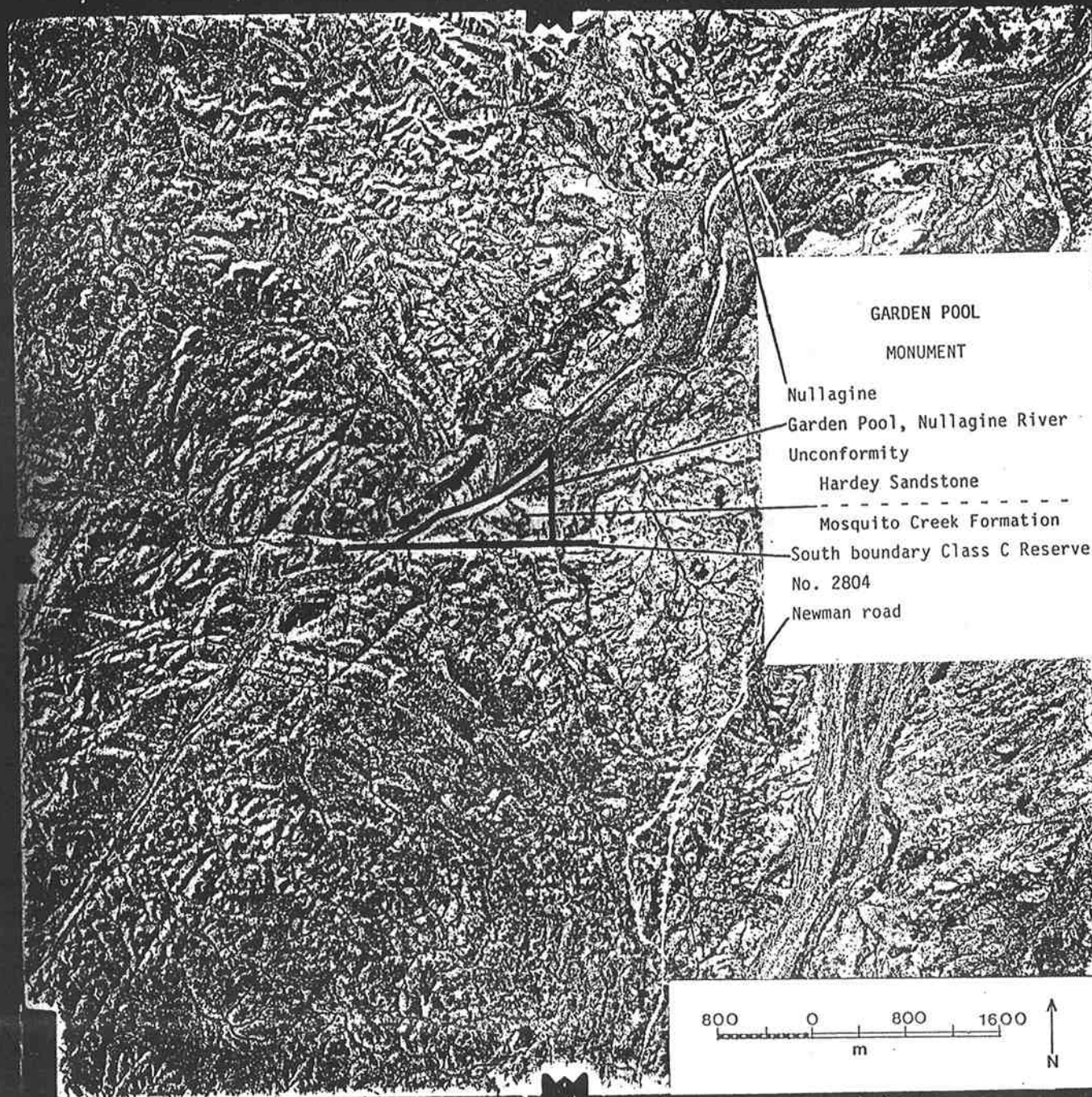


Figure 3

Garden Pool - Gibb Maitland's Sketch

The Plate is clearly explained by the sketch in West. Australia Geol. Survey Bull. 20



WA 1405 NULLAGINE 1:250000 RUN 16 (5204-5254) 1:400000 152.56mm 28.8.72 PROJ. M 22

5209

STATEMENT OF INTEREST

In geomorphological interest equal to the Murchison River Gorge and the finest example of dyke topography in Western Australia, Black Range dyke, a bold gabbroic rampart of the Archaean some 60 m high and up to 200 m in width, rises abruptly out of granite plains to dominate scenery for the 100 km of its length. It has attracted the attention of travellers from early times and an unusual agglomerate at its northern termination was examined by an international geological excursion in 1980.

Location: 1:250,000 Geological Series Marble Bar
lat 21 35 S long 119 28 E

SIGNIFICANCE and VALUE

Classes III and V : Dyke Geomorphology
Education
Great Landscape Value

GEOLOGICAL NOTE

Black Range dyke has been the subject of petrological, palaeomagnetic and geochronological studies. An age of 2280 m.y. is likely to be too young as the dyke appears to have been a feeder for basalts of the much older Fortescue Group. Near the Marble Bar-Wittenoom road at its northern termination, an agglomerate of angular clasts of basalt and dolerite in a tuff-like matrix includes rounded boulders of granitic rock up to half-a-metre in diameter.

References: Lewis, J.D., Rosman, K.R.J., and de Laeter, J.R., 1975, The age and metamorphic effects of the Black Range dolerite dyke: West. Australia Geol. Survey Ann. Rept. 1974, p.80-88.
Hickman, A.H., 1980, Archaean Geology of the Pilbara Block: Excursion Guide Second International Archaean Symposium Perth 1980, Geological Society of Australia Inc., W.A. Division.

Figure: 4

TENURE, ACCESS and POSSIBLE THREATS

Tenures have not been investigated other than to note that the interesting northern termination of the Range appears to be

incorporated within unvested Class C Reserve No. 4974 'Water' of 1034 ha.

The Marble Bar-Wittenoom road passes close to Black Range's northern termination, and roads cross the Range where it is cut by the Shaw River and Cooglegong Creek.

Black Range dyke is not threatened.

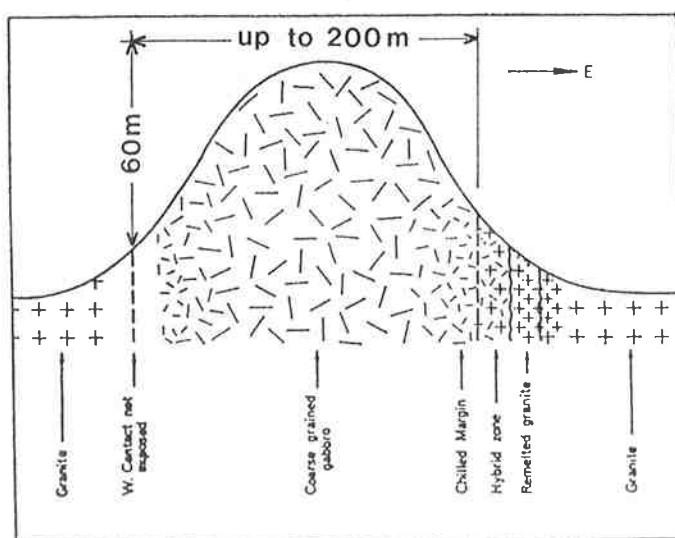
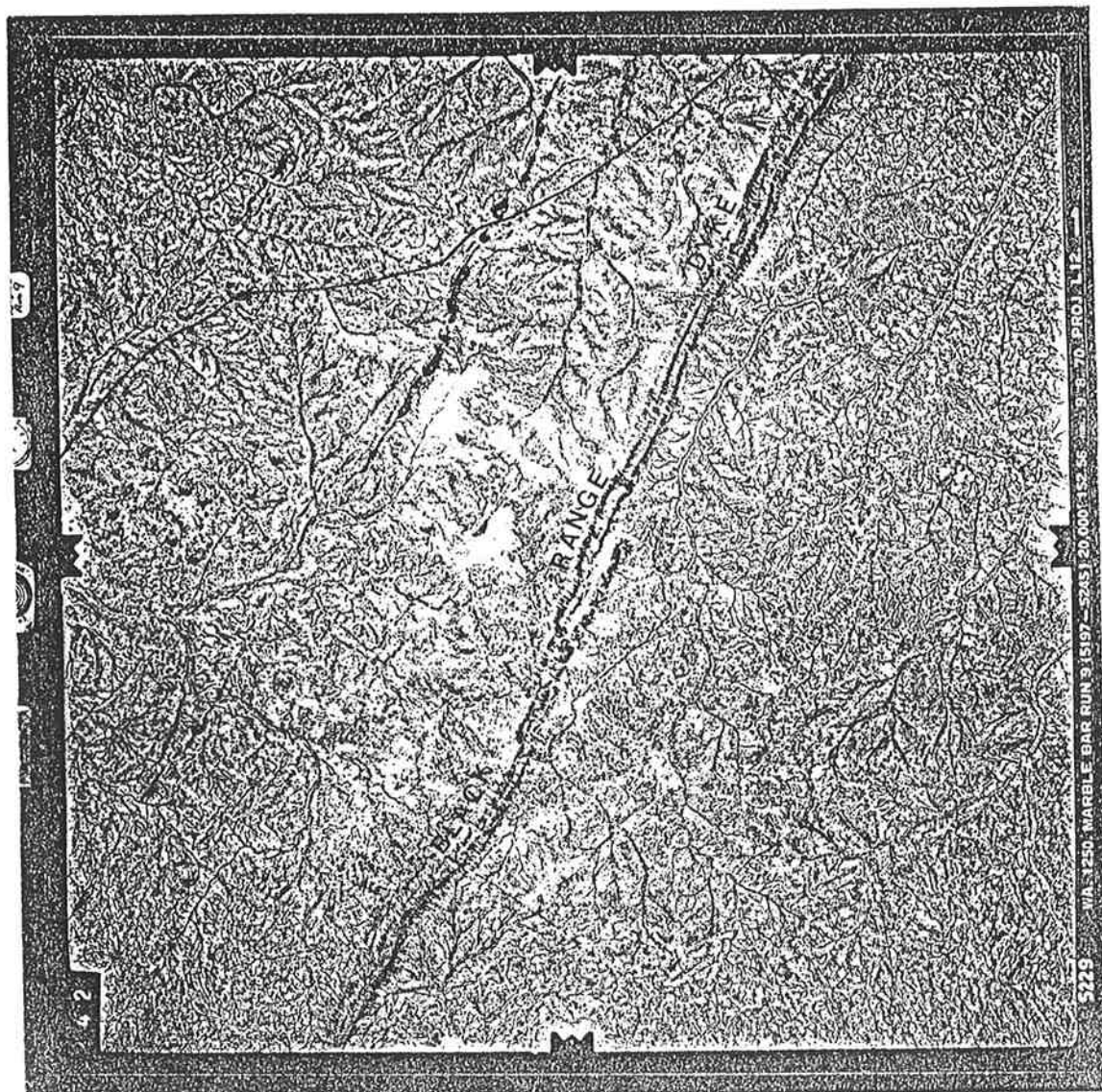
RECOMMENDATIONS

Accessible portions of Black Range where public lookouts could be established such as the northern termination near Marble Bar road should be considered for one or more Monuments.

Protection : normal care.

Presentation : suitable; should the Marble Bar-Wittenoom road be sealed and traffic increases, the possibility of a rest area with notice board and lookout should be investigated. A Geological Monument should include part of the boulder agglomerate.

The Shire of East Pilbara should be consulted.



Diagrammatic cross-section of the Black Range dyke.

Some 10 kilometres of Black Range is shown with midpoint at lat. 21 30 S where the dyke extends northeast for 10 km and southwest for nearly 90 km. Marble Bar road is seen to the north on the west of the Range.

Figure 4

(G.S.W.A., Ann. Rept., 1974)

6.

CARAWINE POOL

This pool in the Oakover River Valley is notable for a nearby exposure of a glaciated pavement but it was too distant to visit during the 1986 inspection and no specific recommendation is made.

Glacial deposits in the region are assigned to the Permian Paterson Formation (formerly 'Braeside Tillite') and striated glaciated pavements are found on older rock surfaces, the most frequently illustrated being the ice-scoured surface of Proterozoic Pinjian Chert Breccia 6 km northeast of Carawine Pool (West. Australia Geol. Survey Bull. 127, p.137). A number of these apparently small and relatively inconspicuous features are scattered through the Oakover Valley (1:250,000 Geological Series Nullagine), and consideration of one or more for listing as a Class III Geological Monument should follow inspections of larger glaciated surfaces though Carawine Pool appears to be the best of these features.

The pavements are robust and lie in remote localities and are unlikely to suffer damage.



Plate 6

NORTH POLE CHERT RIDGES

J.D. Carter

Microfossils were recovered from chert blocks
on these ridges

ARCHAEAN MICROFOSSILS AND STROMATOLITES OF THE PILBARA

STATEMENT OF INTEREST

L.E. de la Hunty of the Geological Survey of Western Australia when mapping manganese deposits in 1959, found remains of ancient life in the Tumbiana Formation of the Archaean Fortescue Group now dated at about 2700 m.y. and since his discovery the Pilbara has become world famous for its testimony to the earliest life known on Earth. This evidence depends upon microfossils and stromatolites: microfossils are morphological fossils, either the remains of a microscopic organism or part of a larger organism too small to be studied without the aid of a microscope and stromatolites are organosedimentary structures commonly laminated and megascopic, produced by the metabolic activities of microorganisms.

As evidence of the great antiquity of Pilbara rocks began to emerge from geochronological studies, the search for signs of early geological processes intensified and in the late 1970s, in the oldest strata, cherts of the Warrawoona Group, stromatolites c.3500 m.y. in age were discovered at North Pole and Strelley Pool and these together with microfossils are the remains of the earliest life known on Earth. Over the years the Tumbiana Formation has been shown to be rich in Archaean life with the Meentheena and Knossos localities especially renowned for their abundant and beautifully preserved stromatolites, and the Carawine Dolomite also has yielded early life forms. The Archaean microfossil and stromatolite record of the Pilbara may be summarised thus:

<u>Strata with Ancient Life</u>	<u>m.y.</u>	<u>Locales Considered</u>
Hamersley Group Carawine Dolomite	c.2500	none (documentation poor)
Fortescue Group Tumbiana Formation	c.2700	Meentheena and Knossos
Warrawoona Group Towers Formation and adjoining horizons	c.3500	North Pole, Strelley Pool and Strelley Pool West

The older locales are of international repute. In the National Geographic Society publication of 1982 'On the brink of tomorrow: Frontiers of Science' the sole reference to Australia relates to stromatolites of Western Australia and shows a field party at North Pole 'in search of life's beginnings'.

(7.)

NORTH POLE

Location: 1:250,000 Geological Series Marble Bar
lat 21 6 S long 119 24 E

SIGNIFICANCE and VALUE

Class I : Palaeontology and Palaeoenvironment
Research
Great Landscape Value

GEOLOGICAL NOTE

Cherty metasediments of the Towers Formation are intercalated with basaltic rocks in a sequence of very low metamorphic grade and in some cherts the remains of evaporites with exquisitely preserved sedimentary structures are seen. Microfossils and stromatolites were identified in cherts in the lower part of the sequence at several localities by a number of parties since the late 1970s and an account of the sequence of discovery events is given in the Precambrian Paleobiology Research Group publication referred to below. Lowe (1983) describes a slightly younger stromatolitic horizon which he informally terms the Strelley Pool Chert.

Buick (1985) disputes the authenticity of Warrawoona Group evidence for early life, stating 'that none of the stromatoloids discovered .. are undoubted stromatolites'. ' .. none possess the microstructural detail or the microfossil content to allow certain interpretation'. It is not clear how certain interpretation of ancient rudimentary life can be reached but in any event, Buick's doubts are not immediately relevant to this survey which is concerned in part with the conservation of geological evidence.

Despite considerable published information, it is extremely difficult to locate precise positions of cherts with organic remains and in September 1986 domical stromatolites were seen at only one locality, though microfossiliferous chert blocks capping low hills were also identified (K. Grey pers. comm.).

References: Schopf, J.W. (Ed.), 1983, Earth's Earliest Biosphere Its origin and evolution: Princeton University Press.

Lowe, D.R., 1983, Restricted shallow-water sedimentation of early Archean stromatolitic and evaporitic strata of the Strelley Pool Chert, Pilbara Block, Western Australia: Precambrian Research 19, p.239-283.

Buick, R., 1985, Life and conditions in the early Archean: Evidence from 3500 m.y. old shallow-water sediments in the Warrawoona Group, North Pole, Western Australia: Univ. West. Australia Science Doctor of Philosophy thesis (unpublished).

Plates: Frontispiece and 6

TENURE, ACCESS and POSSIBLE THREATS

Areas of interest at North Pole lie within Panorama Pastoral Lease 398/623 with owners Messrs. K.H. French and M.D. French contacted through P.O. Box 657, Port Hedland, WA 6721. Domical stromatolites are covered by mining tenement M 45/216.

North Pole is best approached from Marble Bar by taking the Port Hedland road for some 93 km and turning left (that is south, a few kilometres east of the Shaw river crossing) for 43 km to the Panorama Station and barite mine road junction.

The indiscriminate removal of stromatolites is already a serious problem and is considered in the Discussion at the end of this section (p.39).

RECOMMENDATIONS

Information on microfossil and stromatolite localities at North Pole is too incomplete to allow a firm recommendation for a Geological Monument to be made. However, eventually a Class I Monument (high priority protection) should include the microfossil and stromatolite localities shown on aerial photograph WA 1257 Marble Bar Run 2 No. 5021 (p.33).

(8.)

STRELLEY POOL

Location: 1:250,000 Geological Series Marble Bar
lat 21 6 30 S long 119 8 15 E

SIGNIFICANCE and VALUE

Class I : Palaeontology and Palaeoenvironment
Research
Great Landscape Value

GEOLOGICAL NOTE

Discoveries of stromatolites in cherts at a higher stratigraphical level than the first North Pole microfossil and stromatolite finds are described by Lowe (1983) who refers to this sequence as the Strelley Pool Chert after a type section near picturesque Strelley Pool on Six Mile Creek where the creek debouches onto the Shaw River plains through great chert cliffs. Lowe believes the Strelley Pool Chert contains 'some of the best preserved and most widespread stromatolites known from early Archean rocks together with an impressive record of Archean evaporite sedimentation'. This Chert outcrops in the North Pole area and at Spinnaway Creek 50 km southeast of Marble Bar. Microfossils have been identified in chert at Strelley Pool (B. Packer pers. comm.).

Reference: Lowe, D.R., 1983, Restricted shallow-water sedimentation of early Archean stromatolitic and evaporitic strata of the Strelley Pool Chert, Pilbara Block, Western Australia: Precambrian Research 19, p.239-283.

Plates: 7 and 8

TENURE, ACCESS and POSSIBLE THREATS

Unvested Class C Reserve No. 13619 'Timber' incorporates the ground of interest which is partially covered by mining tenements (Mines Department plan North Shaw).

To reach Strelley Pool from the Marble Bar - Port Hedland road, take the North Pole road which leaves southwards a few kilometres east of the Shaw River crossing. After 30.5 km a grid is reached; turn west for 26.6 km, crossing the Shaw River bed and leaving the graded track which turns south at 20.5 km for the rougher westward track to Strelley Pool (4WD).

Over-collecting stromatolites and microfossiliferous rocks is an obvious threat.

RECOMMENDATIONS

A Geological Monument of 2.58 km² corresponding to Class C Reserve No. 13619 is recommended as shown on aerial photograph WA 1253 Marble Bar Run 3 No. 5075 (p.34).

Protection : high priority; see Discussion, p.39.

Presentation : see Discussion, p.39.

Owners of mining tenements and the Shire of East Pilbara should be consulted.

(9.)

STRELLEY POOL WEST

Some 15 km west of Strelley Pool, Barnes (1983) describes a dolomitic sequence about 70 m in length in the Strelley Pool Chert. At c. 3400 m.y., this is probably the oldest carbonate sequence recorded in greenstone terrain and it is understood carbonate stromatolites are found there. For this locality a Class I Geological Monument with a 'high priority' protection status is appropriate but no specific recommendation is made as an inspection is needed - the importance of this locality was appreciated when the thesis of K.R. Barnes was seen at a late date.

'Strelley Pool West' may need to be replaced by a more specific locality name.

SGZ

WA 1257 MARBLE BAR RUN 21 00N 120 00E 120 00E 120 00E 23 0 70 PROJ L12

3
124

NORTH POLE

outline monument

To Port Hedland

Chert with microfossils

Road junction: Panorama

Station-Barite Mine

Old crossroads

Domical stromatolites

800 0 800 1600
m

N

5075 WA 1253 MARBLE BAR RUN 3 (5046-5092) 20000' 152.56mm 18.870 PROJ L12

STRELLEY POOL

MONUMENT

Class C Reserve 13619 'Timber'

Strelley Pool

Chert ridges

Stromatolites

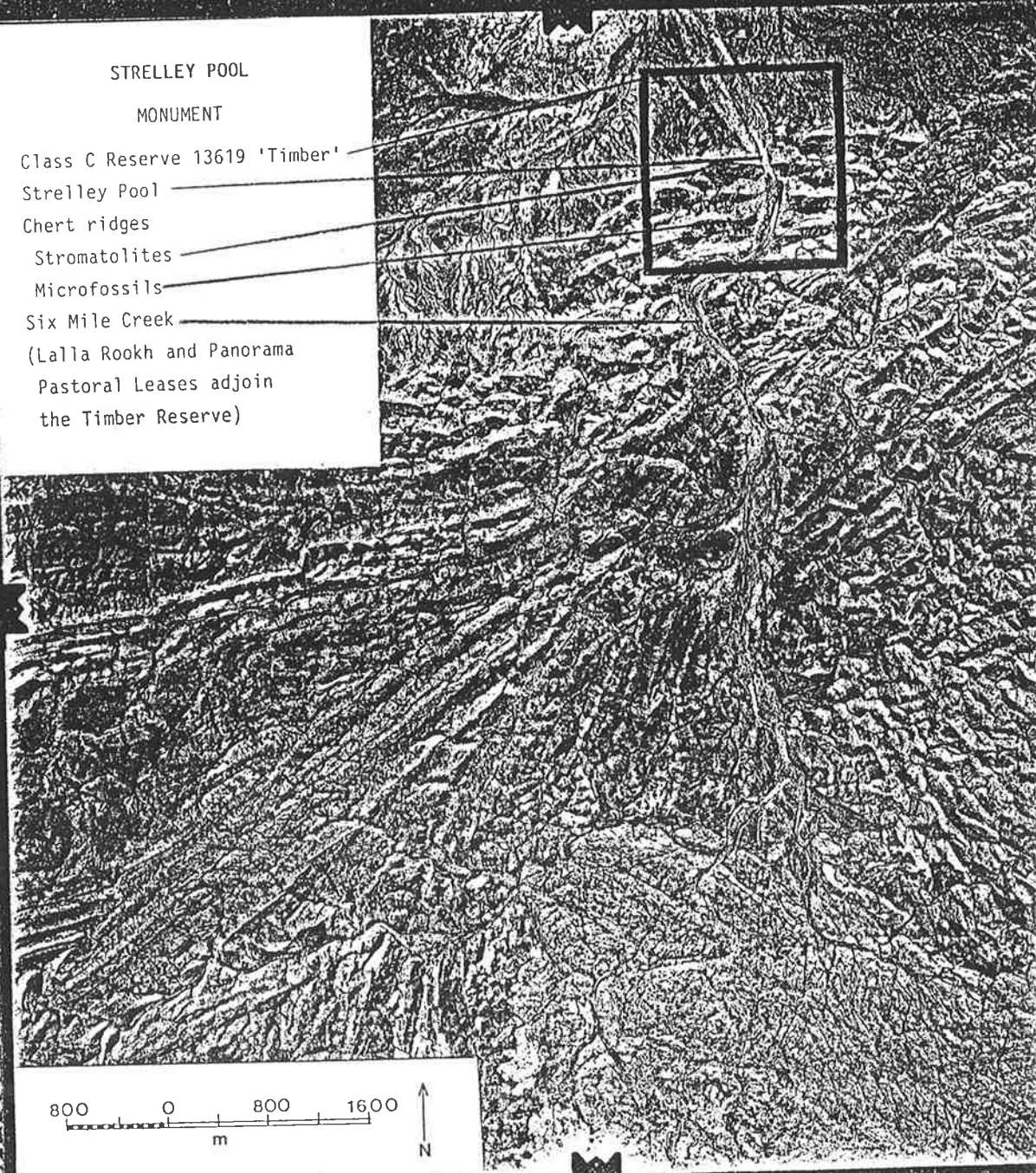
Microfossils

Six Mile Creek

(Lalla Rookh and Panorama

Pastoral Leases adjoin

the Timber Reserve)



Reference: Barnes, K.R., 1983, The geology of part of the Strelley Pool Chert, Pilgangoora Syncline, Pilbara Block, Western Australia: Univ. West. Australia Science Hons. thesis (unpublished).

(10.) MEENTHEENA : MYCENAE AND THORNE BLUFF

Location: 1:250,000 Geological Series Nullagine
lat 21 16 S long 120 27 E

SIGNIFICANCE and VALUE

Class I : Palaeontology
Research
Attractive Setting

GEOLOGICAL NOTE

Stromatolites first recorded in the Tumbiana Formation in 1959 are splendidly displayed near Meentheena some 95 km southeast of Marble Bar where two of the finest localities are the gully Mycenae and Thorne Bluff overlooking the Nullagine River (K. Grey pers. comm.). The lower member of the Tumbiana Formation, the Mingah Tuff, is overlain by the richly fossiliferous stromatolitic Meentheena Carbonate Member, a unit of siliceous limestone, tuff and shale 10 to 50 m thick. The Carbonate Member forms a low, eastward dipping, dissected scarp extending southwards from an old woolshed for some 4 km to the Nullagine River and this scarp incorporates both Mycenae and Thorne Bluff.

No publication devoted to Meentheena stromatolites has appeared so far.

References: de la Hunty, L.E., 1963, The geology of the manganese deposits of Western Australia: West. Australia Geol. Survey Bull. 116.

Hickman, A.H., 1983, Geology of the Pilbara Block and its environs: West. Australia Geol. Survey Bull. 127.

Plate: 9

TENURE, ACCESS and POSSIBLE THREATS

Meentheena lies within Mount Edgar Pastoral Lease 3114/780 with owner, Mr. A.J. Elwood at Suite 1, 19/21 Outram St, West Perth, WA 6005.

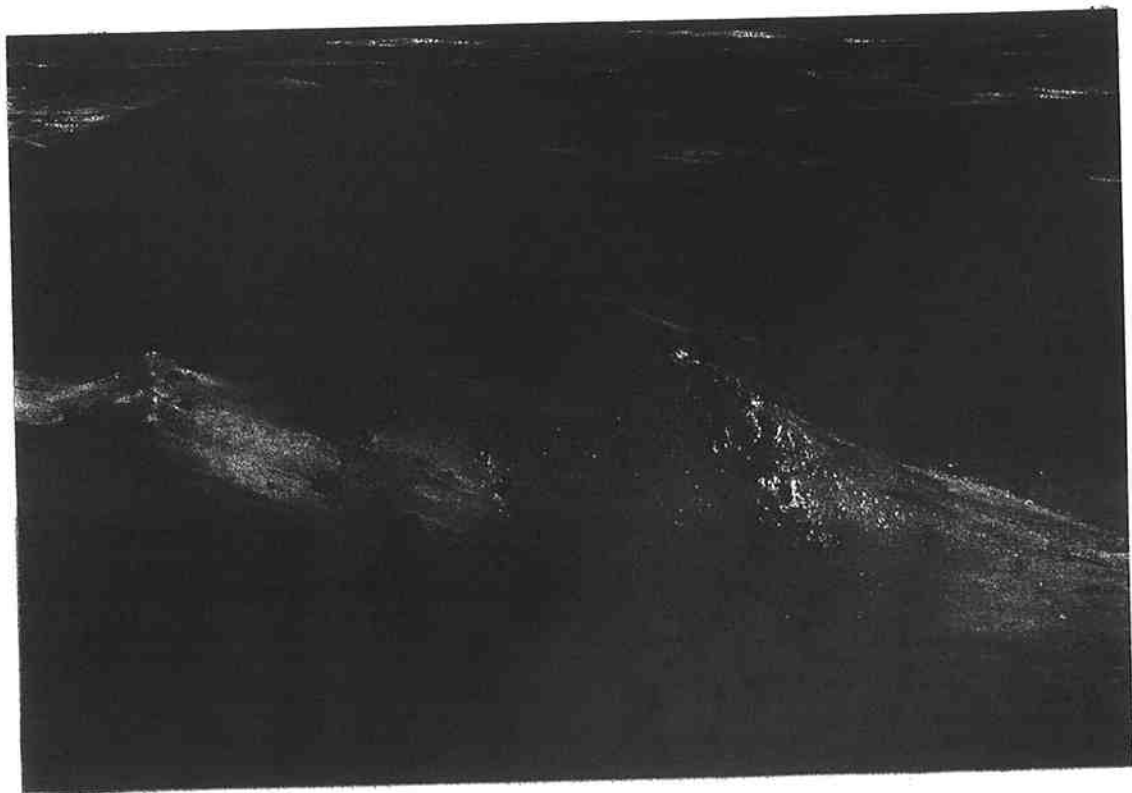


Plate 7 STRELLEY POOL RANGES A.H. HICKMAN
Chert ridges in this Pilbara range country contain evidence
of the earliest life known on Earth

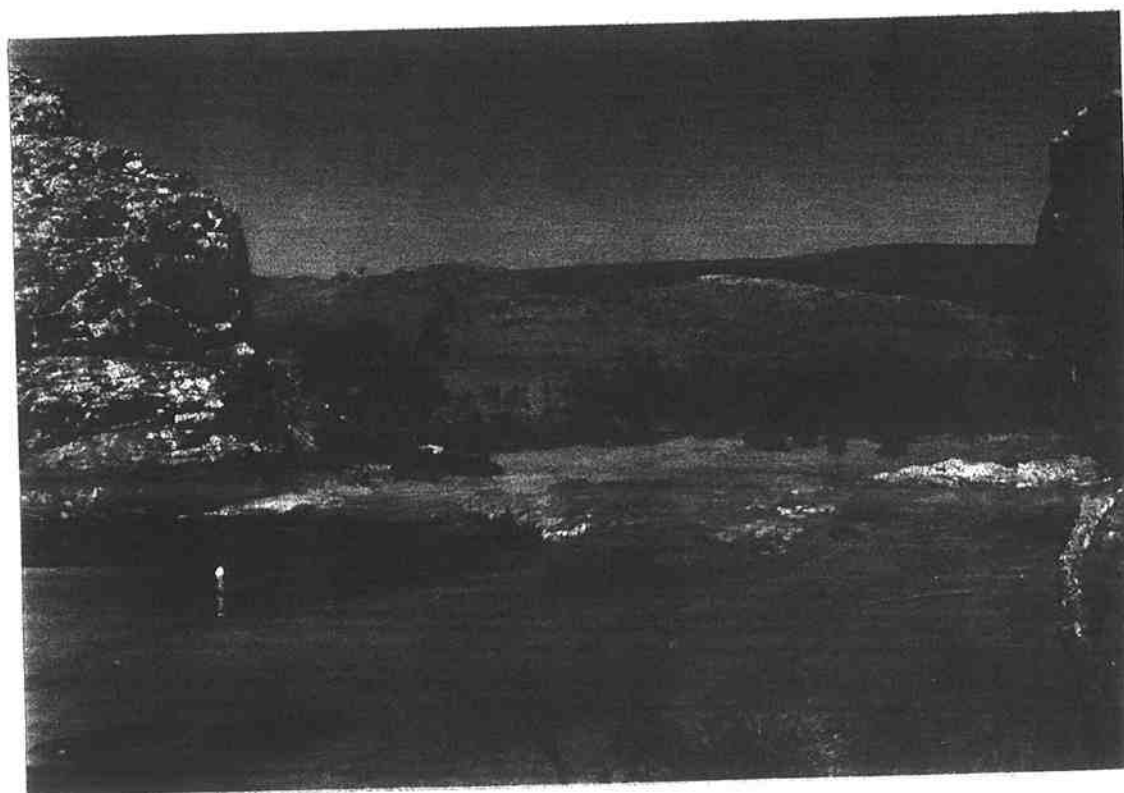


Plate 8 STRELLEY POOL J.D. CARTER
Chert ridges include the stromatolitic
Strelley Pool Chert

From Marble Bar the Nullagine road is taken for 40.6 km to turn east to Mount Edgar Station (3.5 km) where the principal eastward track is followed for 50 km to the old Meentheena woolshed. (Take the left fork at the main bifurcation a few kilometres beyond the homestead.) From the woolshed a track runs south for a few kilometres to the Nullagine River and the stromatolitic rocks lie in the scarp a short distance to the west, with Mycenae 1.5 km south of the woolshed (4WD).

Indiscriminate collecting of stromatolitic material poses a threat.

RECOMMENDATIONS

A Geological Monument of some 5.5 km² is recommended for the scarp extending south from Meentheena woolshed to the Nullagine River as shown on aerial photograph WA 1403 Nullagine Run 5 No. 5036 (p.42).

Protection : high priority; see Discussion, p.39.

Presentation : not suitable; remote.

The owner of Mount Edgar Pastoral Lease and the Shire of East Pilbara should be consulted.

(11.)

KNOSSOS

Location: 1:250,000 Geological Series Roy Hill
lat 22 3 30 S long 118 58 E

SIGNIFICANCE and VALUE

Class I : Palaeontology
Research

GEOLOGICAL NOTE

On the approach to Knossos from Port Hedland (200 km distant), the Chichester Range unveils the great unconformity between granitic rocks and the Fortescue Group in magnificent panoramas both to the east and west of the Newman railway road and at Knossos, a small quarry in a modest cliff of Tumbiana Formation, there is perhaps the most spectacular of all displays of Pilbara stromatolites with beautifully preserved nodular and stratiform accumulations forming tabular and domical biostromes. Cherty stromatolitic limestone in the cliff is interbedded with tuffaceous sandstone showing ripple marks and other evidence of shallow water deposition.

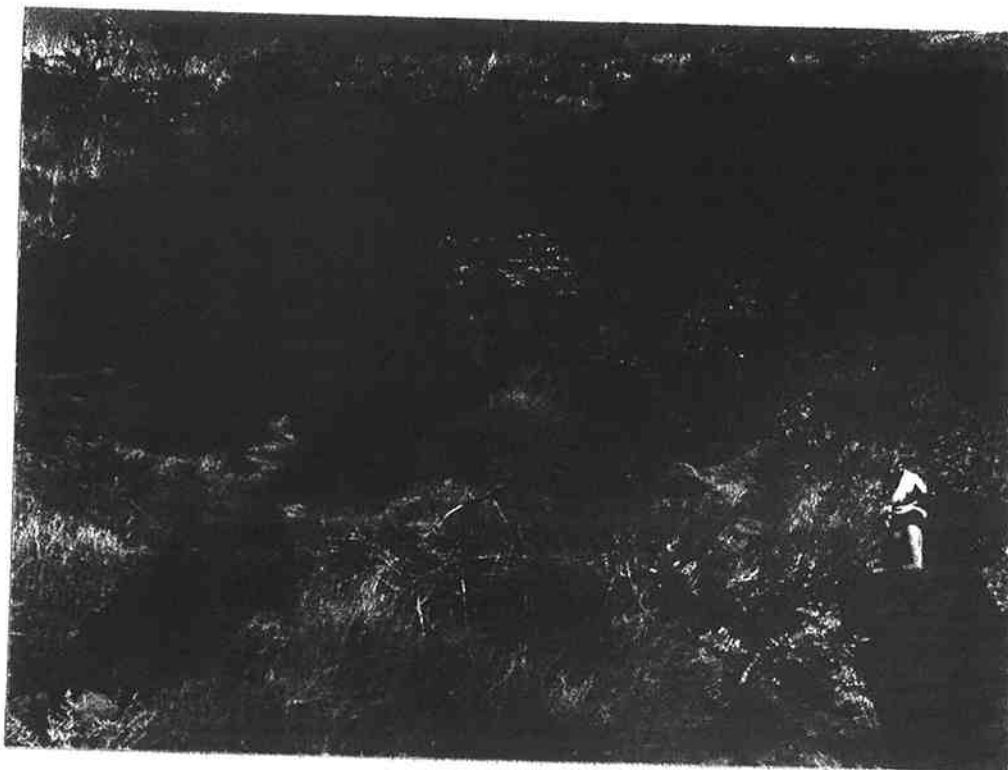


Plate 9

MYCENAE

J.D. Ca

This gully in Tumbiana Formation offers magnificent exposures of Archaean stromatolites

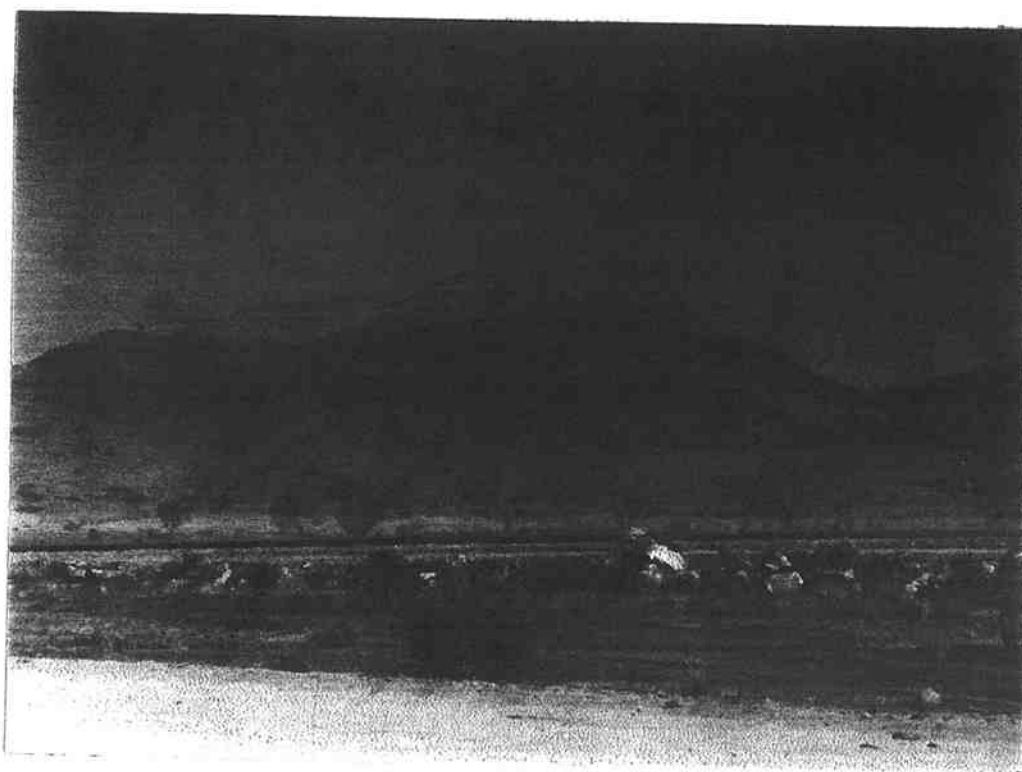


Plate 10

UNCONFORMITY NEAR KNOSSOS

J.D. Car

In the Chichester Range north of Knossos the Tumbiana Formation rests on granitic rocks

Microfossils have been recovered from Knossos and with North Pole and Strelley Pool, this is one of the three localities in the world where convincing evidence of Archaean life has been found.

Reference: Schopf, J.W. (Ed.), 1983, Earth's Earliest Biosphere - Its origin and evolution: Princeton University Press.

Plates: 10 and 11

TENURE, ACCESS and POSSIBLE THREATS

Knossos lies within Vacant Crown Land alongside the Mt. Newman Mining Company railway reserve.

Access is from the private railway maintenance road. The quarry and cliff overlook the road 400 m north of the road-rail crossing at the 211.6 km mark south of Port Hedland. Roads from Wittenoom to Marble Bar and Roy Hill cross the maintenance road.

Ill-considered collecting is a threat.

RECOMMENDATIONS

A Geological Monument is recommended for Knossos; some 15 ha is proposed as shown on aerial photograph WA 1257 Roy Hill Run 1 No. 5069 (p.43).

Protection : high priority; see Discussion, below.

Presentation : not suitable; remote.

The Mt. Newman Mining Co. Pty. Ltd. of Perth who control the railway maintenance road access and the Shire of West Pilbara should be consulted.

DISCUSSION: PILBARA STROMATOLITES

Proposals for these valuable elements of Western Australia's geological heritage needs to take into account among other matters:

that research on early Pilbara life is in an early stage and it may be premature to suggest a final means for conserving this universally important geology,

and that key stromatolite sites have been looted.

Research is in an early stage; for example:

no useful map of North Pole fossil localities is known nor are there maps of the Strelley Pool Chert and its stromatolites;



Plate 11

KNOSSOS

J.D. Cal

This modest cliff face of Tumbiana Formation
contains splendidly preserved Archaean stromatolites
on bedding planes

Knossos is one of several stromatolite localities in the Chichester Range but the only one described so far, and there is no published information on Meentheena stromatolites;

Last year Archaean stromatolites were identified in the Maddina Basalt of the Fortescue Group on the Mount Billroth 1:100,000 sheet in West Pilbara (B. Packer pers. comm.) and early results indicate this will prove to be another important new locality.

Little attention appears to have been given to the need to conserve the ancient life record of the Pilbara and some collecting practices have been quite deplorable:

it is understood that the entire stromatolite content of some North Pole locales has been removed;

geologists have taken North Pole stromatolites for casual display;

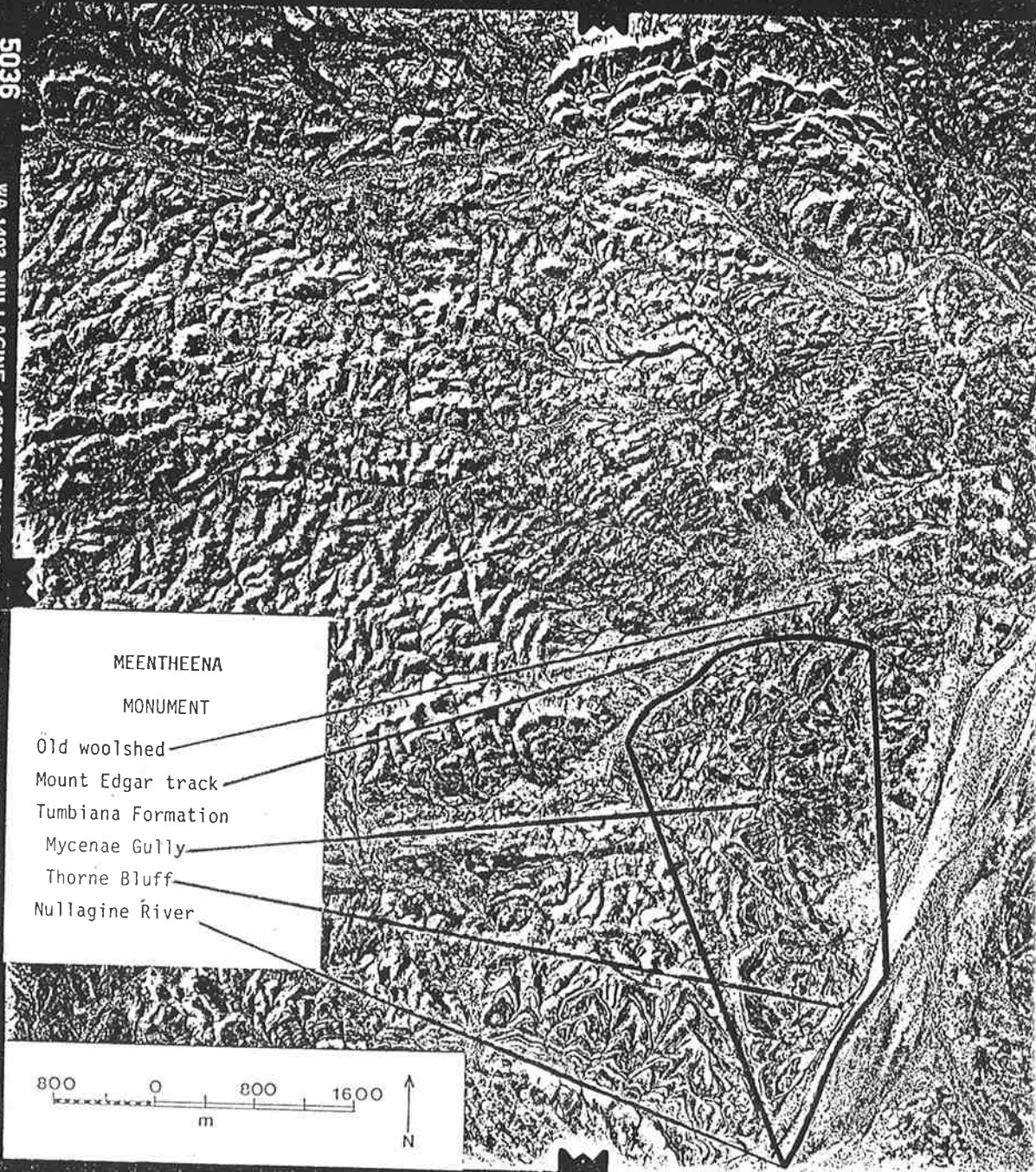
some of the finest examples of Pilbara stromatolites depicted in leading scientific and popular science publications are not held under Western Australia curation but remain overseas despite embargos of the Customs Act - all key material should be housed in the State.

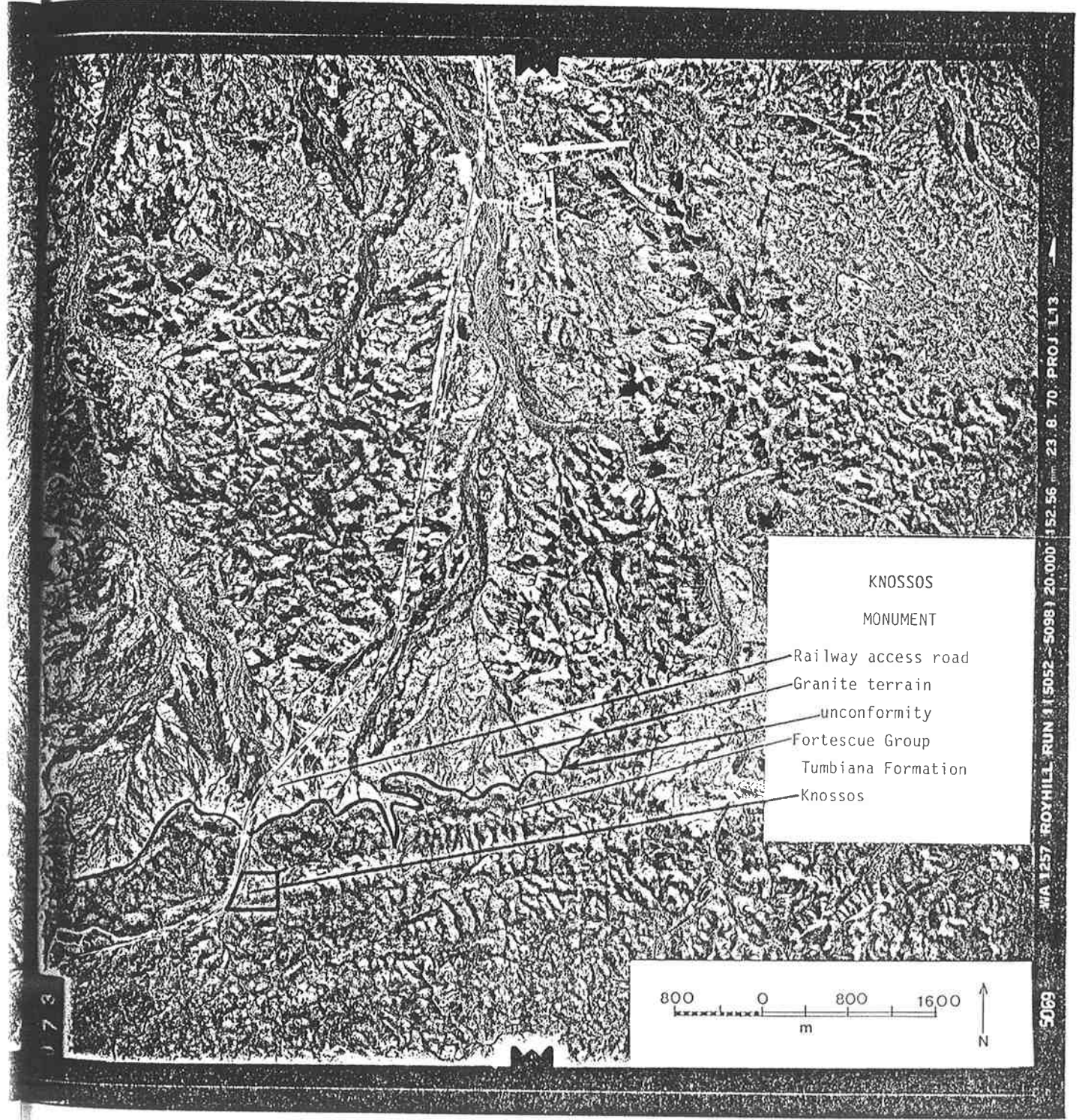
RECOMMENDATIONS

- (i) A survey of the status of research into Pilbara microfossils and stromatolites should be undertaken to determine policies to conserve this evidence of early life. Class A Reserves could be created for geological research and the North Pole-Strelley Pool range country, an area of outstanding natural beauty (Plate 7) but with little obvious land use, could be considered for a Class A Geological Conservation Reserve or a National Park with the theme 'origins of life'.
- (ii) Guidelines should be drawn up to ensure fossil material is handled both in the best interests of research and of the State.
- (iii) The finest examples of fossil material now abroad should be recovered and housed in museums within Western Australia.

5036

WA 1403 NULLAGINE 1:250000 RUN 5 (5001-5051) 1:40000 152.56m 25.8.72 PROJ. M 22





12. WITTENOOM GORGES OF THE HAMERSLEY RANGE

STATEMENT OF INTEREST

Precipitous cliffs of near-horizontal strata of the late Archaean Hamersley Group stand in gorges mellowed by quiet pools and avenues of trees in many parts of the Hamersley Range. Here mineral riches of iron are accompanied by exquisite sedimentary phenomena including banding in iron formation on large and small scales so constant that the thinnest horizons in the most sought after host of iron, the Brockman Iron Formation, can be traced over hundreds of square kilometres and used to correlate distant stratigraphic levels with absolute precision.

There are many gorges in the Hamersley Range but the finest group is found near Wittenoom in the National Park where the principal chasms, Dales, Yampire, Kalamina and Wittenoom, reveal classic sections of iron formation, and shale and dolomite in settings of outstanding natural beauty.

Location: 1:250,000 Geological Series Roy Hill and Mount Bruce
lat 22 30 S long 118 30 E

SIGNIFICANCE and VALUE

Classes I and V : Archaean Iron Formation
Research
Outstanding Natural Beauty

GEOLOGICAL NOTE

The Hamersley Group is dated at about 2500 m.y. and its thickness of 2500 m is assigned to eight formations with rock types in order of importance being iron formation, acid lava, dolerite, shale, dolomite and tuff. In the reference, there is an account of exposures of these lithologies in and around the gorges near Wittenoom. However, many of these exposures are located within the Hamersley Range National Park where rock sampling is not permitted and as the fresh rock surfaces are not always informative, the geological attraction of these gorges is reduced. Fortunately this is not the case at Woongarra Gorge (Ashburton River, p.49) where a full succession of the Hamersley Group may be examined by rock sampling.

Reference: Trendall, A.F., 1976, Geology of the Hamersley Basin :

Figure 5

TENURE, ACCESS and POSSIBLE THREATS

The Geological Monument outlined on Figure 5 falls within the National Park or Vacant Crown Land and incorporates many small reserves and mining tenements.

Access from Wittenoom is sign-posted.

No threats are foreseen.

RECOMMENDATIONS

To propose a Geological Monument a more than short examination of the many features exposed in the gorges is necessary and this task was beyond the capacity of the survey. However an outline for a Monument is shown on Figure 5 and on this are plotted approximate positions of stops of the 25th International Geological Congress excursion in 1976.

- Protection : normal care; use of essential parts of this ground is supervised.
- Proposal : a geological guide with map at 1:50,000 scale would benefit a majority of visitors.
- Presentation : there is great scope here to enhance public enjoyment of the more frequently visited parts of the gorges by notice boards explaining geology.

The National Parks and Nature Conservation Authority and the Shire of West Pilbara would need to be consulted among others.

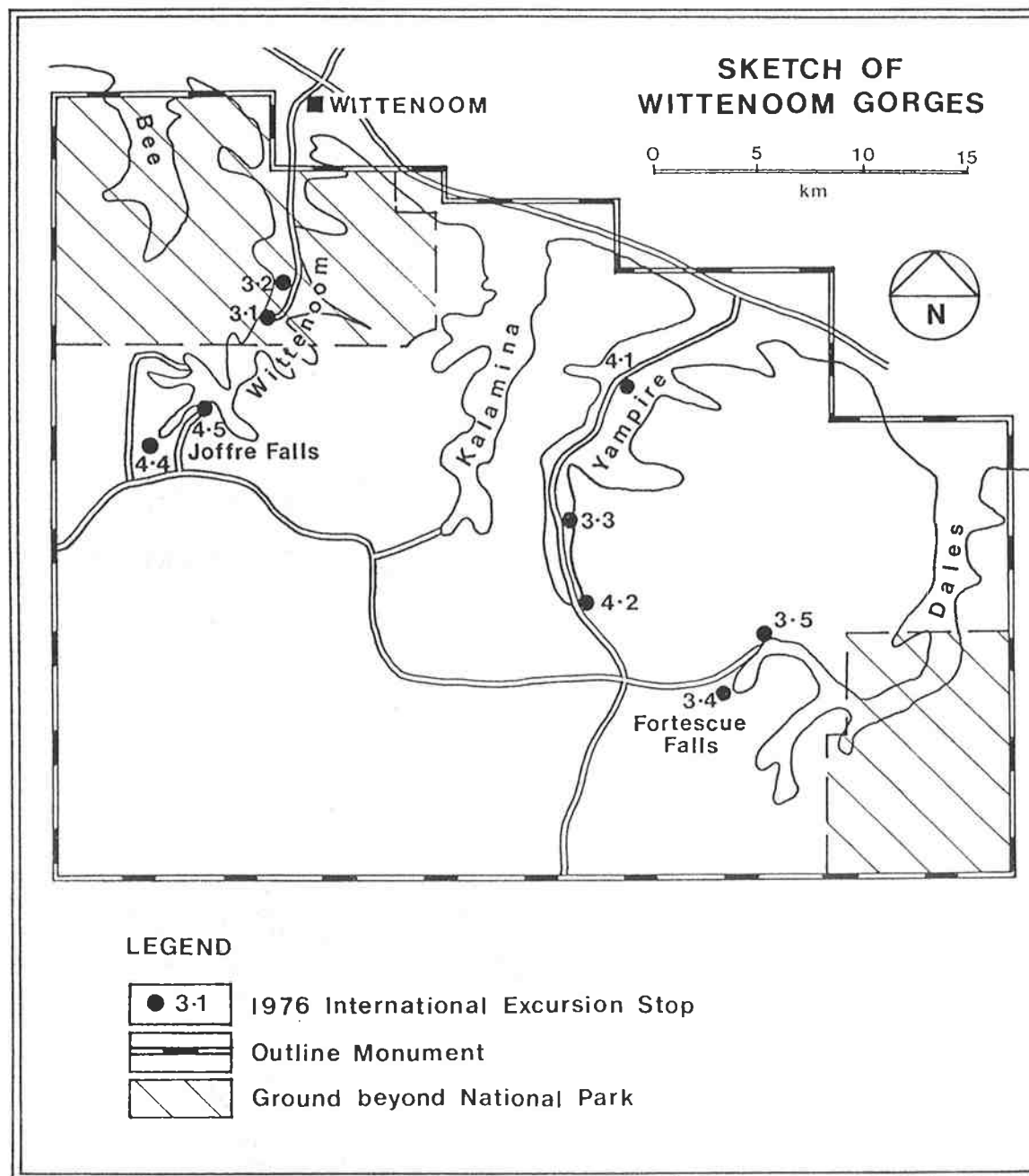


Figure 5

ASHBURTON RIVER

ARCHAEAN AND PROTEROZOIC SEDIMENTARY BASINS

Localities considered in the drainage of the Ashburton River system lie within easy reach of the Nanutarra-Wittenoom and Ashburton Downs-Meekatharra roads (Figure 6). Top Camp Unconformity was recommended before the survey and further features were examined with this result:

13. Woongarra Gorge	Monument
14. Meteorite Bore	Site
15. Mount Blair West	Monument
16. Top Camp Unconformity	Monument
17. Three Corner Bore East	Site
18. Three Corner Bore Southwest	Site
19. Duck Creek Gorge	Monument
20. Urandy Bore West	Site
21. Wyloo Submarine Canyon	outline site
22. Mount Stuart	outline monument
23. Ten Mile Creek	Monument

Strata of most of the great Precambrian basins of the northwest of the State are represented and among these are the Hamersley, Turee Creek and Wyloo Groups, the Capricorn Formation and Bangemall Group, and the features offer a traverse of basins ranging in age from Archaean to Middle Proterozoic with, generally, reasonable access.

No example of the Fortescue Group is included, an omission which could be made good by exposures along the Paraburdoo spur road. Suggestions for representation of the Bresnahan Group and improved representation of the Bangemall Group are made at the end of this section.

ASHBURTON RIVER

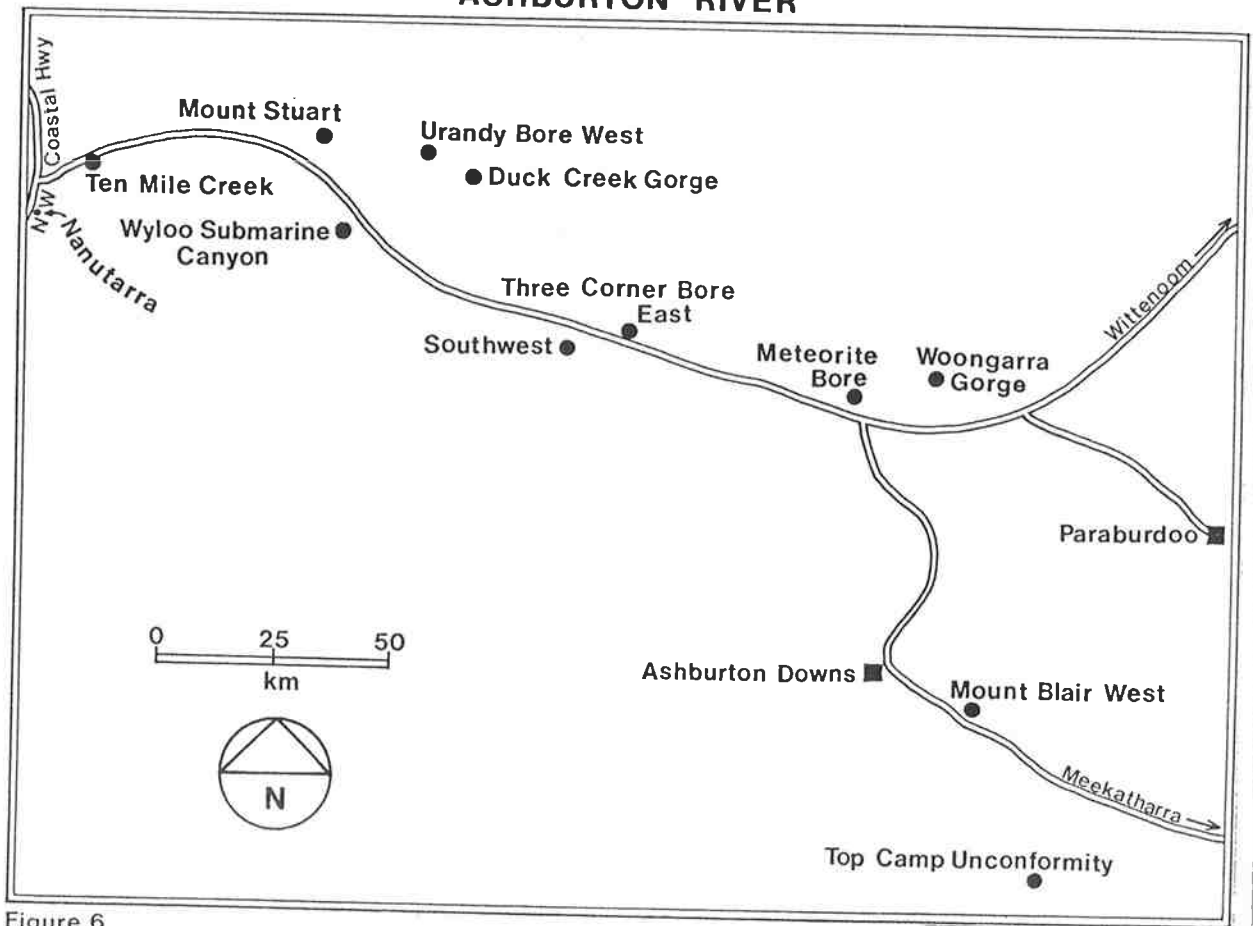


Figure 6

WOONGARRA GORGE

STATEMENT OF INTEREST

Trees and pools grace a magnificent sequence of inclined strata in Woongarra Gorge where more than 2000 m of the Hamersley Group famous for its iron formations of the late Archaean-Early Proterozoic is revealed by the Beasley River. Eight formations are clearly exposed and offer a research locale of the highest value and unlike the Wittenoom Gorges of the Hamersley Range, geological use of this gorge is not restricted by sampling bans.

Location: 1:250,000 Geological Series Mount Bruce
lat 22 52 S long 117 7 E

SIGNIFICANCE and VALUE

Classes I and V : Archaean Stratigraphy
Research
Great Landscape Value

GEOLOGICAL NOTE

The Hamersley Group is represented by:

<u>top</u>	Boolgeeda Iron Formation	Mount McRae Shale	
	Woongarra Volcanics	Mount Sylvia Formation	
	Weeli Wolli Formation	Wittenoom Dolomite	
	Brockman Iron Formation	Marra Mamba Iron Formation	<u>bottom</u>

Among many features of interest, excellent exposures of the Dales Gorge and Joffre Members of the Brockman Iron Formation should be mentioned as well as unusually clear demonstrations of rhyolitic rocks of the Woongarra Volcanics.

Reference: Trendall, A.F., 1976, Geology of the Hamersley Basin : 25th International Geological Congress, Excursion Guide No. 43 A.

Plate: 12

TENURE, ACCESS and POSSIBLE THREATS

Woongarra Gorge lies within Wyloo Pastoral Lease 3114/647 of Wyloo Pastoral Co. Pty. Ltd., 1179 Hay St, West Perth, WA 6005. It is incorporated within mining tenement TR 5572H for iron of Hamersley Exploration Pty. Ltd.

Woongarra Pool at the southwest entrance to the gorge lies some 13 km north of the Nanutarra-Wittenoom road and is reached by a track leaving the road 20.6 km west of the Paraburdoo turn-off (or 10.8 km east of the Ashburton Downs road).

There is no apparent threat to these robust rocks.

RECOMMENDATIONS

A Geological Monument of approximately 15 km² is recommended as shown on aerial photograph WA 1264 Mount Bruce Run 15 No. 5044 (p.51).

- Protection : normal care; the gorge apparently receives many casual visitors without suffering pronounced ill-effect.
- Proposal : its value would be improved by a 1: 5000 geological map showing the better teaching surfaces.
- Presentation : a variety of robust geology with relatively easy access offsets remoteness and thus there is potential for public presentation.

The owners of Wyloo Station and the mining tenement, and the Shire of West Pilbara should be consulted.

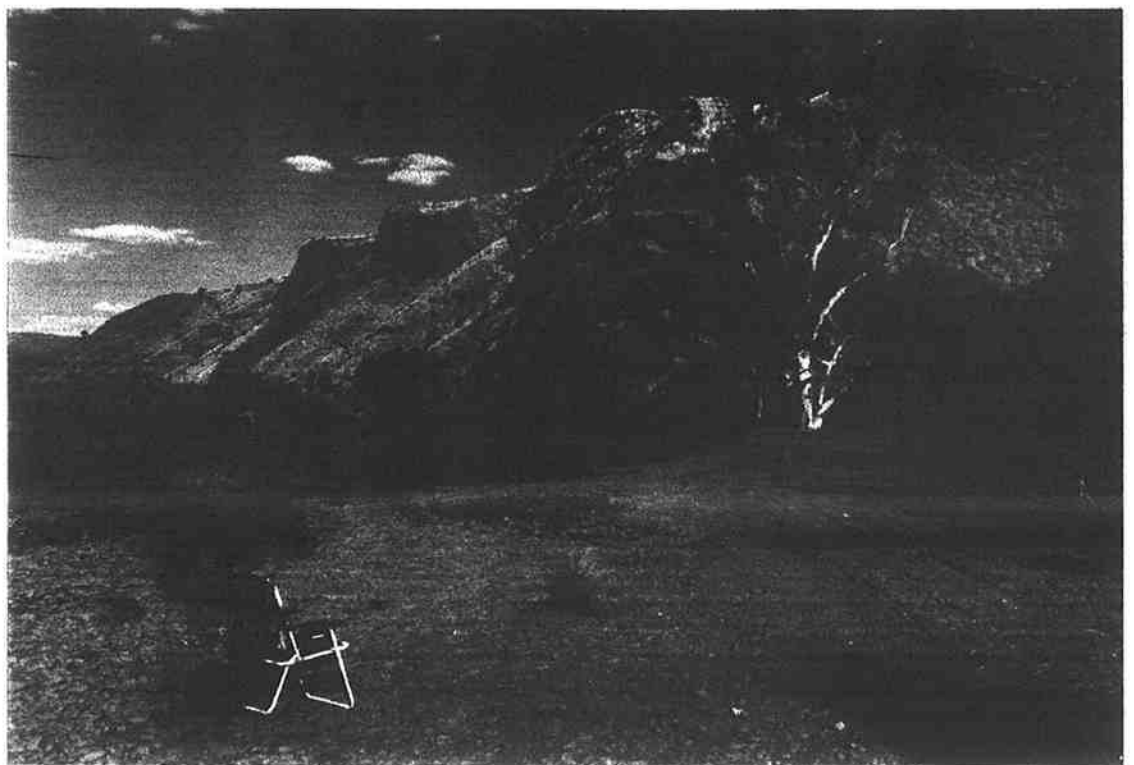
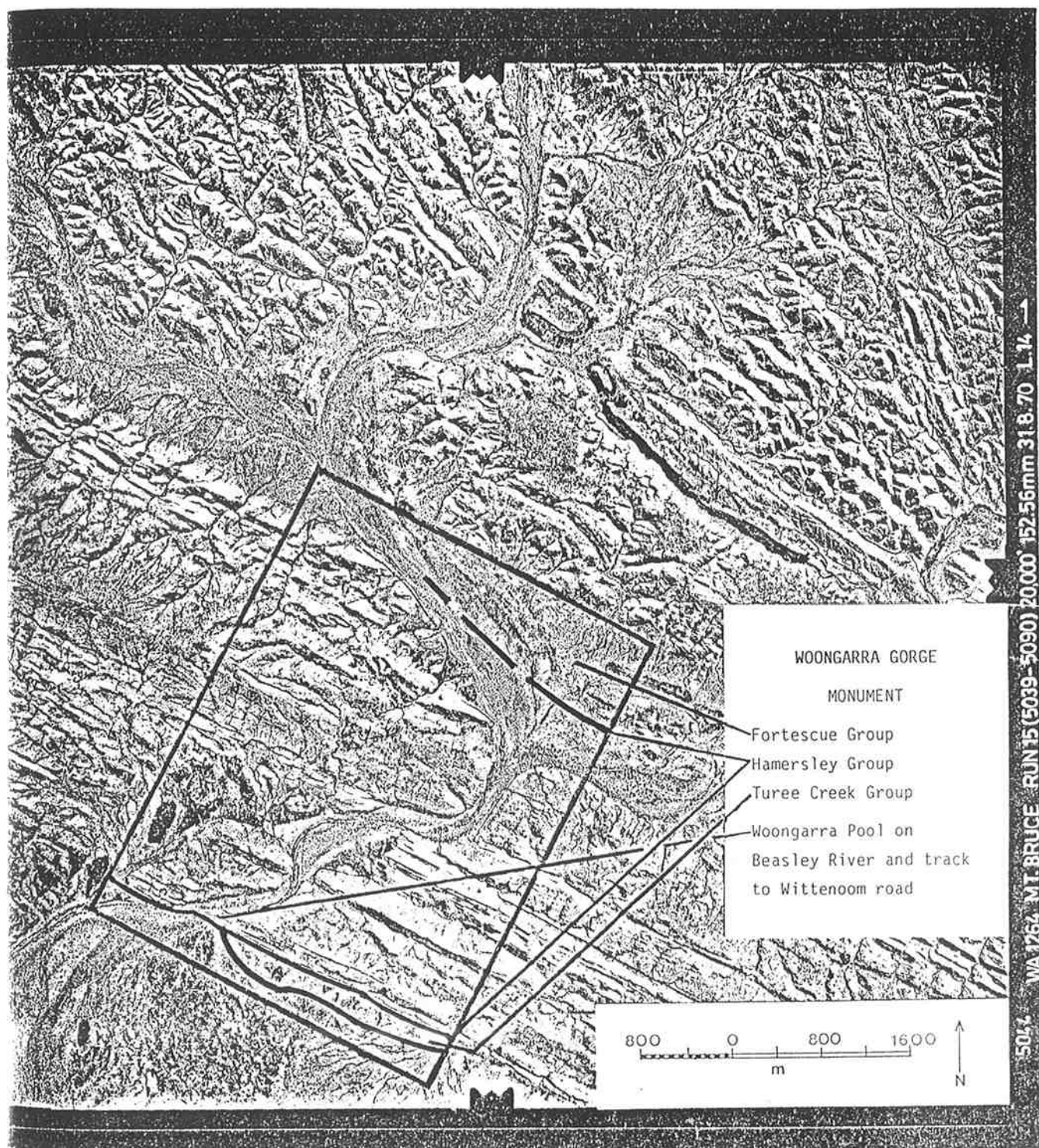


Plate 12

WOONGARRA GORGE

J.D. Carter

Trees and pools grace a classic sequence of Hamersley Group



STATEMENT OF INTEREST

Here an ancient glaciation is suggested by striated and faceted boulders of sandstone and acid volcanics bound within fine-grained sediments of the Turee Creek Group of the Lower Proterozoic and this horizon could correspond to clearly identified glacial events at about 2200 m.y. in South Africa and Canada.

Location: 1:250,000 Geological Series Mount Bruce
lat 22 50 30 S long 117 2 30 E

SIGNIFICANCE and VALUE

Class III : Proterozoic Glaciation
Research

GEOLOGICAL NOTE

Local evidence for this Lower Proterozoic glacial event is slender. Only a small proportion of boulders are striated and faceted and no example was identified during a brief visit in 1986.

Reference: Trendall, A.F., 1976, Striated and faceted boulders from the Turee Creek Formation - evidence for a possible Huronian glaciation on the Australian Continent: West. Australia Geol. Survey Ann. Rept. 1975, p. 88-92.

TENURE, ACCESS and POSSIBLE THREATS

Meteorite Bore lies within Wyloo Pastoral Lease 3114/647 of the Wyloo Pastoral Co. Pty. Ltd., 1179 Hay St, West Perth, WA 6005.

To reach Meteorite Bore from the Nanutarra-Wittenoom road take the northward track leaving the road 7.2 km east of the Beasley River crossing (or 3.6 km west of the Ashburton Downs road) for 4.8 km to the airstrip near the bore where low strike ridges lie some 600 m northeast of the bore (4WD).

There are no obvious threats.

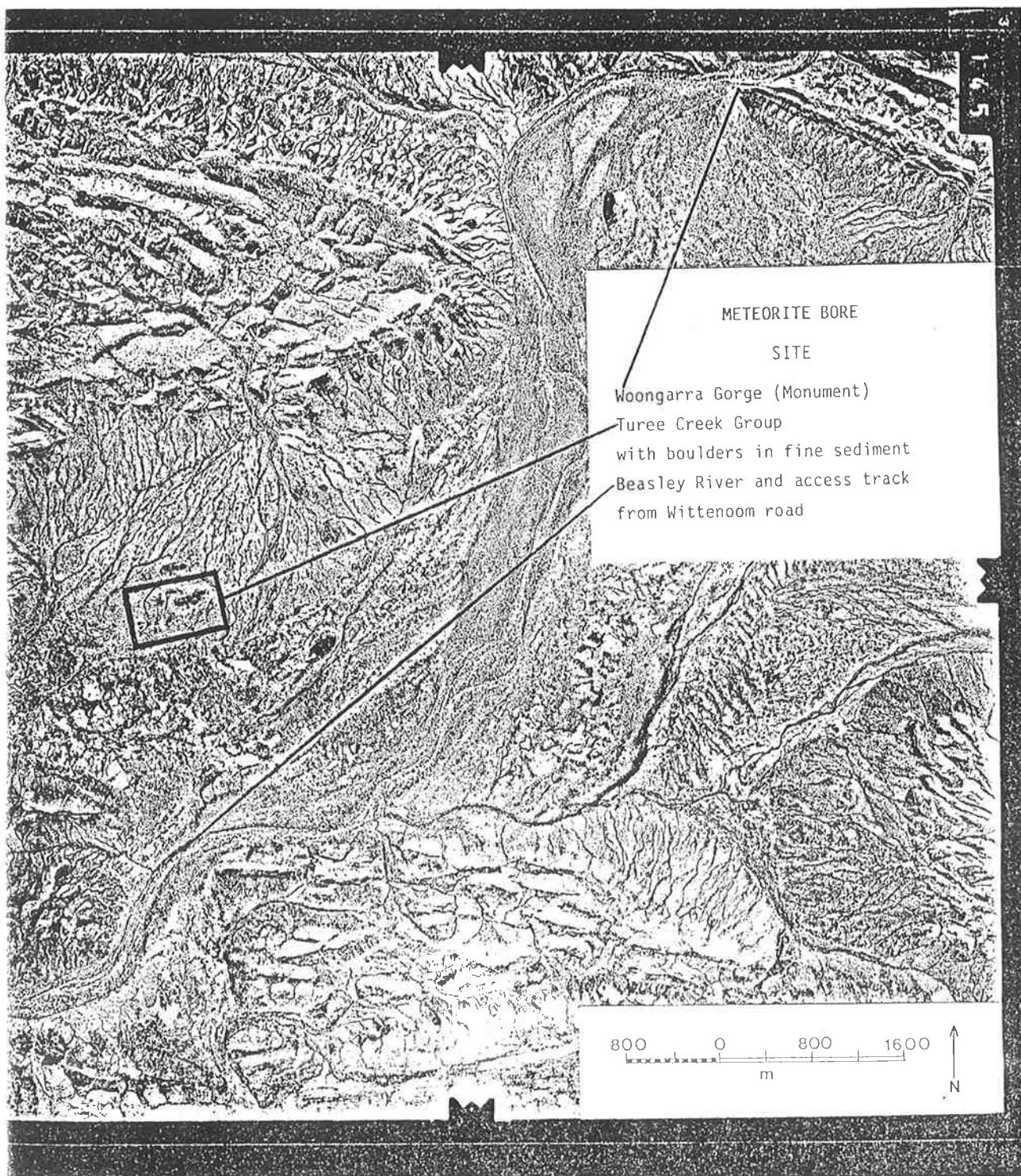
RECOMMENDATIONS

A Geological Site of approximately 45 ha is recommended as shown on aerial photograph WA 1264 Mount Bruce Run 16 No. 5136 (p.53).

Protection : normal care.

Presentation : not suitable; remote and geology not readily appreciated.

The owners of Wyloo Station and the Shire of West Pilbara should be consulted.



STATEMENT OF INTEREST

On the southern slopes of the Mount Blair range the unconformity between Proterozoic sedimentary rocks of the Ashburton Formation of the Wyloo Group and the Capricorn Formation is unusually well-exposed. Both formations are largely composed of mudstone and sandstone displaying various sedimentary structures and stromatolites clung to the eroded Ashburton Formation surface. This section was examined by an international excursion in 1985.

Location: 1:250,000 Geological Series Turee Creek
1at 23 27 S long 117 8 30 E

SIGNIFICANCE and VALUE

Class III : Proterozoic Unconformity
Reference
Attractive Setting

GEOLOGICAL NOTE

The Wyloo Group, about 2000 m.y. old, was deposited in the Ashburton Trough and is unconformably overlain by the Capricorn Formation, a thick deltaic sequence representing the final infill at possibly 1600 m.y.

Reference: Thorne, A.M., 1985, Ashburton Fold Belt, in Capricorn Orogen Excursion Notes: West. Australia Geol. Survey (unpublished).

TENURE, ACCESS and POSSIBLE THREATS

Mount Blair range is part of Ashburton Downs Pastoral Lease 3114/1132 with owners c/- Box 24, Perenjori, WA 6620. Mining tenement E 08/152 includes Mount Blair West.

'Section hill', a short distance west of Mount Blair, stands on the east of the Ashburton Downs-Meekatharra road, some 13 km south-east of Ashburton Downs Station, on the south face of the range.

There are no obvious threats.

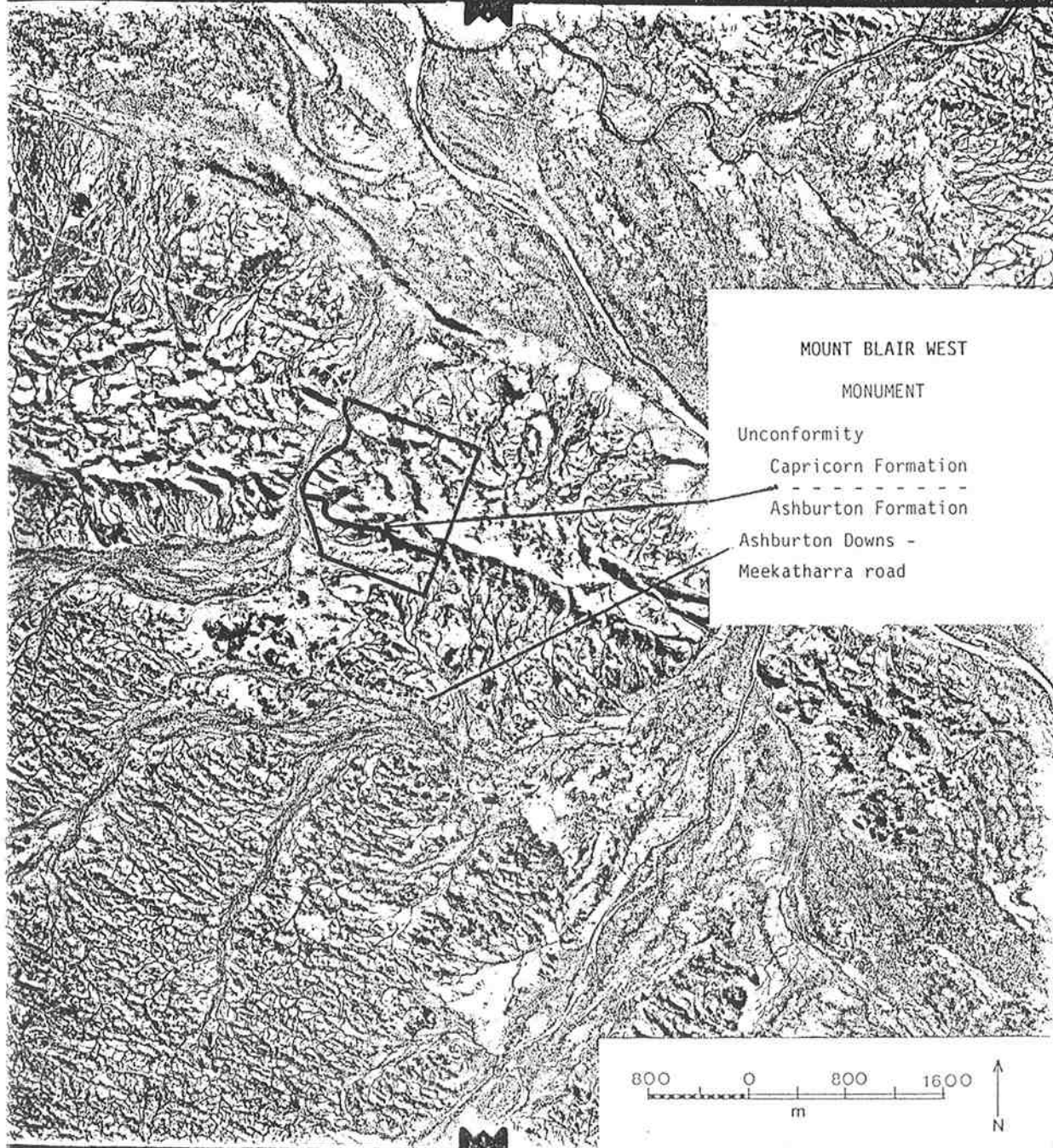
RECOMMENDATIONS

A Geological Monument of approximately 1.5 km² is proposed as shown on aerial photograph WA 1581 Turee Creek Run 8 No. 5411 (p.55).

Protection : normal care.

Presentation : not suitable; the section lacks visual appeal.

The owners of Ashburton Downs Station and the mining tenement, and the Shire of West Pilbara should be consulted.



MOUNT BLAIR WEST
MONUMENT

Unconformity
Capricorn Formation

Ashburton Formation
Ashburton Downs -
Meekatharra road

800 0 800 1600
m

N

5411 WA 1581 THREE CREEK 1:250000 SHEET RUN 8 (5405-5450) SCALE 1:40000 152.576mm 23.8.75 PROJ. 74

STATEMENT OF INTEREST

'It would be difficult indeed to find a more perfect example of an unconformity than is here disclosed' so wrote H.W.B. Talbot in 1926 when describing the magnificent exposure of the great angular unconformity between Proterozoic sediments of the Wyloo and Bangemall Groups in the quiet and beautiful chasm on Fords Creek. Towering walls rise to 100 m and more and in them steeply tilted, dark layers of Ashburton Formation mudstone and siltstone stand below gently dipping, stromatolitic dolomite of Top Camp Formation, and a profusion of colours, lithologies and angles of repose join with clear exposure and pristine landscapes to create a brilliant geological scene.

Location: 1:250,000 Geological Series Turee Creek
lat 23 46 S long 117 17 E

SIGNIFICANCE and VALUE

Class II : Proterozoic Unconformity
Reference
Great Landscape Value

GEOLOGICAL NOTE

Top Camp was an alluvial gold workings in the early part of the century and its name is given to the basal formation of the Bangemall Group, a sequence of sandstone, shale, chert and dolomite some 1200 m.y. old. At Top Camp Unconformity dolomites of the Top Camp Formation overlie the Ashburton Formation, the uppermost formation of the Wyloo Group of probably 2000 m.y.

References: Talbot, H.W.B., 1926, A geological reconnaissance of part of the Ashburton drainage basin: West. Australia Geol. Survey Bull. 85.

Thorne, A.M., 1985, Ashburton Fold Belt, in Capricorn Orogen Excursion Notes: West. Australia Geol. Survey (unpublished).

Plate: 13

TENURE, ACCESS and POSSIBLE THREATS

The unconformity at Fords Creek lies within Vacant Crown Land.

From Ashburton Downs Station take the Meekatharra road for some 40 km to cross Fords Creek where near a bore a track runs southward to Top Camp Bore. Continue south to Fords Creek and follow the track alongside the creek bed to the chasm lying approximately 20 km from the Meekatharra road (4WD). This is a general instruction and care should be taken.

No threats are foreseen.

RECOMMENDATIONS

A Geological Monument of about 4 km² is proposed as shown on WA 1580 Turee Creek Run 13 No. 5215 (p.58).

Protection : normal care.

Proposal : the fine panoramas of Fords Creek deserve an expert photographic study.

Presentation : not suitable; remote.

The Shire of West Pilbara should be consulted.



Plate 13

TOP CAMP UNCONFORMITY

A.M. Thorne

Ashburton Formation underlies the Bangemall Group in this magnificent example of an angular unconformity

5215

WA 1580 TURE CREEK 1:50000 SHEET RUN 13 (6179-5225) SCALE 1:40000 152576mm 22.75 PROL R 4

TOP CAMP UNCONFORMITY
MONUMENT

Fords Creek

Ashburton Formation

'unconformity gorge'

Top Camp Formation

800 0 800 1600
m

N

17. & 18. THREE CORNER BORE : EAST & SOUTHWEST

STATEMENT OF INTEREST

Two large-scale sections of deltaic sediments illustrating the depositional history of a Lower Proterozoic basin are exposed near Three Corner Bore on Wyloo Station, one a few kilometres east of the bore in a gorge and the second in attractive hills a similar distance southwest of the bore. These strata belong to the Lower Proterozoic Wyloo Group and in the gorge they rest unconformably upon Woongarra Volcanics of the Hamersley Group and include a spectacular conglomerate composed of iron formation clasts among an **upward fining** arenaceous sequence. Southwest of the bore in hilly terrain of strongly contrasting lithologies such as dolomite and basalt, an interesting variation in basin fill is demonstrated by an **upward coarsening** sequence of mudstone, sandstone and conglomerate.

While neither rare nor critical, each section is a striking example of its kind and both were examined by an international excursion in 1985.

(17.) THREE CORNER BORE EAST

Location: 1:250,000 Geological Series Wyloo
lat 22 48 15 S long 116 34 30 E

SIGNIFICANCE and VALUE

Class IV : Proterozoic Environment
Education
Attractive Setting

GEOLOGICAL NOTE

At 'section gorge' where Beasley River Quartzite rests on Woongarra Volcanics, three sedimentary associations of conglomerate, sandstone and mudstone are interpreted as debris flow deposits passing upwards into a braided streamflow and sheetflood sequence and finally into tidally reworked shoreline deposits. The gorge is used as a reference section for Beasley River Quartzite and the spectacular Three Corner Conglomerate Member carries rounded fragments of enriched iron formation

testifying to the antiquity of iron mineralising processes in the Hamersley Group from which the conglomerate was derived.

Reference: Thorne, A.M., 1985, Ashburton Fold Belt, in Capricorn Orogen Excursion Notes: West. Australia Geol. Survey (unpublished).

TENURE, ACCESS and POSSIBLE THREATS

This locality is within Wyloo Pastoral Lease 3114/647 of the Wyloo Pastoral Co. Pty. Ltd., 1179 Hay St, West Perth, WA 6005. 'Section gorge' lies about 500 m north of the Nanutarra-Wittenoom road 31.5 km east of Metawandy Creek (or approximately 42 km west of Beasley River bridge) and is the first break in the low range which runs eastwards near this part of the road.

There are no obvious threats.

RECOMMENDATIONS

A Geological Site of about 1.2 km² is recommended as shown on aerial photograph WA 1247 Wyloo Run 14 No. 5035 (p.62).

Protection : normal care.

Presentation : the Three Corner Conglomerate Member is visually a splendid lithology but the gorge is a little beyond reach of the normal traveller.

The owners of Wyloo Station and the Shire of West Pilbara should be consulted.

(18.) THREE CORNER BORE SOUTHWEST

Location: 1:250,000 Geological Series Wyloo
lat 22 48 30 S long 116 28 E

SIGNIFICANCE and VALUE

Class IV : Proterozoic Environment
Education
Attractive Setting

GEOLOGICAL NOTE

Cheela Springs Basalt outcrops on lower ground and is overlain by the Woolly Dolomite, stromatolitic in part, and at 'section hill' the dolomite underlies an upward coarsening series of mudstone, sandstone and conglomerate, a prograding sequence of the Mount McGrath Formation recording the local abandonment of a deltaic system.

Reference: Thorne, A.M., 1985, Ashburton Fold Belt, in Capricorn Orogen Excursion Notes: West. Australia Geol. Survey (unpublished).

TENURE, ACCESS and POSSIBLE THREATS

This terrain lies within Wyloo Pastoral Lease 3114/647 of the Wyloo Pastoral Co. Pty. Ltd., 1179 Hay St, West Perth, WA 6005, and mining tenement E 08/100.

'Section hill', difficult to reach because of poor access tracks, is approached from Three Corner Bore which lies a kilometre south of the Nanutarra-Wittenoom road some 27 km east of the Metawandy Creek crossing. From the bore take the westward track for 5 km and turn south at a track junction for 3.5 km to arrive at the foot of a scarp and 'section hill' (4WD).

There are no threats.

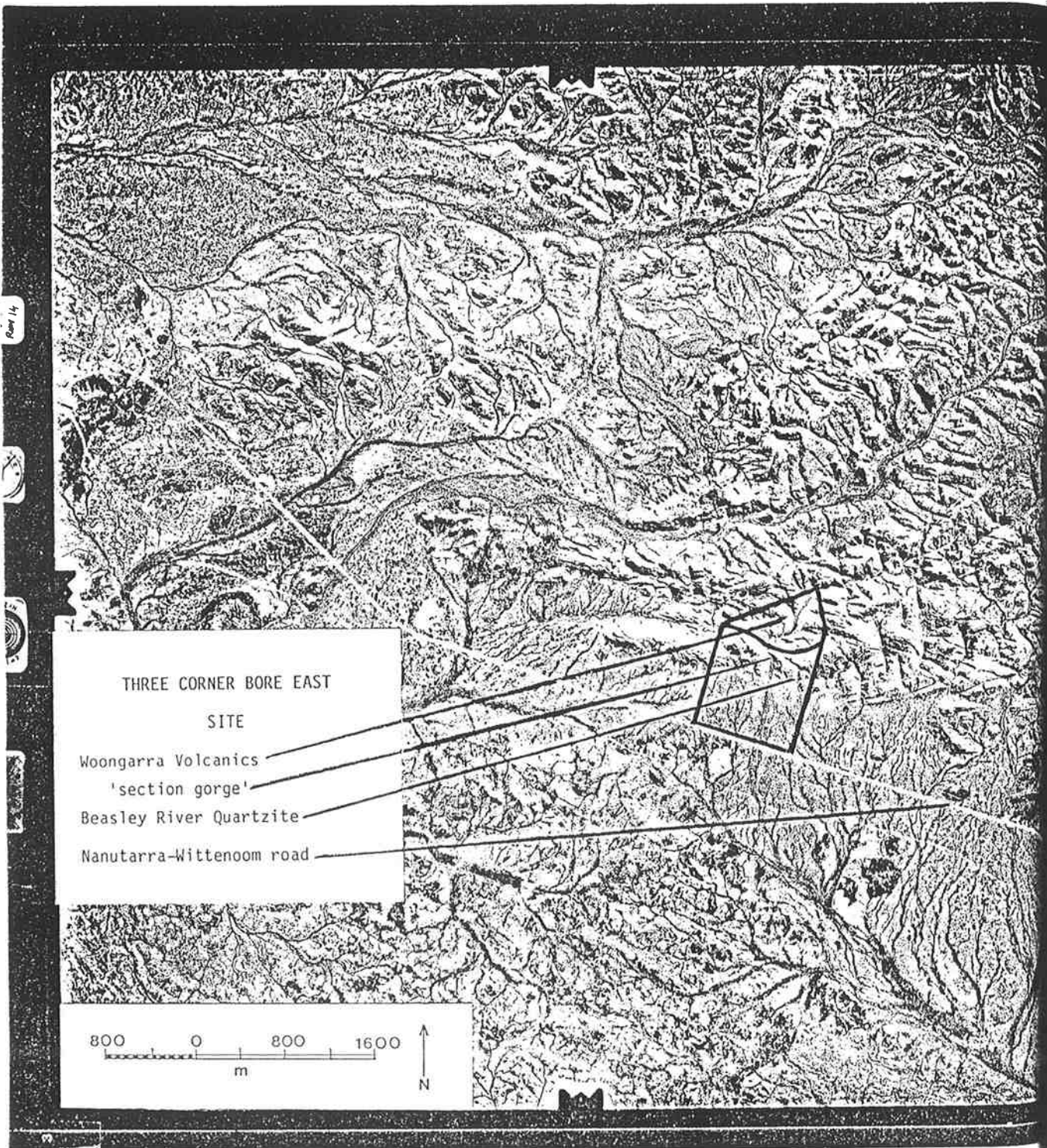
RECOMMENDATIONS

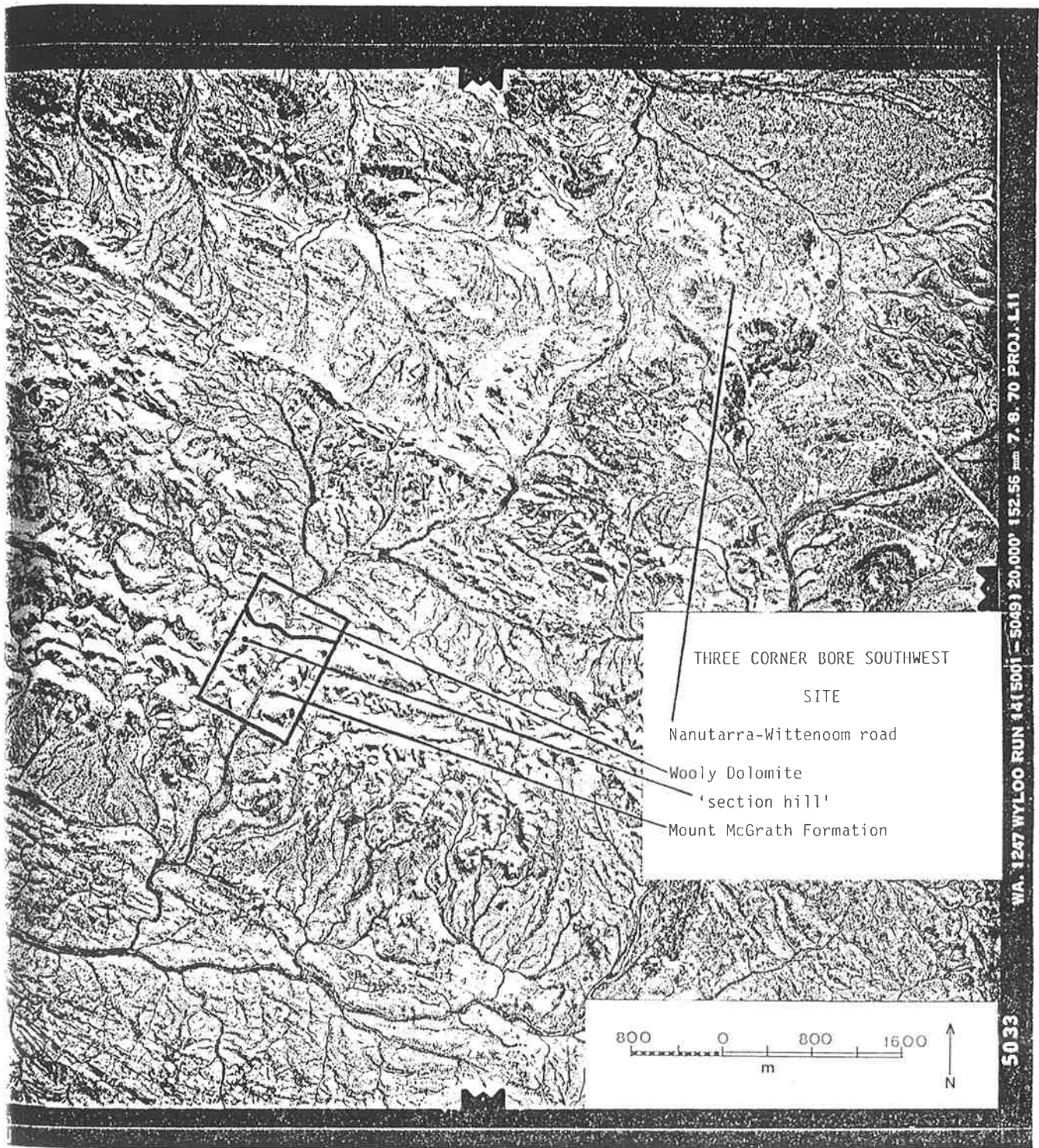
A Geological Site of some 1.2 km² is recommended as shown on aerial photograph WA 1247 Wyloo Run 14 No. 5033 (p.63).

Protection : normal care.

Presentation : not suitable; remote.

The owners of Wyloo Station and the mining tenement, and the Shire of West Pilbara should be consulted.





STATEMENT OF INTEREST

In a tranquil gorge lined by warm, bronze-coloured cliffs of Lower Proterozoic Duck Creek Dolomite, a classic section of upward shallowing sedimentary sequences reveals splendid friezes of stromatolites with facies related variations of these ancient life-forms. The perfection of preservation and clearness of exposure of layer upon layer of stromatolites make this a rare phenomenon even on a universal scale and Duck Creek Gorge is assessed by many as one of the finest sedimentary faces in Western Australia.

Location: 1:250,000 Geological Series Wyloo
lat 22 28 S long 116 19 E

SIGNIFICANCE and VALUE

Class I : Proterozoic Stromatolites
Research
Attractive Setting

GEOLOGICAL NOTE

The stromatolitic dolomites are assigned to the Duck Creek Dolomite of the Wyloo Group (c.2000 m.y.). In the gorge walls, branching columnar stromatolites and microdigitate forms are seen together in upward shallowing sequences where branching varieties grew in shallow lagoons and microdigitate forms flourished in tidal pools.

Reference: Grey, K., and Alan M. Thorne, 1985, Biostratigraphic significance of stromatolites in upward shallowing sequences of the early Proterozoic Duck Creek Dolomite, Western Australia: Precambrian Research 29, p. 183-206.

Plate: 14

TENURE, ACCESS and POSSIBLE THREATS

Duck Creek Gorge is situated within Mount Stuart Pastoral Lease 3114/1057 (via Carnarvon, WA 6701).

A straightforward access is by the Red Hill road which leaves the Nanutarra-Wittenoom road northward some 3 km west of Mount Stuart Station. After 2.2 km turn east onto Duck Creek road for 26 km and then take the track south to Duck Creek (8.5 km) where the gorge lies 1 to 2 km upstream (4WD).

Indiscriminate collecting of stromatolites and mindless hammering of cliff faces are likely threats.

RECOMMENDATIONS

A Geological Monument of approximately 2.1 km² is recommended as shown on aerial photograph WA 1248 Wyloo Run 9 No. 5026 (p.66).

Protection : high priority; although protected to some extent by isolation this valuable record could attract many geological parties over the years and there may be need to provide against visitor induced degradation.

Proposal : an illustrated guide to this outstanding geology should be prepared.

Presentation : not suitable; remote.

The owners of Mount Stuart Station and the Shire of West Pilbara should be consulted.

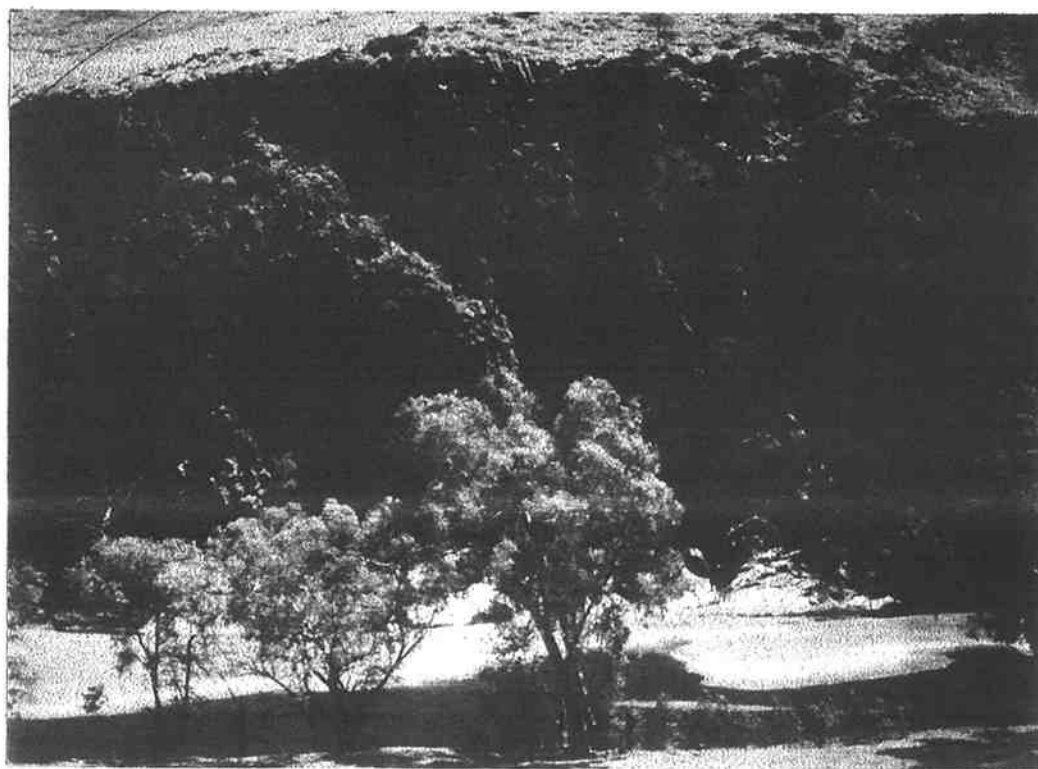
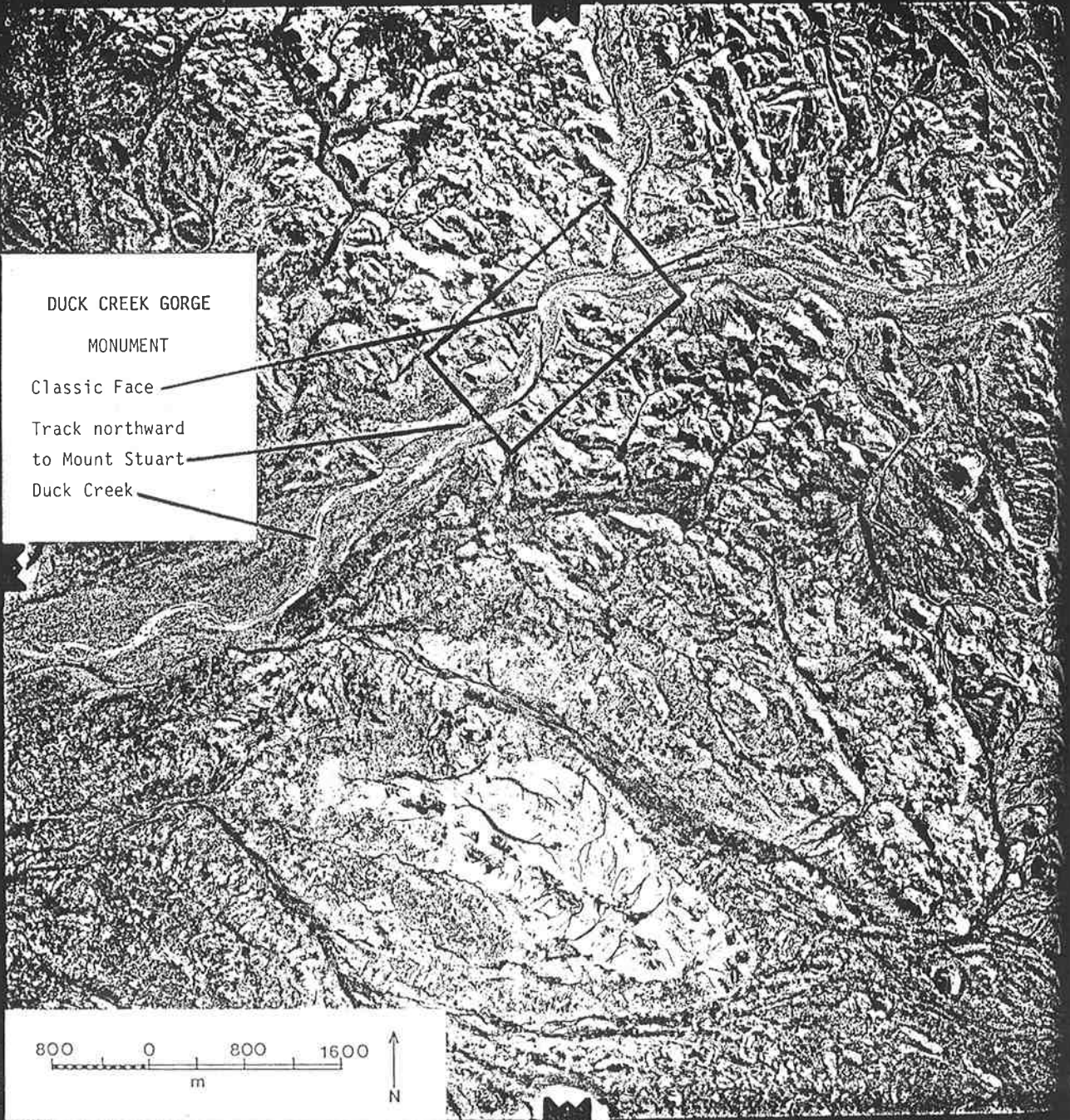


Plate 14 DUCK CREEK GORGE A.M. Thorne
Splendid friezes of stromatolites are seen
in these dolomite cliffs

5026

WA. 1248. WYLOO RUN 9 (5001 - 5052) 20,000' 152.56' 8. 8. 70. PROJ. L11



STATEMENT OF INTEREST

An unusually clear section of reddish gold Duck Creek Dolomite and basaltic rocks of June Hill Volcanics of the Lower Proterozoic is exposed around the summit of a hill near Urandy Bore some 20 km east of Mount Stuart and includes readily visible interbedded dolomite and pillow breccia with tuff.

This section was examined by an international excursion in 1985.

Location: 1:250,000 Geological Series Wyloo
lat 22 26 30 E long 116 15 15 E

SIGNIFICANCE and VALUE

Class III : Proterozoic Stratigraphy
Education
Attractive Setting

GEOLOGICAL NOTE

These dolomites and basalts belong to the Wyloo Group now given an approximate age of 2000 m.y. The section of more than 30 m, is situated about 5 km north of June Hill and in this district June Hill Volcanics are about 120 m thick and consist of basaltic agglomerate, tuff and lava resting on Duck Creek Dolomite.

Reference: Thorne, A.M., 1985, Ashburton Fold Belt, in Capricorn Orogen Excursion Notes: West. Australia Geol. Survey (unpublished).

Plate: 15

TENURE, ACCESS and POSSIBLE THREATS

The hill is situated 7 km west of Urandy Bore on Mount Stuart Pastoral Lease 3114/1057 with the owner at Mount Stuart Station via Carnarvon, WA 6701.

Take the Red Hill road which leaves the Nanutarra-Wittenoom road northwards about 3 km west of Mount Stuart station entrance. After 2.2 km turn east to follow Duck Creek road for 26 km and then turn south onto the track to Duck Creek Gorge and at about 1.5 km 'section hill' lies a kilometre to the west (4WD).

No threat is foreseen.

RECOMMENDATIONS

A Geological Site of some 30 ha is recommended as shown on aerial photograph WA 1248 Wyloo Run 8 No. 5075 (p.69).

Protection : normal care.

Presentation : not suitable; remote.

The owners of Mount Stuart Station and the Shire of West Pilbara should be consulted.

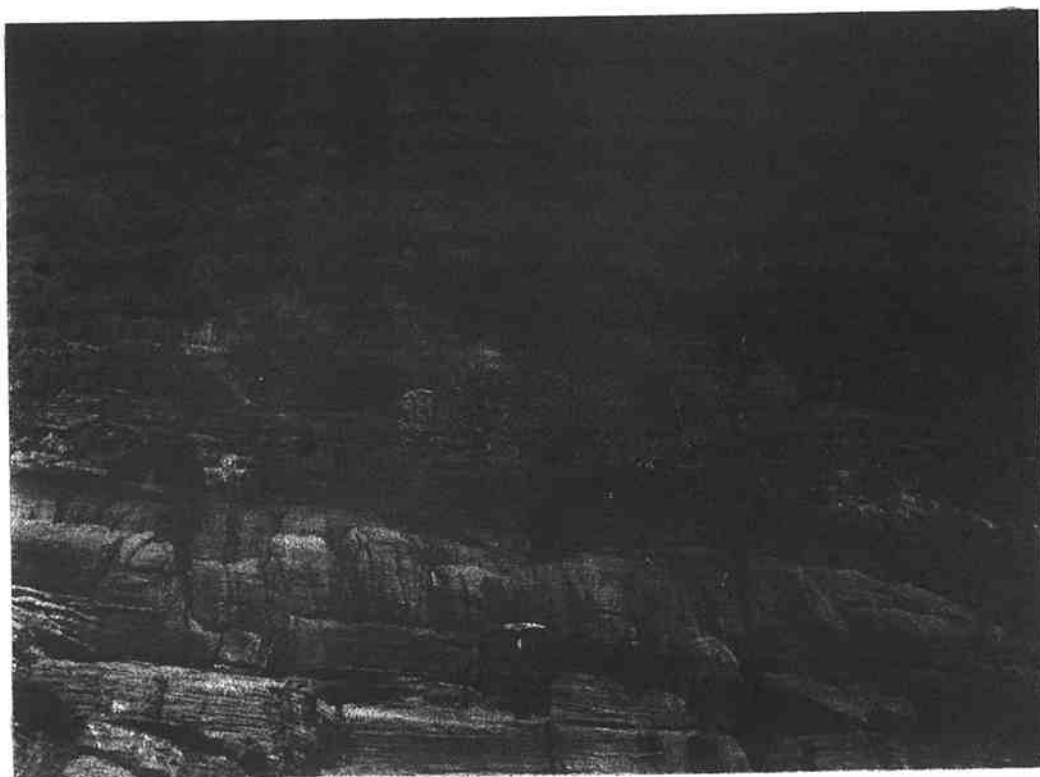
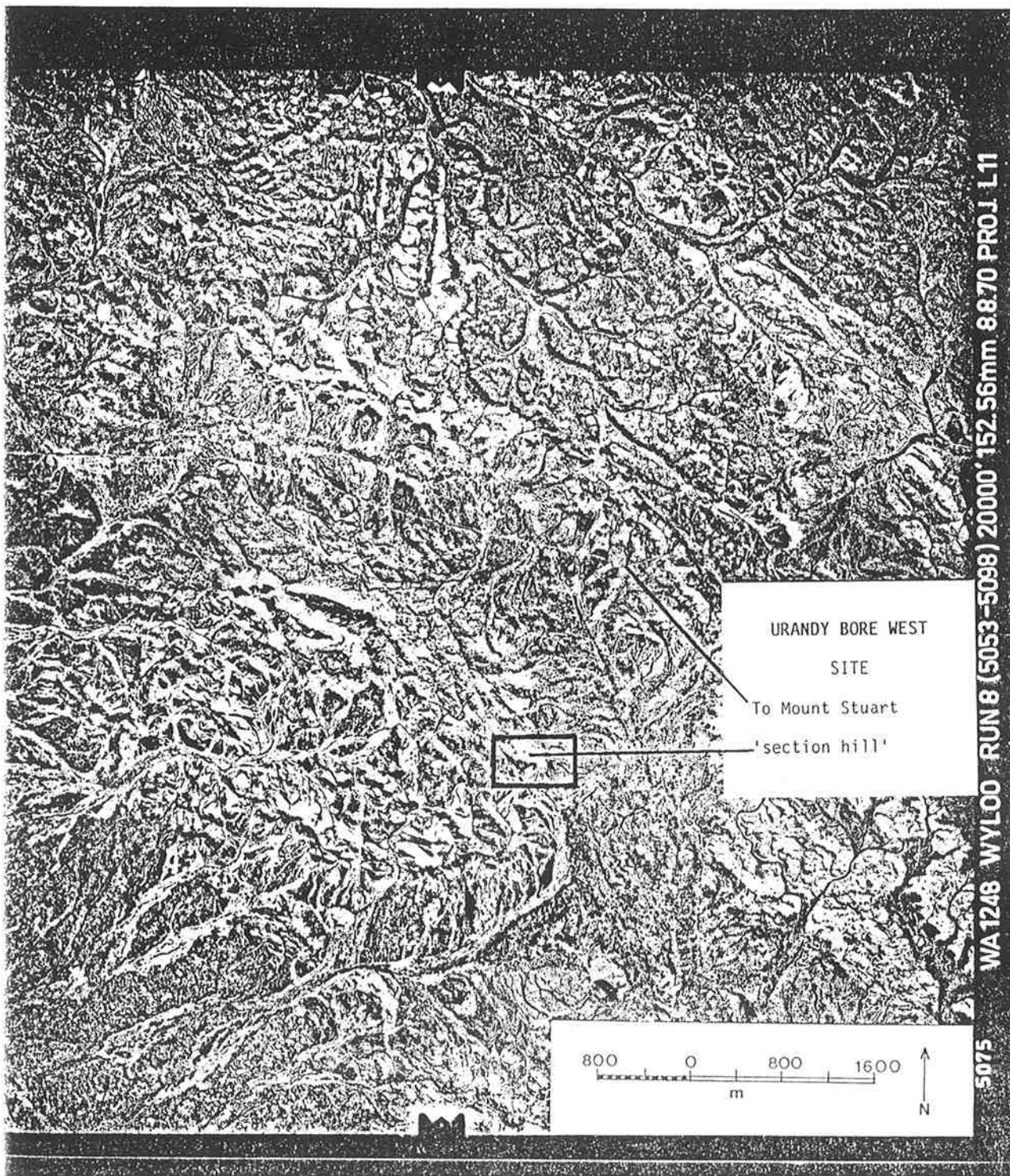


Plate 15

SECTION HILL, URANDY BORE WEST

J.D. Carter

Duck Creek Dolomite underlies basalt of June Hill Volcanics



STATEMENT OF INTEREST

Huge exotic rafts or olistoliths, of dolomite and lesser blocks of sandstone engulfed in slaty rocks of the Ashburton Formation are found in a belt several kilometres long in hilly country 12 km northwest of Wyloo Station and this enigmatic admixture is interpreted as marking an early Proterozoic submarine canyon. The canyon cut through Duck Creek Dolomite and underlying formations of the Wyloo Group to uncover the Fortescue Group, and as it was filled by fine sediment in Ashburton Formation times, wall collapses fed blocks of dolomite and then sandstone into the muddy sediments bringing about an inverted sequence of Wyloo Group lithologies for Duck Creek Dolomite rafts tens of metres across, float in slates below blocks of sandstone which resemble facies in the Mount McGrath Formation.

Location: 1:250,000 Geological Series Wyloo
lat 22 34 S long 116 6 E

SIGNIFICANCE and VALUE

Class III : Proterozoic Environment
Education
Attractive Setting

GEOLOGICAL NOTE

Rocks of the 2000 m.y. Wyloo Group found in the submarine canyon appear to be:

Ashburton Formation	infill with an inverted sequence of:
Duck Creek Dolomite	lower exotic rafts,
Mount McGrath Formation	rare higher exotic blocks.

Large-scale collapses in the Wyloo Group have been recorded at different stratigraphic levels from a number of localities in the Ashburton Trough.

Reference: Horwitz, R.C., 1981, Large scale slumping in the Ashburton Trough of Western Australia: Precambrian Research 14, p.389-401.

Plate: 16

TENURE, ACCESS and POSSIBLE THREATS

This terrain lies within Mount Stuart Pastoral Lease 3114/1057 with owner at Mount Stuart Station via Carnarvon, WA 6701, and is covered in part by mining tenement P 08/204.

Exotic rafts and blocks in Ashburton Formation are clearly displayed south of the Nanutarra-Wittenoom road 9.7 km east of the Duck Creek crossing (or 17.5 km west of Wyloo Station turn-off). At this point where Mindle Bore is seen, take the southward track for 1.8 km and some 300 m to the west, large rafts of dolomite lie in Ashburton Formation slate (4WD).

No threats are foreseen.

RECOMMENDATIONS

An outline site of 3.8 km² is recommended as shown on aerial photograph WA 1247 Wyloo Run 10 No. 5215 (p.73).

Protection : normal care.

Proposal : a large-scale map (1:5000) is required to appreciate this unusual geology and it should be centred on the area of the huge rafts mentioned in the access instruction. From the map a specific Site could be described.

Presentation : not suitable; this geology is not readily appreciated.

The owners of Mount Stuart Station and the mining tenement, and the Shire of West Pilbara should be consulted.

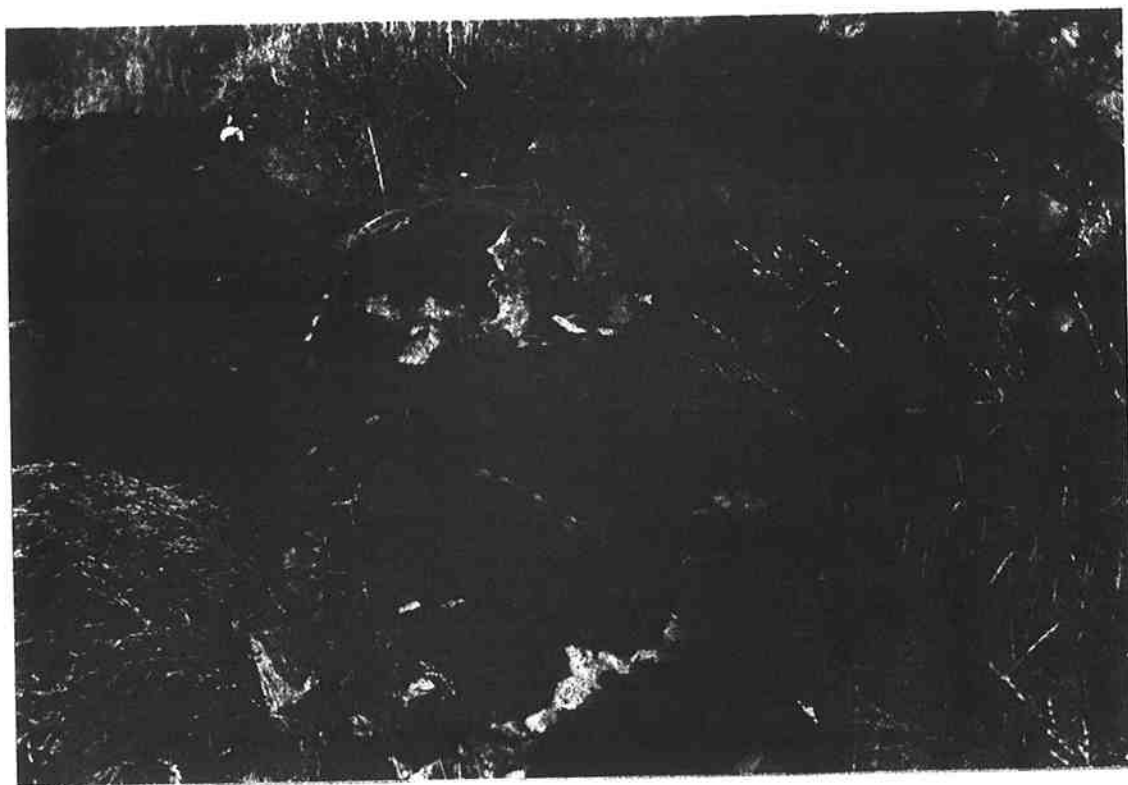
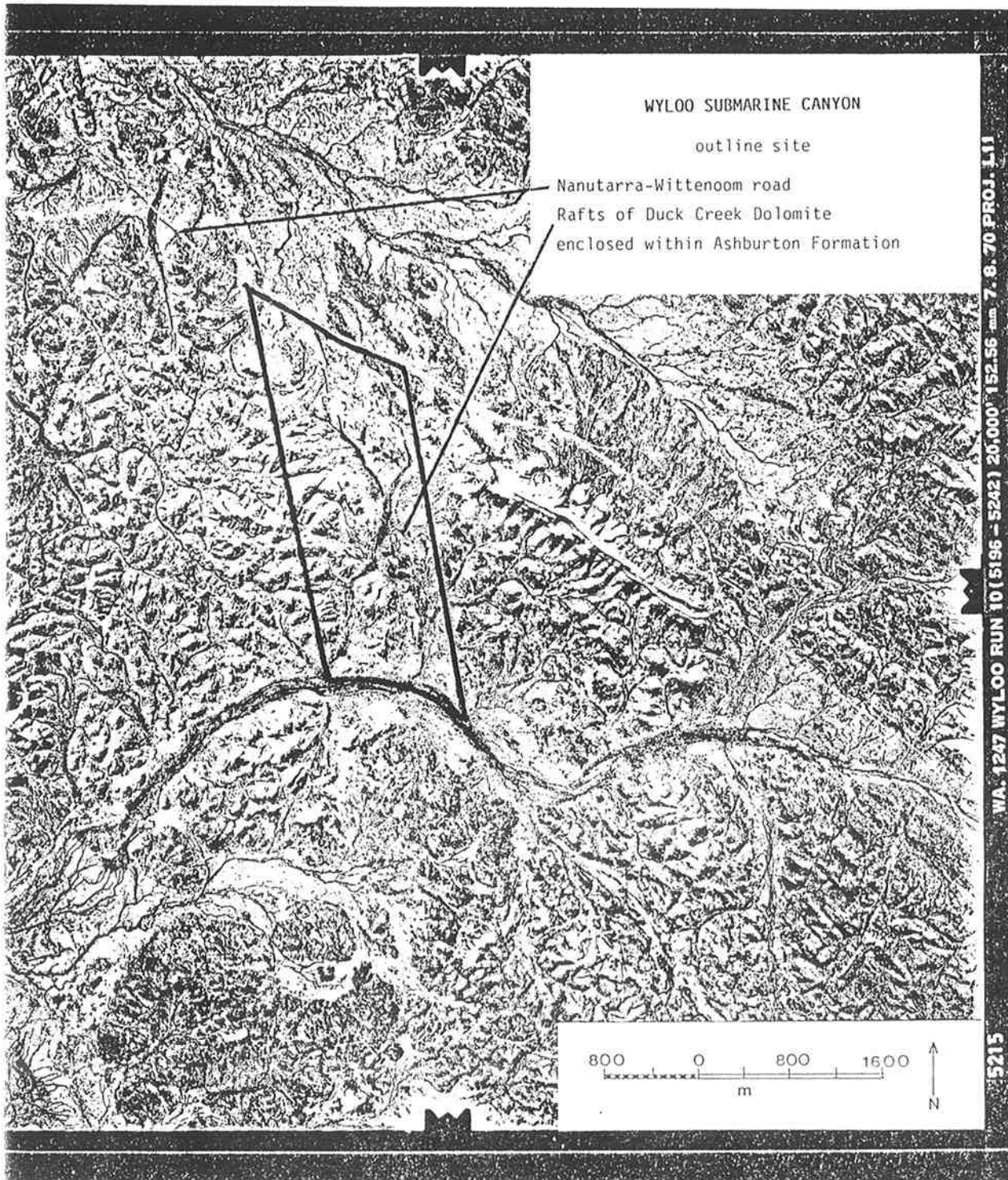


Plate 16

WYLOO SUBMARINE CANYON

J.D. Carter

Duck Creek Dolomite block in Ashburton Formation slate.
Some blocks of dolomite are tens of
metres across and form hillocks



STATEMENT OF INTEREST

The youngest of the great sequences of Precambrian banded iron formation for which the Pilbara is famous, is handsomely displayed in the Mount Stuart massif where iron formation of the Ashburton Formation is seen in bold panoramas of large convolute folds. Iron formation with a variety of sedimentary structures on the east of the massif is matched in interest along the western flank just below the iron formation, by outcrops of large exotic blocks or olistoliths, of acid volcanics, dolomite and basalt emplaced by marine slumping.

Iron formation at Mount Stuart was examined by an international excursion in 1985.

Location: 1:250,000 Geological Series Wyloo
lat 22 25 S long 116 3 E

SIGNIFICANCE and VALUE

Class III : Proterozoic Iron Formation
Research
Attractive Setting

GEOLOGICAL NOTE

The Ashburton Formation is the youngest formation of the approximately 2000 m.y. Wyloo Group. At Mount Stuart, banded iron formation, siltstone and mudstone are some 370 m thick and the underlying assemblage which includes olistoliths is clearly exposed along the west of the massif.

References: Horwitz, R.C., 1981, Large scale slumping in the Ashburton Trough of Western Australia: Precambrian Research 14, p. 389-401.

Thorne, A.M., 1985, Ashburton Fold Belt, in Capricorn Orogen Excursion Notes: West. Australia Geol. Survey (unpublished).

TENURE, ACCESS and POSSIBLE THREATS

Mount Stuart lies within Mount Stuart Pastoral Lease 3114/1057 with the owner at Mount Stuart Station via Carnarvon, WA 6701. The outline monument now proposed to embrace the massif, abuts against or may incorporate a southernmost strip of Red Hill Pastoral Lease 3114/463. It is covered in part by mining tenement E 08/146.

Mount Stuart is seen from the Nanutarra-Wittenoom road and is reached by taking the Red Hill road which leaves the sealed road northward 3 km west of Mount Stuart station entrance. After 2.2 km turn east onto the Duck Creek road.

No threats are foreseen.

RECOMMENDATIONS

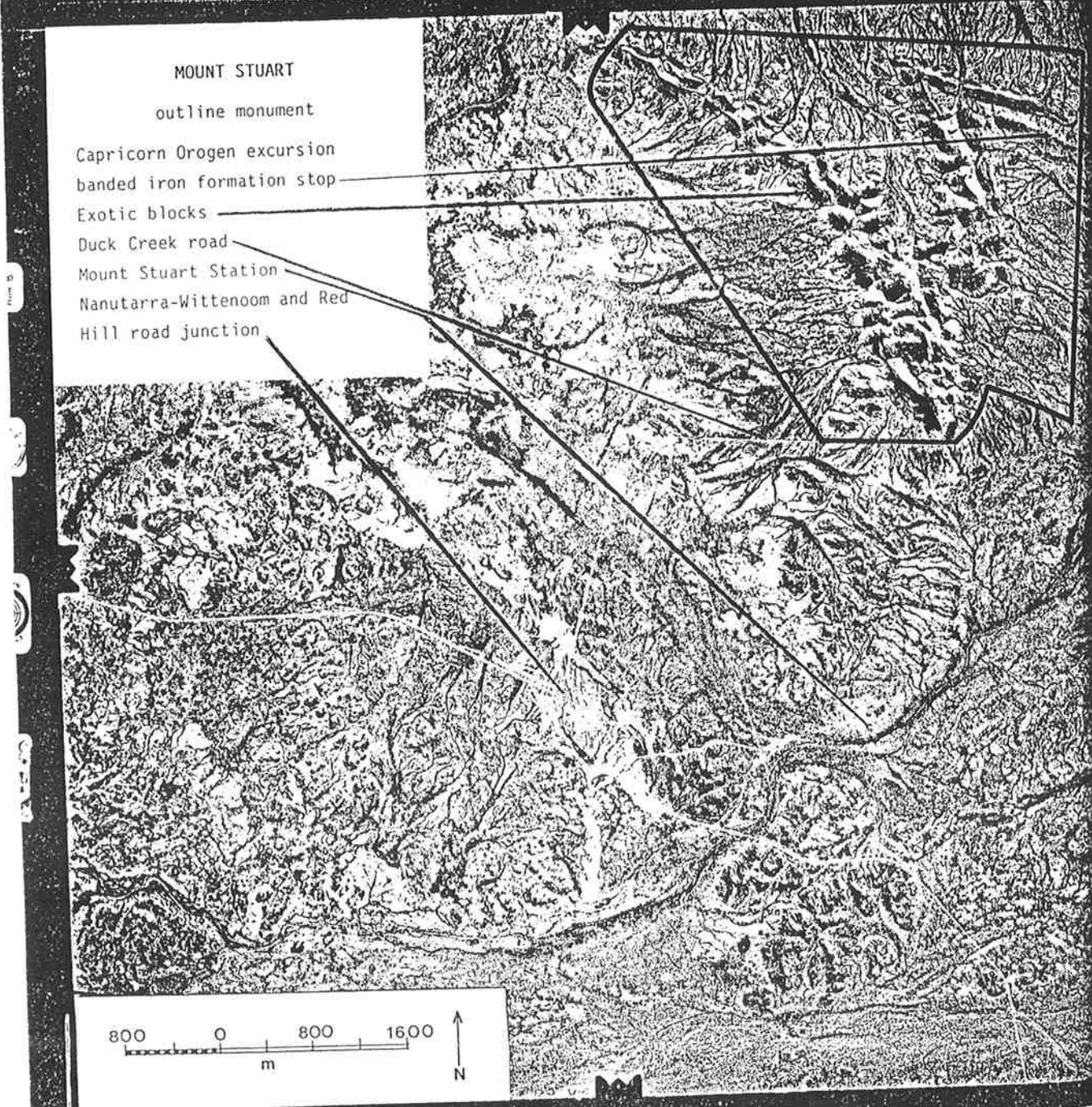
An outline monument of approximately 11 km² is recommended as shown on aerial photograph WA 1248 Wyloo Run 8 No. 5069 (p.76).

Protection : normal care.

Proposal : this massif embraces many interesting geological features set in a semi-wilderness and has more than ordinary potential for student parties but to realise this, a geological map at a scale of 1:20,000 is needed and this could be used to determine specific boundaries for a Geological Monument.

Presentation : not suitable; this geology is not readily appreciated.

The owners of Mount Stuart Station (and possibly Red Hill Station) and the mining tenement, and the Shire of West Pilbara should be consulted.



STATEMENT OF INTEREST

A little east of Nanutarra the road to Wittenoom passes through low ridges of sedimentary rocks and at the roadside a major unconformity within the Proterozoic is marked by slate of the Ashburton Formation of the Wyloo Group abutting against tilted layers of conglomerate at the base of the younger Bangemall Group.

Location: 1:250,000 Geological Series Wyloo
lat 22 28 30 S long 115 36 E

SIGNIFICANCE and VALUE

Classes III and V : Proterozoic Unconformity
Education

GEOLOGICAL NOTE

Outcrop of slate of the approximately 2000 m.y. Wyloo Group is poor though the conglomerate of the 1200 m.y. Bangemall Group is splendidly exposed and deserves examination.

Plate: 17

TENURE, ACCESS and POSSIBLE THREATS

This part of the Wittenoom road crosses Pastoral Lease 3114/1096 Nanutarra of the Nanutarra Pastoral Co. Pty. Ltd. and Hope Range Pastoral Co., c/- N.W. & C.A. Bates, Nanutarra Station via Carnarvon, WA 6701. Part of the ground is incorporated within mining tenement E 08/157.

The unconformity is found alongside the Nanutarra-Wittenoom road 9.1 km east of the turn-off from the North West Coastal Highway and is 2.5 km west of the Ten Mile Creek crossing.

No threats are foreseen.

RECOMMENDATIONS

A Geological Monument of 55 ha is recommended as shown on aerial photograph WA 1248 Wyloo Run 9 No. 5047 (p.79).

Protection : normal care.

Presentation : although poor exposure of the Ashburton Formation lowers the value of this feature, a roadside rest area with a notice board should be considered.

The owners of the Nanutarra Pastoral Lease and the mining tenement, the Shire of West Pilbara and the Main Roads Department should be consulted.

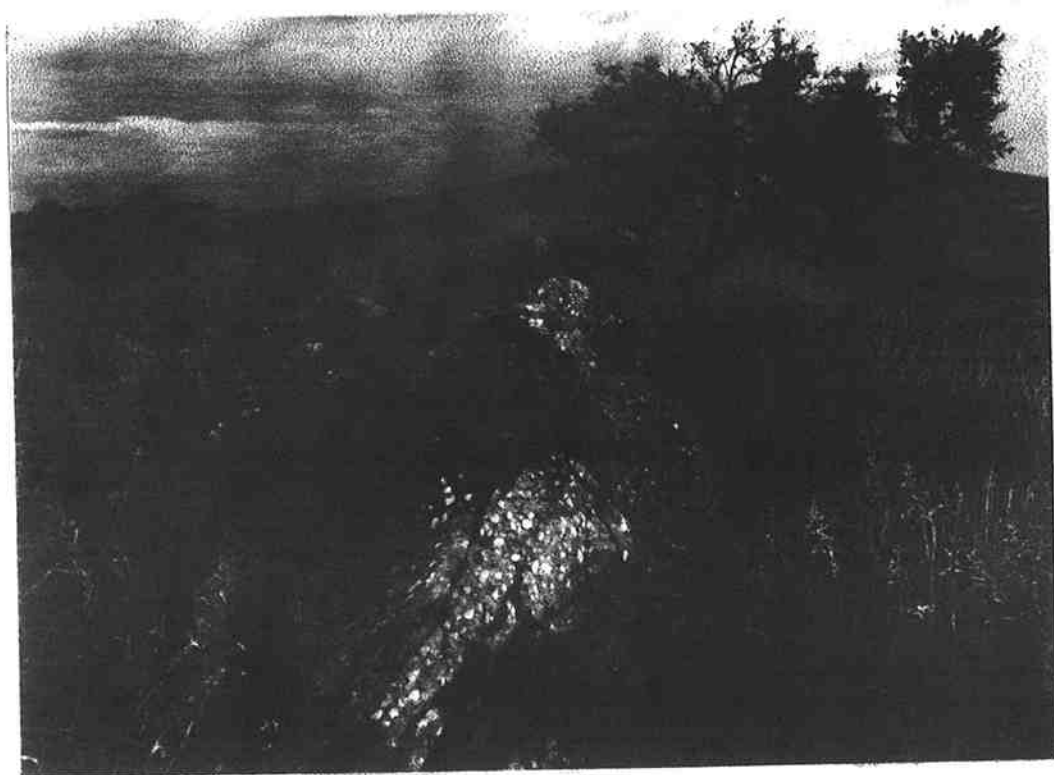
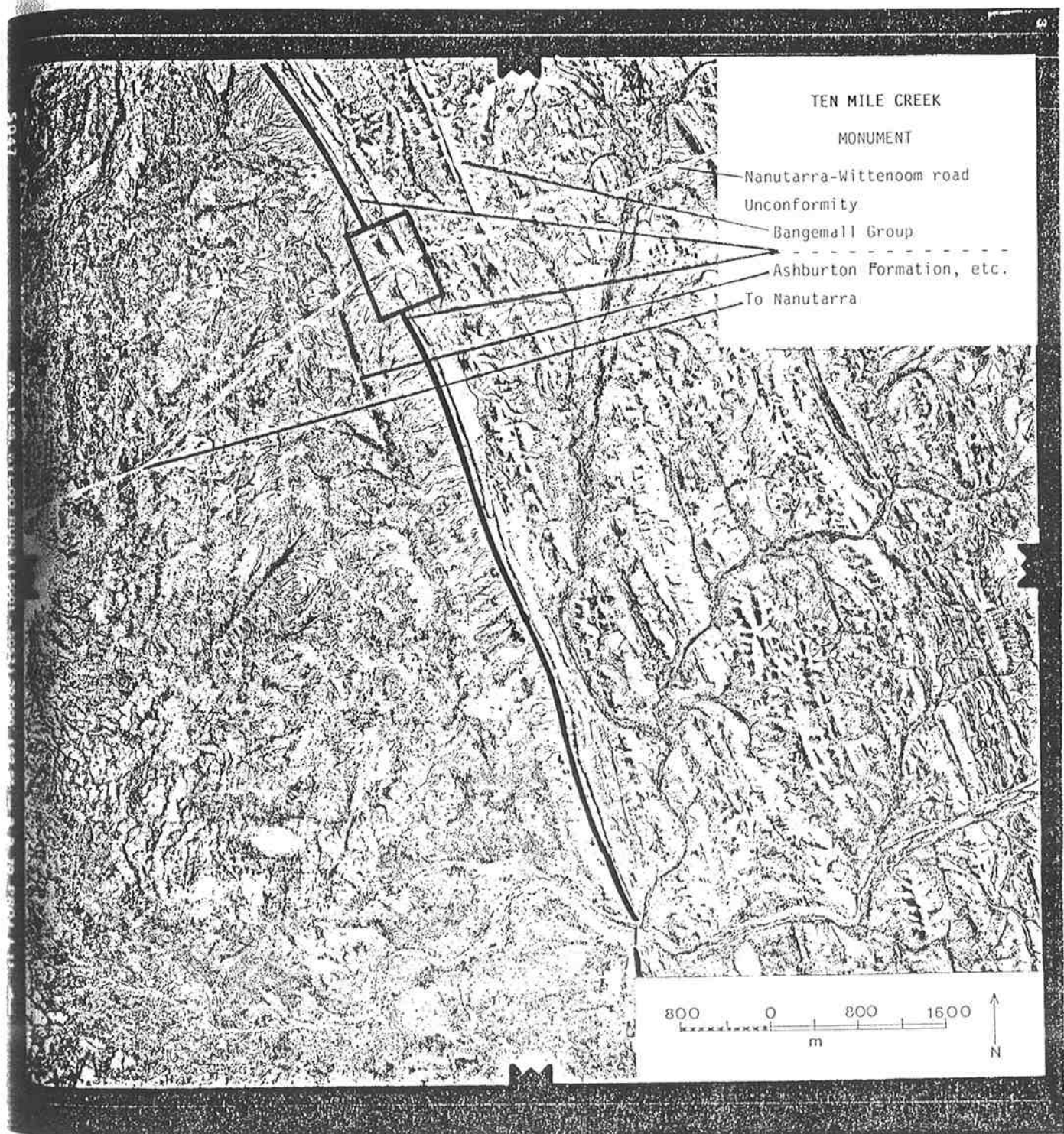


Plate 17

TEN MILE CREEK

J.D. Carter

At the roadside Bangemall Group conglomerate rests on
slate of the Ashburton Formation exposed
in the low ground on the right



OTHER LOCALITIES

Nanutarra-Wittenoom Roadside Pillow Basalt: pillow basalt of the Jeerinah Formation, the youngest formation of the 2700 m.y. Fortescue Group, is exposed in cuttings along the Nanutarra-Wittenoom road near the Paraburdoo turn-off (R.C. Horwitz pers. comm.). Pillow structures are clearly seen but as these outcrop along narrow verges of a sealed road carrying fast traffic their examination is rather hazardous and no recommendation is made. The best exposure is found 4.5 km west of the Paraburdoo turn-off (26.9 km east of the Ashburton Downs road) and other examples are seen 16.1 km and 16.7 km west of the Paraburdoo turn-off (Mount Bruce 1:250,000 Geological Series).

Features of merit worth recording for future consideration include:

Mount Bresnahan - stacked profiles of stream sections in the Proterozoic Bresnahan Group are exposed in three-dimensions (Turee Creek 1:250,000 Geological Series; P.C. Muhling pers. comm.);

Ashburton Downs-Meekatharra Roadside Unconformity - a few kilometres north of the Turee Creek 1:250,000 Geological Series sheet (southern) boundary, the unconformity between the Wyloo and Bangemall Groups is seen;

Pingandy Creek - an excellent example of a large stromatolite reef in the Bangemall Group (Mount Egerton 1:250,000 Geological Series and Stop B-7 of the 1985 Capricorn Orogen Excursion Notes; West. Australia Geol. Survey);

Irregully Gorge - fine exposures of the Bangemall Group with stromatolites and sedimentary structures (Edmund 1:250,000 Geological Series).

MINILYA RIVER AND NORTH WEST CAPE

TRAVERSE OF PHANEROZOIC GEOLOGY

Phanerozoic strata of the northern part of the Carnarvon Basin are well-exposed at a number of localities near Minilya River and in a series of anticlines lying within North West Cape (Figure 7), and many fine geological features combine with attractive riverine and hilly terrain to make this part of the Carnarvon Basin one of considerable merit for geological and natural history education generally.

Four features were added to those recommended prior to the survey with this result:

Minilya River

24. Gneudna Paddock-Williambury	Monument
25. Minilya River South Branch Boulder Bed	Monument
26. K 52 Hill	Site
27. Gooch Range Southern Termination	Monument
28. Coolkilya Pool	Monument
29. Wandagee Hill	Monument
30. Wandagee Radiolarite Quarry	Site

North West Cape

31. Remarkable Hill	Monument
32. Cape Range	outline monument

A traverse should commence at the eastern margin of the Carnarvon Basin in Gneudna Paddock where highly fossiliferous limestones of the Devonian and nearby fossiliferous limestones of the Carboniferous are found in a somewhat rugged and wild setting with Precambrian crystalline hills on the east. A short distance to the west the most famous of the glacial boulder beds of the late Carboniferous-early Permian Lyons Formation is seen at the Minilya River South Branch crossing. A little further to the west there are considerable exposures of fossiliferous Permian limestones in appealing landscapes around K 52 Hill and then the type section of the Moogooloo Sandstone appears in the massive rampart of Gooch Range. Younger fossiliferous type sections of Permian formations are clearly displayed at Coolkilya Pool and Wandagee Hill and to the north around Remarkable Hill and in North West Cape, there are splendid expositions of Cretaceous and Tertiary strata along escarpments and within magnificent canyons.

Reasonably good access to the conveniently close-spaced Minilya River features is gained from the Wandagee-Middalya-Williambury-Gascoyne Junction road which leaves the North West Coastal Highway eastwards some 5 km south of the Minilya River crossing.

MINILYA RIVER AND NORTH WEST CAPE

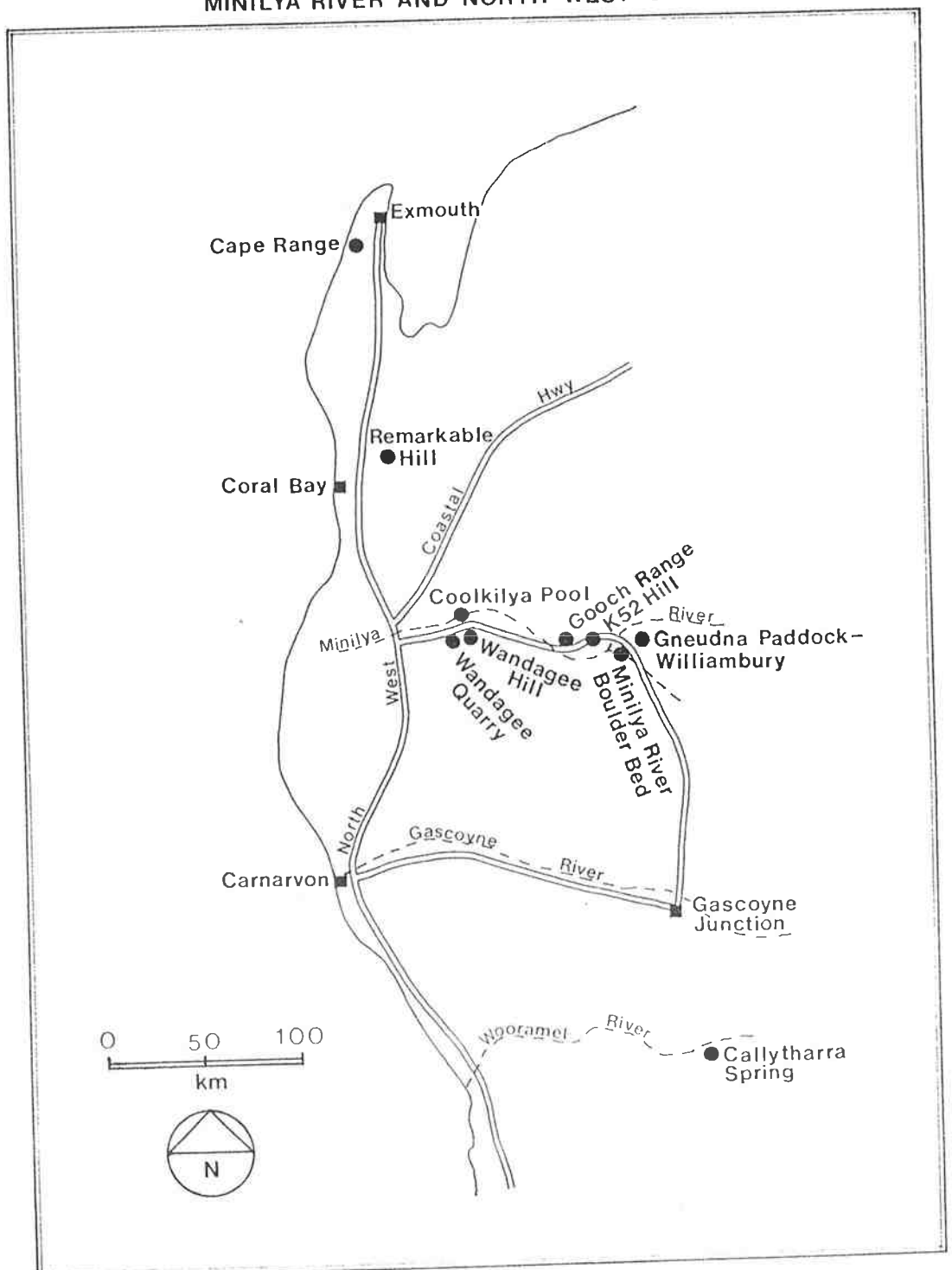


Figure 7

STATEMENT OF INTEREST

A thick and spectacular sequence of the Devonian and early Carboniferous forms almost continuous exposures incorporating the type sections of six formations near Minilya River along the eastern margin of the Carnarvon Basin. This includes the richly fossiliferous Gneudna Formation and Moogooree Limestone and outcrops generally are clear and free from threat, and offer great opportunities for research and education.

This is a well-known teaching locality.

Location: 1:250,000 Geological Series Winning Pool-Minilya
lat 23 55 S long 115 12 E

SIGNIFICANCE and VALUE

Class II : Palaeozoic Stratigraphy
Research
Attractive Setting

GEOLOGICAL NOTE

The gently westward dipping succession of predominantly shallow marine sandstone, shale and limestone of some 2100 m rests on an irregular surface of Precambrian granite and gneiss:

Carboniferous		Devonian	
	m		m
top			
Yindagindy Formation	c.70	Willaraddie Formation	294
Williambury Formation	325	Munabia Sandstone	555
Moogooree Limestone	326	Gneudna Formation	517
		Nannyarra Sandstone	59
		bottom	

Type sections of formations from the basal Nannyarra Sandstone through to the Williambury Formation are defined here, the more noteworthy being those of the fossiliferous Gneudna Formation and the Moogooree Limestone. The former has many horizons crowded with brachiopods, corals, conodonts and stromatoporoids while the Moogooree Limestone contains coquinas of these forms as well as quiet water colonial species and algal limestone. The remainder of the sequence consists largely of sandy rocks apart from the

Yindagindy Formation which includes some thin limestones.

Reference: Hocking, R.M., Moore, P.S., and van de Graaff, W.J.E., (in Press), The geology of the Carnarvon Basin : West. Australia Geol. Survey Bull.

Plate: 18

TENURE, ACCESS and POSSIBLE THREATS

Williambury Pastoral Lease 3114/1118 includes Gneudna Paddock and owners are contacted through GPO Box G400, Perth WA 6001.

Access is from the Williambury Station-Gascoyne Junction road some 8 km south of the Minilya River crossing by turning east onto Microwave Tower road and proceeding east into Gneudna Paddock or north by poor tracks to Moogooree Limestone type sections. Aerial photographs are needed if type sections are to be found (4WD).

Although to some extent protected by isolation, the fossil beds are obvious targets for collectors and in September 1985 a lapidarist was working through Gneudna Paddock.

RECOMMENDATIONS

It is desirable to treat the six close-spaced type sections of the continuous Devonian-Carboniferous succession together even though a large tract of country is involved and accordingly a Geological Monument of some 90 km² is recommended as shown on Winning Pool Runs 15, 16 and 17, aerial photographs Nos. 5347 (WA 1641), 5232 and 5212 (WA 1635), respectively (p.86).

- Protection : high priority; type sections of the Gneudna Formation and Moogooree Limestone should be reserved for research.
- Proposal : a geological map of 1:40,000 or larger scale is needed, showing type sections and exposures suitable for general educational purposes.
- Presentation : a little remote but the potential for public education and enjoyment of these clear and informative exposures is high.

The owners of Williambury Pastoral Lease and the Shire of Carnarvon should be consulted.

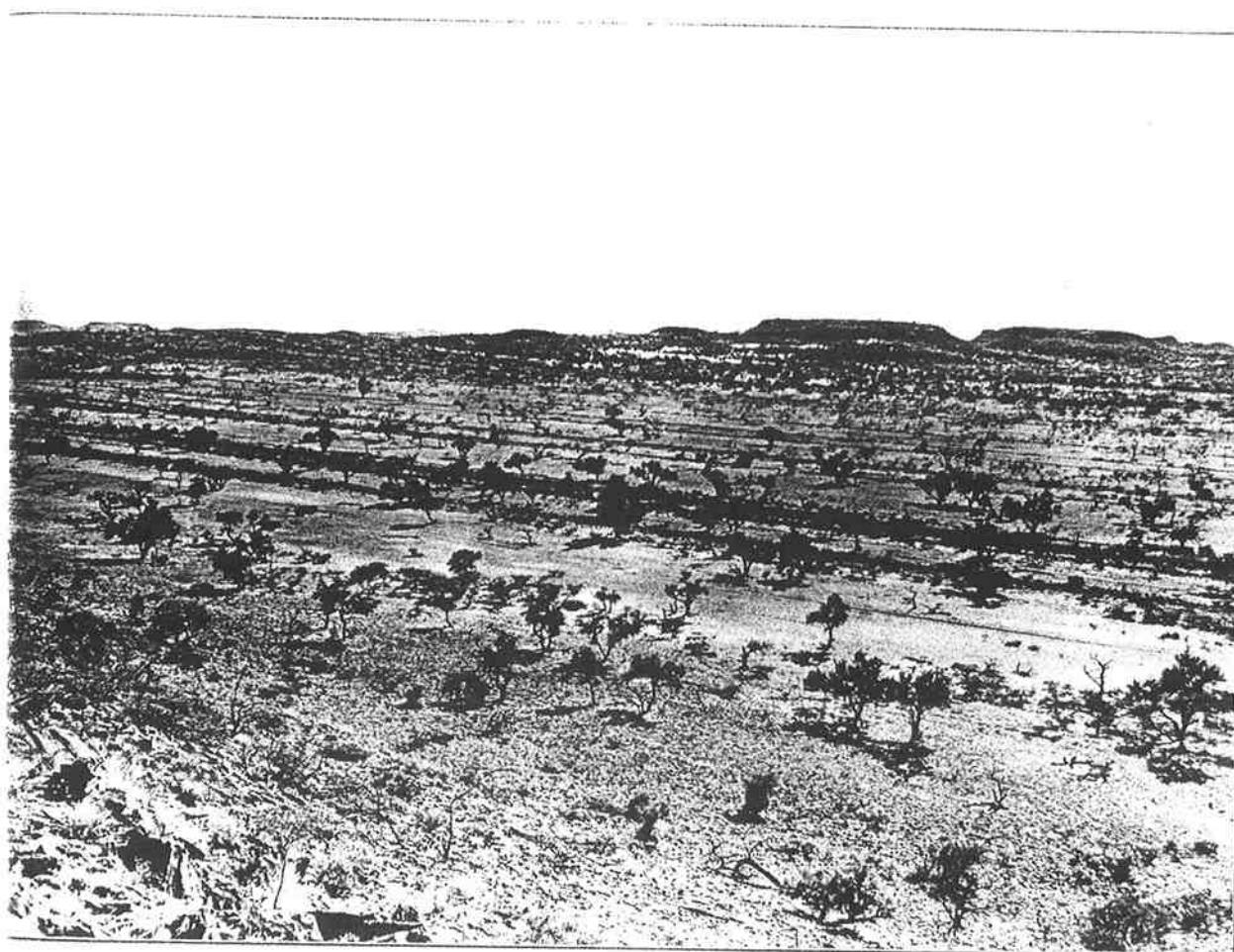


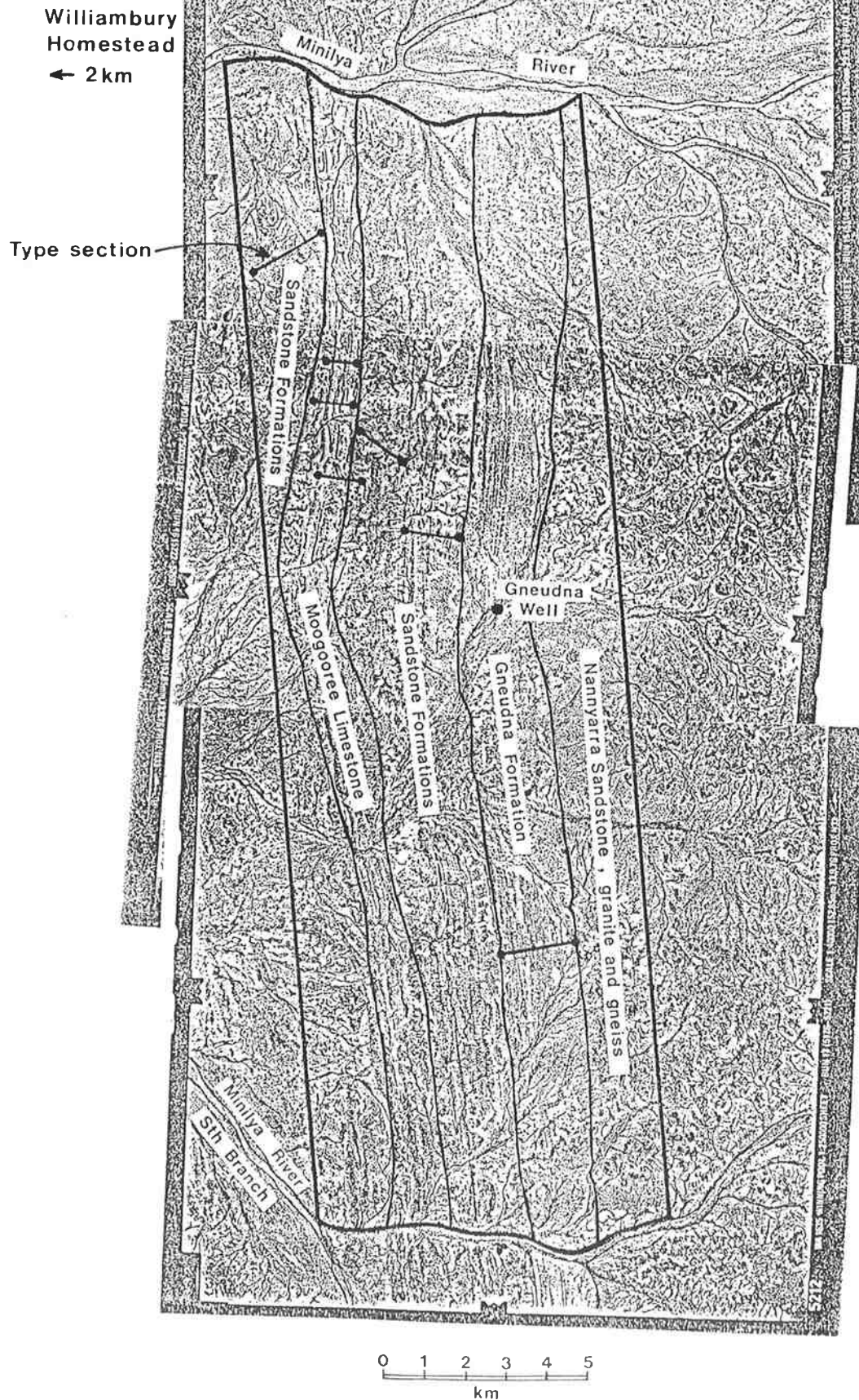
Plate 18

GNEUDNA Paddock

Nigel Drake

Strike ridges of highly fossiliferous Devonian limestones

GNEUDNA Paddock WILLIAMSBURY MONUMENT



25. MINILYA RIVER SOUTH BRANCH BOULDER BED

STATEMENT OF INTEREST

One of the best examples of a glaciogene boulder bed of the late Carboniferous-early Permian Lyons Formation is found on the north bank of the Minilya River South Branch at the roadside some 15 km south of Williambury Station. Here a fine display of erratic lithologies includes a prominent granite boulder more than 4 m in diameter, the largest glacial boulder known in the Formation.

Location: 1:250,000 Geological Series Winning Pool-Minilya
lat 23 59 S long 115 10 E

SIGNIFICANCE and VALUE

Classes III and V : Palaeozoic Glaciogene Lithology
Education

GEOLOGICAL NOTE

In the Lyons Formation the effects of several successive glaciations perhaps extending over a period of more than 20 m.y. can be detected. At South Branch erratics include sedimentary, metamorphic and igneous rocks largely carried from the north-east.

Reference: Hocking, R.M., Williams, S.J., Laving, I.H., and Moore, P.S., 1985, Winning Pool-Minilya, W.A.: West. Australia Geol. Survey 1:250,000 Geol. Series Explan. Notes.

Plate: 19

TENURE, ACCESS and POSSIBLE THREATS

This locality lies within Williambury Pastoral Lease 3114/1118 with address GPO Box G400 Perth, WA 6001. The bed with its conspicuous granite boulders lies alongside the Williambury Station-Gascoyne Junction road immediately north of the Minilya River South Branch crossing.

Road metal has been won from a small pit by the Shire of Carnarvon and the pit will be used for reinstating the river crossing after periodic floods.

RECOMMENDATIONS

A Geological Monument of some 30 ha is recommended as shown on aerial photograph WA 1635 Winning Pool Run 17 No. 5211 (p.89).

Protection : normal care; the Shire of Carnarvon should be invited to ensure that the large granite boulder and its surrounds for 50 m are not worked for road metal.

Presentation : this road carries sparse traffic but a rest area and notice board explaining the huge boulders and medley of erratics should be considered.

The owners of Williambury Pastoral Lease and the Shire of Carnarvon should be consulted.

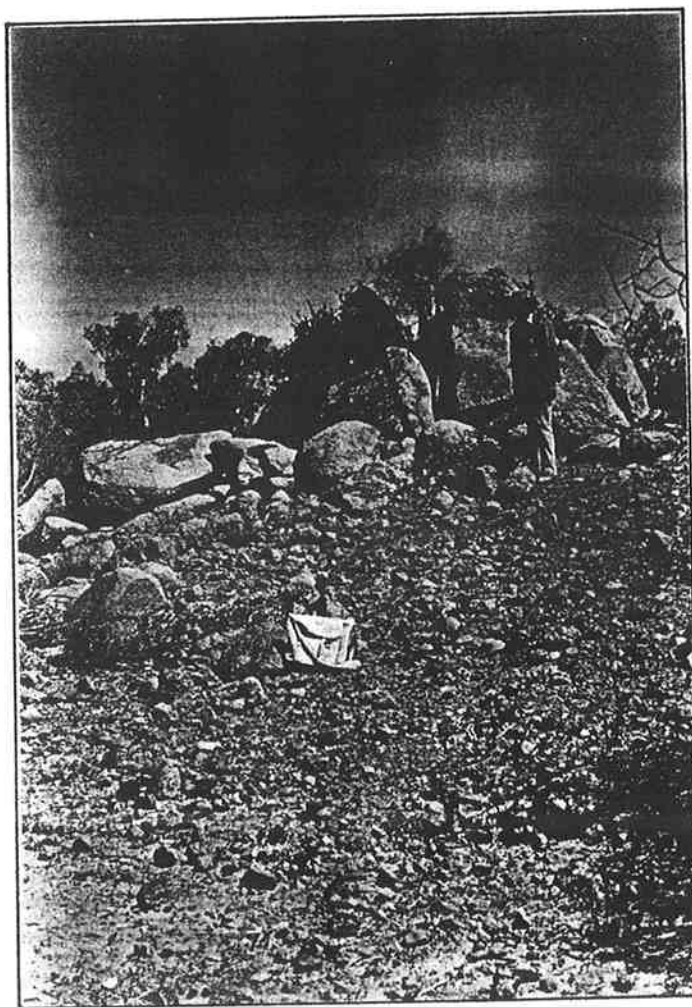
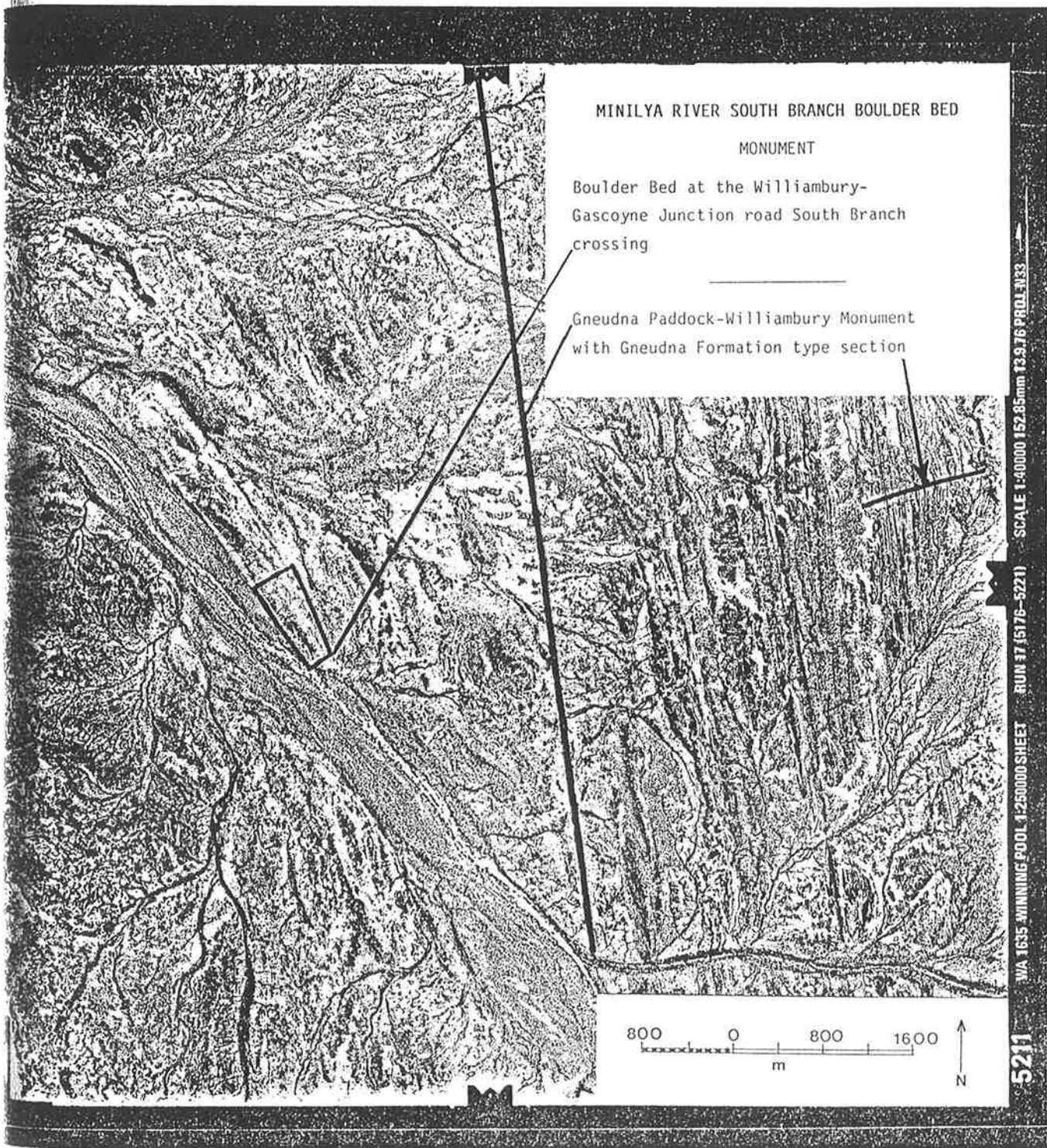


Plate 19

SOUTH BRANCH BOULDER BED

Nigel Drake

These great boulders of granite were transported by ice



MINILYA RIVER SOUTH BRANCH BOULDER BED
MONUMENT

Boulder Bed at the Williambury-
Gascoyne Junction road South Branch
crossing

Gneudna Paddock-Williambury Monument
with Gneudna Formation type section

800 0 800 1600
m

N

SCALE 1:40000 152.85mm 13.9.76 PROL N33

RUN 17 (5176-5221)

WA 1635 WINNING POOL 1:250000 SHEET

5211

STATEMENT OF INTEREST

Landscapes of great visual appeal around K 52 Hill are carved from flat-lying Moogooloo Sandstone resting unconformably upon considerable exposures of highly fossiliferous Callytharra Formation limestone. These elements of early Permian strata provide an instructive if slightly strenuous teaching locale handsomely set in a semi-wilderness.

K 52 Range roadside exposures were examined by an excursion of the Third International Gondwana Symposium in 1973.

Location: 1:250,000 Geological Series Winning Pool-Minilya
lat 23 53 S long 114 56 E

SIGNIFICANCE and VALUE

Classes IV and V : Permian Relationships
Education
Great Landscape Value

GEOLOGICAL NOTE

The Callytharra Formation, the chief mapping horizon of the Permian in the Carnarvon Basin, is some 160 m thick in this district and its grey-green limestone and siltstone contain a rich invertebrate fauna corresponding to the fauna of the Fossil Cliff Member of Coal Seam Park in Geraldton Hinterland. Unconformably overlying the limestone is marine sandstone of the Moogooloo Sandstone which rests on the Callytharra Formation at slightly varying levels and caps K 52 Hill and other principal hills.

Reference: Geological Survey of Western Australia, 1975, Geology of Western Australia: West. Australia Geol. Survey, Mem. 2, 541 p.

Plate: 20

TENURE, ACCESS and POSSIBLE THREATS

Pastoral Lease 3114/656 Middalya contains K 52 Hill with owners at Middalya Station, via Carnarvon, WA 6701.

The Middalya-Williambury road crosses K 52 Range and access to

K 52 Hill is gained from station tracks on the west of the Range.

There are no obvious threats other than excessive removal of fossil material.

RECOMMENDATIONS

A Geological Site of some 15 km² is recommended as shown on aerial photograph WA 1641 Winning Pool Run 15 No. 5340 (p.92).

Protection : normal care.

Proposal : a geological map at a scale of 1:20,000 or larger, showing geological trails with fossil localities, unconformity exposures, karst topography etc, is needed.

Presentation : the road is not frequently used but a rest area and notice board could be considered.

The owners of Middalya Pastoral Lease and the Shire of Carnarvon should be consulted.

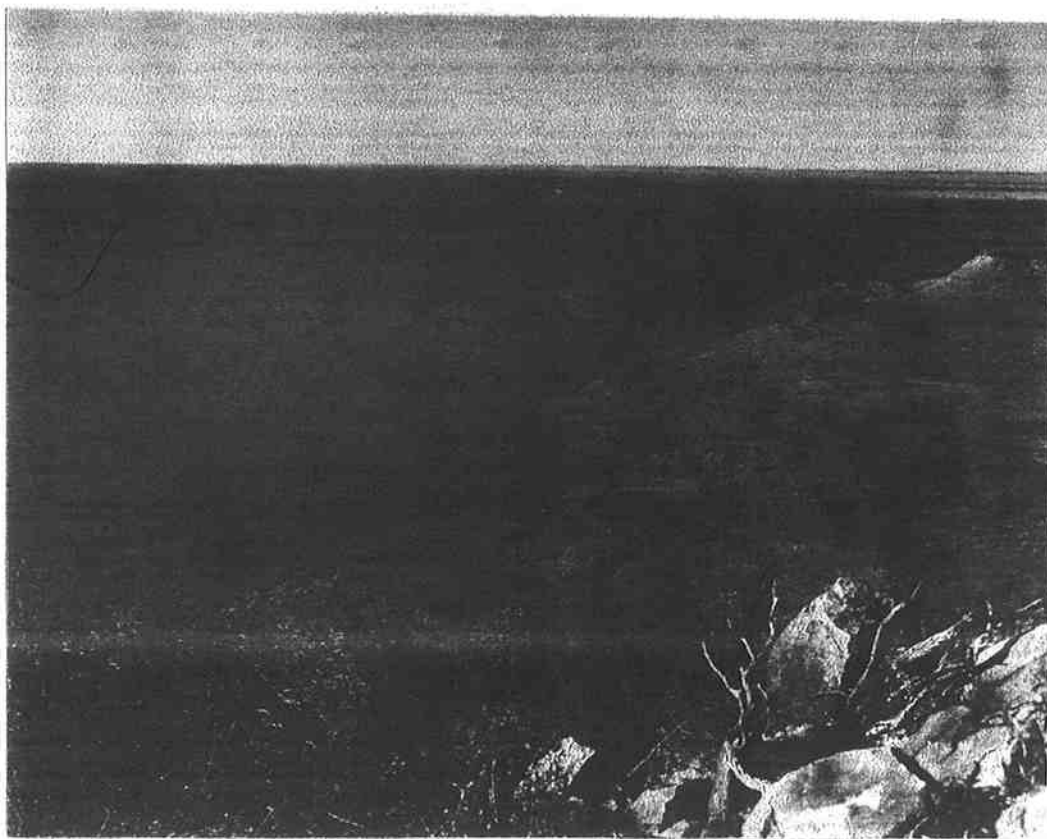
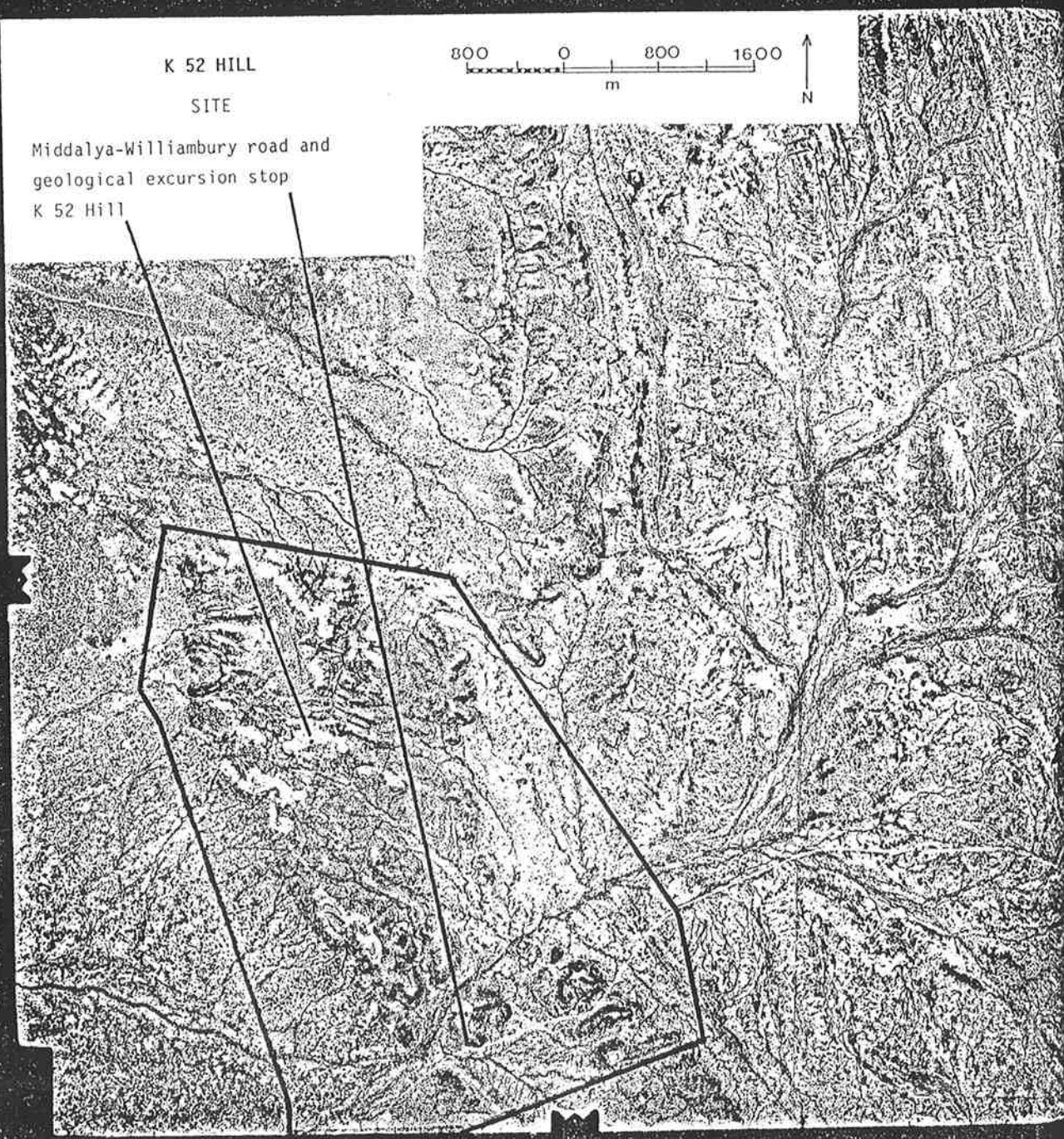


Plate 20

K 52 RANGE

Nigel Drake

View from K 52 Hill to south: limestone pavements of the Callytharra Formation are capped by Moogooloo Sandstone



2

27. GOOCH RANGE SOUTHERN TERMINATION

STATEMENT OF INTEREST

Castellations of Billidee Formation cap the massive southern termination of Gooch Range where the early Permian Wooramel Group is seen. The Group here contains the type section of Moogooloo Sandstone, a formation responsible for much of the attractive scenery in the eastern part of the Carnarvon Basin.

Location : 1:250,000 Geological Series Winning Pool-Minilya
lat 23 51 S long 114 48 E

SIGNIFICANCE and VALUE

Class III : Permian Stratigraphy
Reference
Great Landscape Value

GEOLOGICAL NOTE

Along the east of Gooch Range the highly fossiliferous early Permian Callytharra Formation underlies shallow marine clastics of the three formations of the Wooramel Group. Thinly bedded siltstone and sandstone of the basal Cordalia Sandstone are overlain by the 57 m type section of cross-bedded and ripple marked Moogooloo Sandstone and this sparkles because of authigenic overgrowths on quartz grains. On the summit of the Range outlier hills of Billidee Formation contain siltstone and sandstone.

Reference: Hocking, R.M., Williams, S.J., Lavaring, I.H., and Moore, P.S., 1985, Winning Pool-Minilya, W.A. : West. Australia Geol. Survey 1:250,000 Geol. Series Explan. Notes.

Plate: 21

TENURE, ACCESS and POSSIBLE THREATS

Gooch Range lies within Middalya Pastoral Lease 3114/656 of Middalya Station via Carnarvon, WA 6701.

Access is by a sandy track leaving the road to Williambury just east of the Minilya River where the right-hand of two tracks is taken for some 10 km to Mongie No. 2 Bore. A re-entrant containing the Moogooloo Sandstone type section lies a little south of west from the bore (4WD).

There are no obvious threats.

RECOMMENDATIONS

A Geological Monument of some 7.3 km² is recommended as shown on aerial photograph WA 1641 Winning Pool Run 15 No. 5337 (p.95).

Protection : normal care; the geology is robust.

Presentation : not suitable; remote.

The owners of Middalya Pastoral Lease and the Shire of Carnarvon should be consulted.

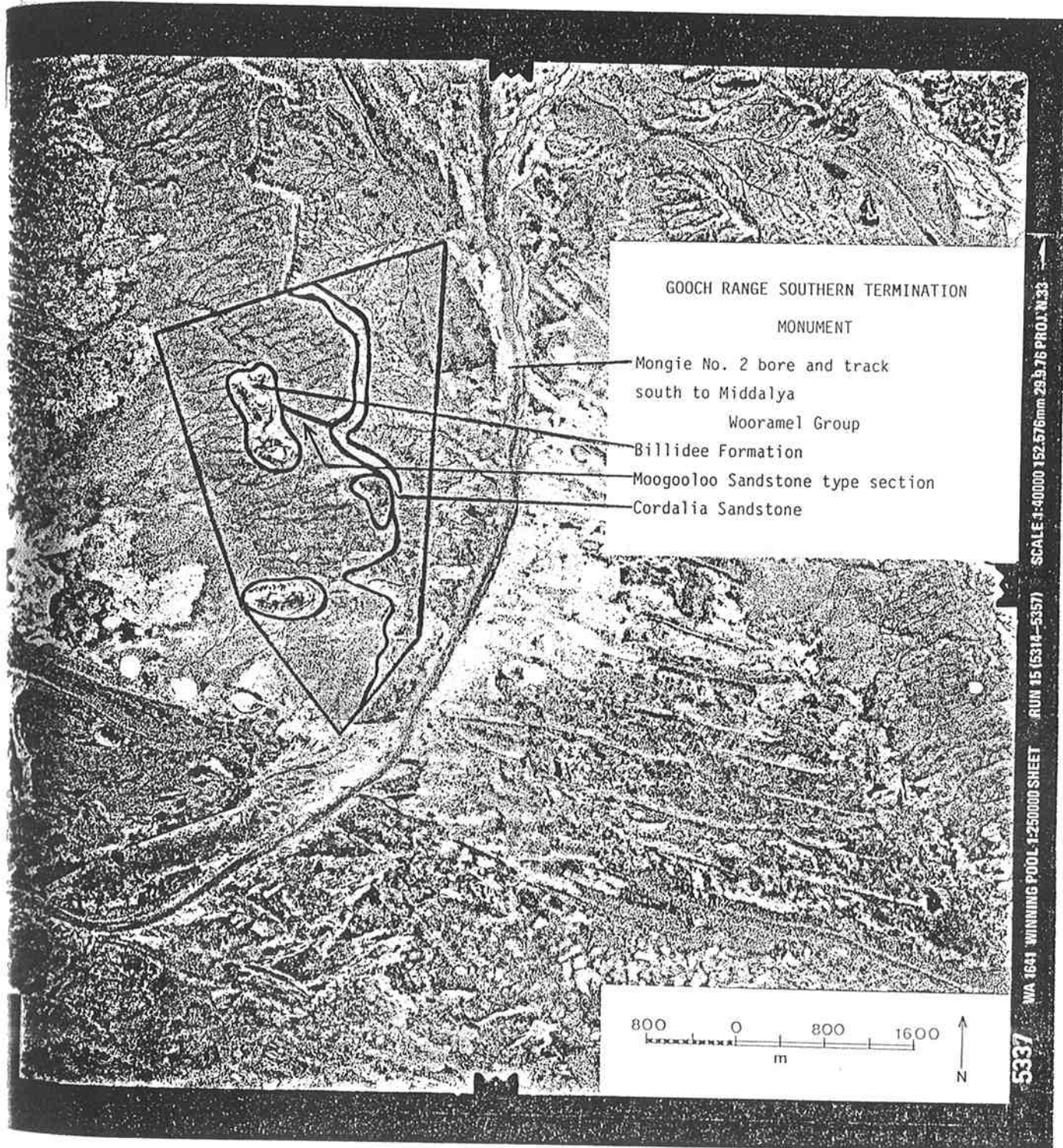


Plate 21

GOOCH RANGE

Nigel Drake

Castellations of Billidee Formation cap Gooch Range
which contains the type section of Moogooloo Sandstone
in an escarpment just beyond the castellations



GOOCH RANGE SOUTHERN TERMINATION
MONUMENT

Mongie No. 2 bore and track
south to Middalya

Wooramel Group

Billidee Formation

Moogooloo Sandstone type section

Cordalia Sandstone

800 0 800 1600
m

N

SCALE 1:40000 152.576mm 29.576 PROJ. N 33

RUN 15 (5314-5357)

WA 1641 WINNING POOL 1:250000 SHEET

5337

STATEMENT OF INTEREST

Near picturesque Coolkilya Pool on the Minilya River there are excellent exposures of early Permian fossiliferous strata of the Byro Group including the upper part of the Cundlego Formation and the type sections of Quinannie Shale and Wandagee Formation, and the latter contains an especially rich invertebrate fauna. In contrast to many shaley riverine sections, outcrops are relatively clear and provide a valuable research and teaching locality.

Coolkilya Pool is visited by teaching excursions.

Location: 1:250,000 Geological Series Winning Pool-Minilya
lat 23 44 S long 114 25 E

SIGNIFICANCE and VALUE

Class II : Permian Stratigraphy
Research
Attractive Setting

GEOLOGICAL NOTE

The section forms the eastern limb of the Minilya Syncline and outcrops well in an area of minor dissection on the north bank of the river. Upstream from Coolkilya Pool, sandstone of the Cundlego Formation forms prominent ridges. To the west the 135 m thick type section of Quinannie Shale is found as carbonaceous shale and siltstone and near Coolkilya Pool these pass into a fining upwards sequence of some 173 m of sandstone, siltstone and shale of Wandagee Formation with fossil bands in the lower part. These are moderately rich in species but very abundant in individuals including foraminifera, corals, bryozoans, crinoids, brachiopods, molluscs, ammonoids and nautiloids.

Reference: Condon, M.A., 1967, The geology of the Carnarvon Basin, Western Australia, Part 2 Permian stratigraphy: Australia Bur. Mineral Resources, Bull. 77.

Plate: 22

TENURE, ACCESS and POSSIBLE THREATS

Coolkilya Pool lies within Wandagee Pastoral Lease 3114/840 with owners at 61 Viking Road, Dalkeith, Perth, WA 6009.

Access is from the road to Willimbury by proceeding east from the North West Coastal Highway for 45.5 km, passing a southern turn-off to Wandagee Sheds after 40 km. A track on a mud flat leads northwards through a gate for 3.7 km to the Minilya River just above Coolkilya Pool (4WD). Aerial photographs should be used to locate type sections.

Collection of fossil material should be controlled and sampling restricted to the regolith when possible.

RECOMMENDATIONS

A Geological Monument of about 2 km² is recommended as shown on aerial photograph WA 1641 Winning Pool Run 13 No. 5390 (p.98).

Protection : high priority; fossils should be removed very sparingly.

Presentation : not suitable; somewhat difficult access.

The owners of Wandagee Pastoral Lease and the Shire of Carnarvon should be consulted.



Plate 22

COOLKILYA POOL

Nigel Drake

A tranquil setting for early Permian fossiliferous strata

5390

WIA 1641 WINNING POOL 1:250000 SHEET

RUN 13 (5358-5404)

SCALE 1:40000 152.576mm 295.76 PROJ. N.33

COOLKILYA POOL MONUMENT

Baker Formation
&
Nalbia Sandstone
Wandagee Formation
Quinnanie Shale
Cundlego Formation
'White Gum Rock',
3.7 km south to
Wandagee road
Minilya River

800 0 800 1600
m

N

WANDAGEE HILL**STATEMENT OF INTEREST**

This landmark hosts the type sections of the fossiliferous Coolkilya Sandstone and overlying Mungadan Sandstone of the early Permian Kennedy Group and was visited by an excursion of the Third International Gondwana Symposium in 1973.

Location: 1:250,000 Geological Series Winning Pool - Minilya
lat 23 49 S long 114 27 E

SIGNIFICANCE and VALUE

Class III : Permian Stratigraphy
Research

GEOLOGICAL NOTE

The 116 m type section of the Coolkilya Sandstone outcrops on the lower slopes and the type section of the 36 m thick Mungadan Sandstone extends to the trig point of Wandagee Hill.

Reference: Geological Survey of Western Australia, 1975, Geology of Western Australia: West. Australia Geol. Survey, Mem. 2, 541 p.

TENURE, ACCESS and POSSIBLE THREATS

Wandagee Hill lies within Wandagee Pastoral Lease 3114/840 with owners at 61 Viking Road, Dalkeith, Perth, WA 6009.

Access is obtained from a road just south of the Hill which joins the Williambury road 6 km south of Wandagee Station, or via Wandagee Woolshed (p.102; 4WD).

Threats are posed by indiscriminate fossil collecting.

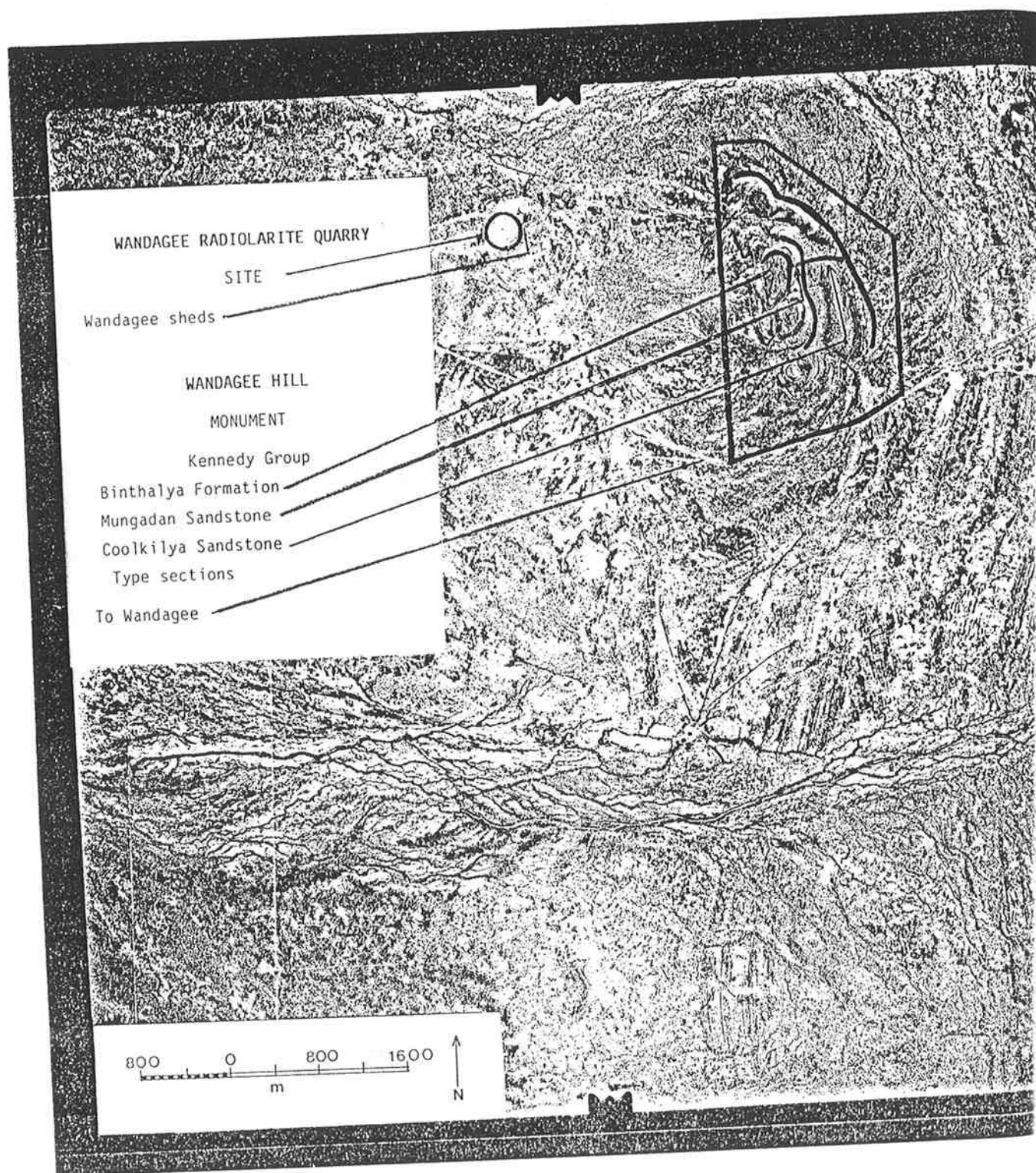
RECOMMENDATIONS

A Geological Monument of some 3.8 km² is recommended as shown on aerial photograph WA 1641 Winning Pool Run 15 No. 5326 (p.100).

Protection : high priority; collect fossils with care.

Presentation : not suitable; remote.

The owners of Wandagee Pastoral Lease and the Shire of Carnarvon should be consulted.



WANDAGEE RADIOLARITE QUARRY**STATEMENT OF INTEREST**

One of the rare secondary sources of diamond indicator minerals is represented by the early Cretaceous Windalia Radiolarite near Wandagee Hill. Here the formation is well-displayed in a small disused quarry immediately west of Wandagee Station sheds and a 50 m³ sample from the quarry revealed sizeable counts of kimberlitic garnet, ilmenite and chrome diopside.

Location: 1:250,000 Geological Series Winning Pool-Minilya
lat 23 49 S long 114 25 30 E

SIGNIFICANCE and VALUE

Class III : Diamond Exploration
Reference

GEOLOGICAL NOTE

Some 20 kimberlite intrusions of the Jurassic Wandagee Field fed diagnostic minerals into sediments accumulating during Cretaceous times. The kimberlites lack obvious outcrop and were detected initially by steam sediment surveys. None carry commercial diamond.

The quarry contains a face of some 3 to 4 m of flat-lying porcelaneous radiolarian siltstone and chert. Kimberlite indicator minerals in Windalia Radiolarite are microscopic and are identifiable only in the laboratory.

References: Stockdale Prospecting Limited, 1979-81, Winning Pool, Western Australia Department of Mines, WAMEX Item No. 1651.
Jaques, A.L., Ferguson, J. and Smith, C.B., 1984: Kimberlites in Australia in Glover, J.E., and Harris, P.G., (Eds), Kimberlite Occurrence and Origin: A basis for conceptual models in exploration pp. 227-274. Publication No. 8, Geology Department and University Extension, The University of Western Australia.

Plate: 23

TENURE, ACCESS and POSSIBLE THREATS

The radiolarite quarry lies within Wandagee Pastoral Lease 3114/840 with owners at 61 Viking Road, Dalkeith, Perth WA 6009.

Wandagee Station sheds are reached from the North West Coastal Highway by turning east some 5 km south of Minilya River onto the Wandagee road and after 40 km turning south to the sheds' access road, proceeding to a junction and turning east towards Wandagee Hill (4WD).

Use of the quarry for waste disposal is an obvious threat.

RECOMMENDATIONS

A Geological Site of about a hectare is recommended as shown on aerial photograph WA 1641 Winning Pool Run 15 No. 5326 (p.100).

Protection : normal care; the owner of the Pastoral Lease should be invited to preserve the quarry.

Presentation : not suitable; remote.

The owners of Wandagee Pastoral Lease and the Shire of Carnarvon should be consulted.

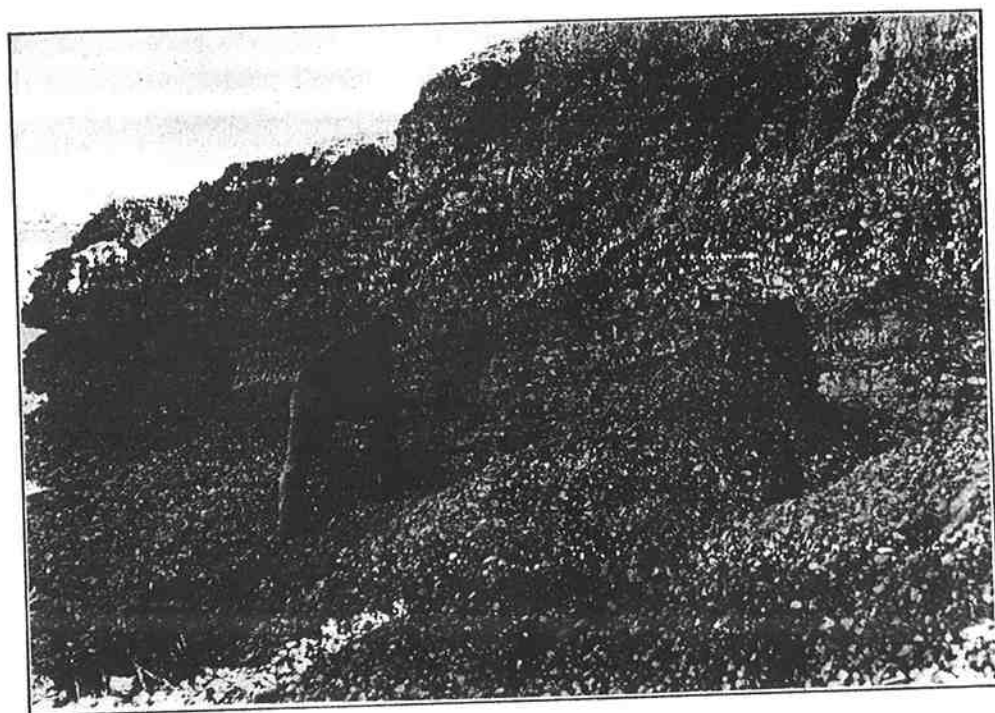


Plate 23

WANDAGEE RADIOLARITE QUARRY

Nigel Drake

Kimberlite indicator minerals were recovered here

31.

REMARKABLE HILL

STATEMENT OF INTEREST

Attractive landforms in the south Giralda Range 120 km south of Exmouth include Remarkable Hill which rises to 216 m and provides a clear section of gently dipping Upper Cretaceous and early Tertiary fossiliferous sedimentary rocks. This fine geological exposition is set amidst appealing scenery with abundant birdlife.

Location: 1:250,000 Geological Series Winning Pool-Minilya
lat 23 1 30 S long 114 5 E

SIGNIFICANCE and VALUE

Class III : Cretaceous-Tertiary Stratigraphy
Education
Outstanding Natural Beauty

GEOLOGICAL NOTE

On the east of Remarkable Hill the Upper Cretaceous Korojon Calcarene rises in low bluffs where the calcarenite is formed largely by fragments of the giant bivalve *Inoceramus*. It is overlain by a thin marl of the Maastrichtian, the Miria Formation. The bulk of Remarkable Hill consists of Paleocene and Lower Eocene calcarenites of the Cardabia Group and four of its five members are present: the Boongerooda Greensand (disconformably resting on the Miria Formation) and the Wadera, Pirie and Cashin Calcarenes. The latter caps the Hill and the Group here is probably about 40 m thick.

Reference: Hocking, R.M., Williams, S.J., Lavaring, I.H., and Moore, P.S., 1985, Winning Pool-Minilya, W.A. : West. Australia Geol. Survey 1:250,000 Geol. Series Explan. Notes.

Plate: 24

TENURE, ACCESS and POSSIBLE THREATS

Remarkable Hill is situated within Cardabia Pastoral Lease 3114/729 with owners at Cardabia Station via Carnarvon, WA 6701.

Access is by station tracks leaving the Exmouth road eastwards at the Coral Bay turn-off. The main track is followed for about 20 km to shearing sheds where the northern track is taken for some 15 km to a point where Remarkable Hill lies 2 km to the west (4WD).

There are no obvious threats but should Remarkable Hill become regularly used trails should be established to confine degradation.

RECOMMENDATIONS

Any suggestion to isolate Remarkable Hill from the south Giralia Range where it is one of a community of landforms would be ill-judged and thus it is recommended that a Geological Monument should extend from Remarkable Hill north to Stone Road, to include a 'section hill' where there is a roadside 'Remarkable Hill sequence'. Approximately 26 km² are involved and this proposal is shown on aerial photograph WA 1634 Winning Pool Run 1 No. 5944 (p.106).

- Protection : high priority; indiscriminate fossil collecting and the possibility of footpath degradation needs to be taken into consideration.
- Proposal : a geological map on a scale of 1:20,000 or larger would enhance interest.
- Presentation : although remote there is high potential as this is good walking country with readily appreciated geology. It is not far from Coral Bay and access is not unreasonably difficult, and the terrain is much easier than that of Cape Range. The classic sections of C-Y and Toothawarra Creeks which lie a little to the north (Other Localities, p.110) could be considered for inclusion in the Monument or as complementary monuments.

The owners of Cardabia Pastoral Lease and the Shire of Carnarvon should be consulted.

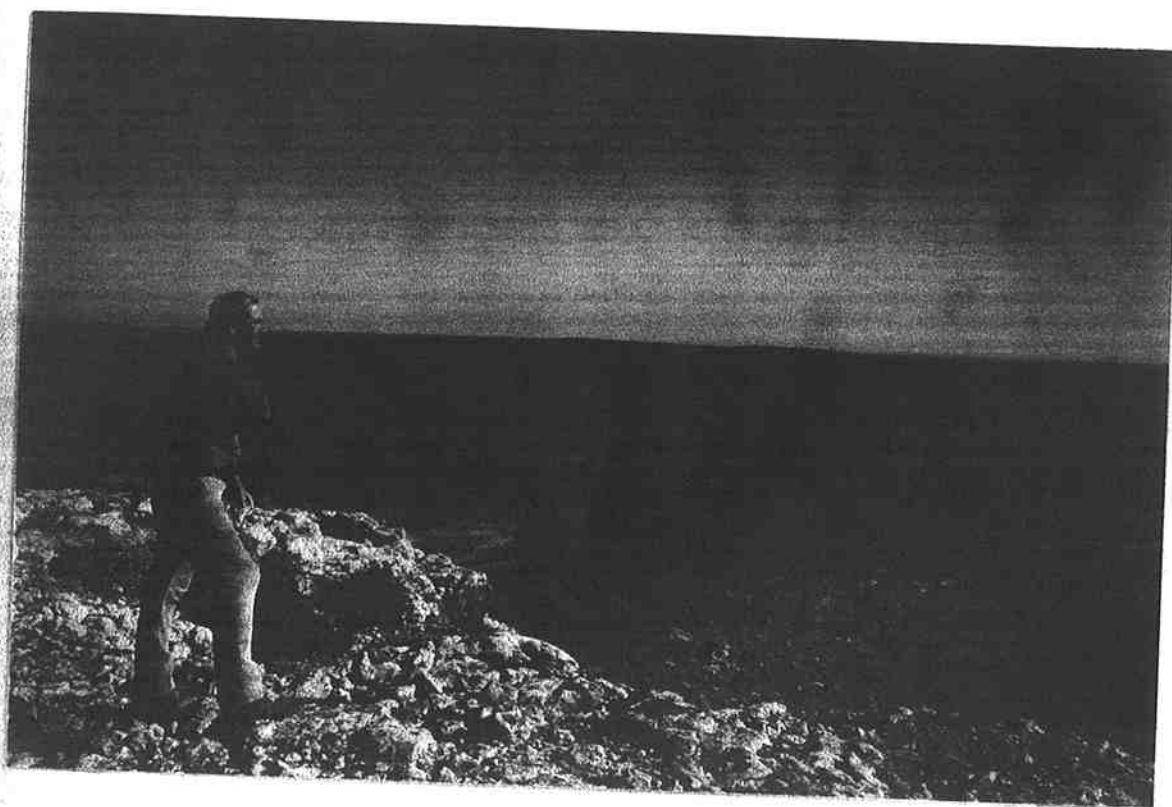
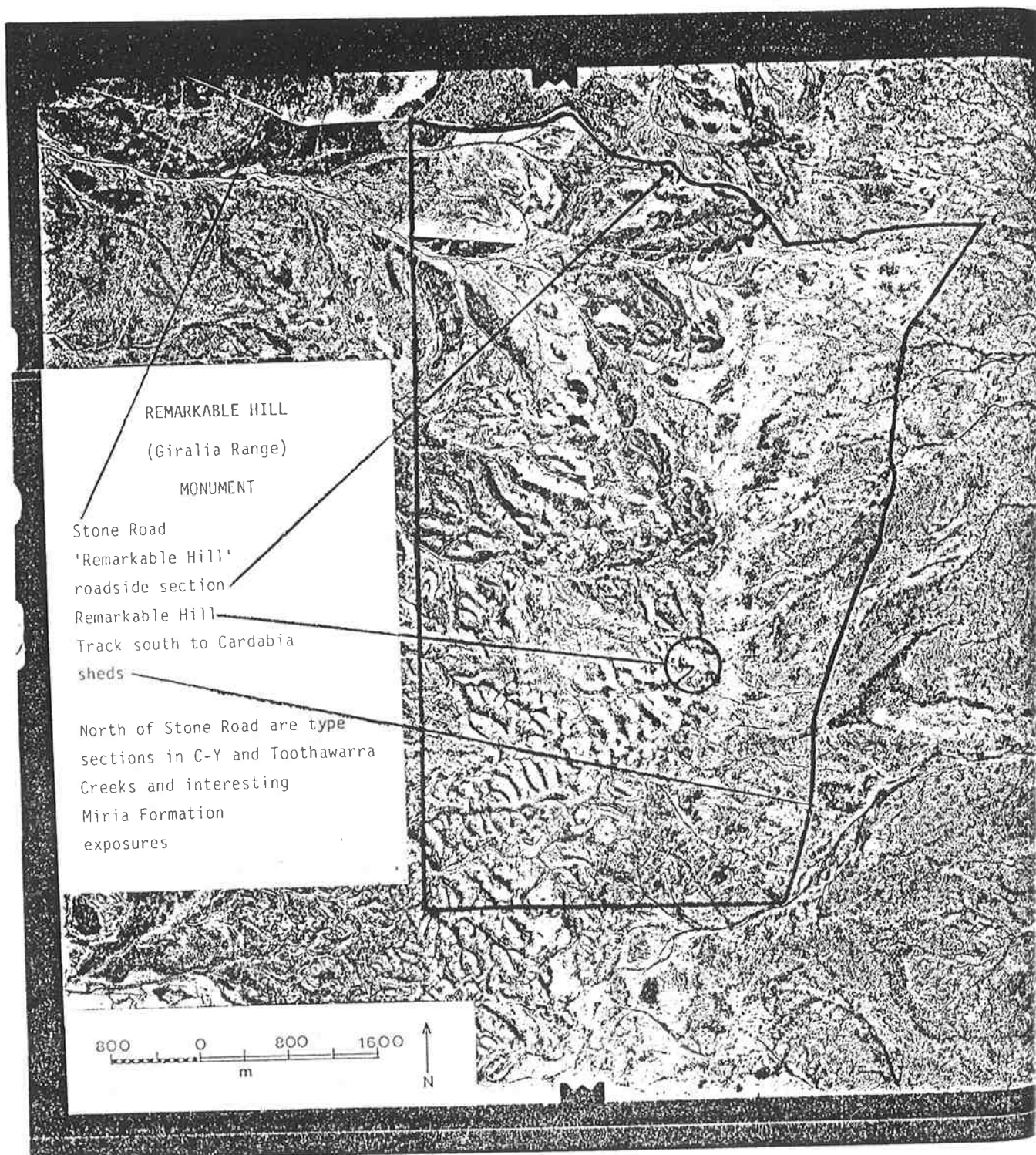


Plate 24

REMARKABLE HILL

Nigel Drake

On the summit with views of Cretaceous and Eocene strata
of the Giralia Range to south and west



STATEMENT OF INTEREST

The natural rock arches, windows and bridges in rugged ranges and magnificent canyons carved from gently dipping Tertiary and Quaternary strata in the National Park on North West Cape need little advocacy for a listing among geological monuments. Just east of the Park in the headwaters of Badjirrajirra Creek, the type sections of the Mandu and Tulki Limestones of the Oligocene are found. On the west of the Cape, warped marine terraces provide evidence that the underlying structure, the Cape Range Anticline, is still undergoing deformation.

Location: 1:250,000 Geological Series Yanrey-Ningaloo
lat 22 5 S long 114 E

SIGNIFICANCE and VALUE

Classes III and V : Tertiary Stratigraphy
Reference
Outstanding Natural Beauty

GEOLOGICAL NOTE

Fine geological features occur in the central portion of the National Park between Shot Hole Canyon and the west coast, and then south to a line from Mandu Mandu Creek to Charles Knife Road where Cape Range Anticline exposes:

Pliocene to Holocene:	Bundera Calcarenite with Jurabi and Tantabiddi Members
	Exmouth Sandstone with Muiron and Milyering Members

Miocene and Oligocene:	Vlaming Sandstone
Cape Range Group	Pilgramunna Formation
	Trealla Limestone
	Tulki Limestone
	Mandu Limestone

Most of the imposing scenery is carved out of the Mandu and Tulki Limestones: the latter forms the spectacular red-brown cliffs capping the canyon walls where the well-bedded Mandu Limestone appears. The overlying Trealla Limestone and its arenaceous equivalent, the Pilgramunna Formation, and the Vlaming Sandstone occur as erosional remnants along the western side of the Range.

Four marine terraces are preserved on the west coast and on these are found the clastic members of the Exmouth Sandstone and Bundera Calcareenite. Warping of the young terraces shows that folding occurred during the Pleistocene and it seems likely that deformation of the Cape Range structure is still continuing.

Reference: Van de Graaff, W.J.E., Denman, P.D., and Hocking, R.M., 1976, Emerged Pleistocene marine terraces on Cape Range, Western Australia: West. Australia Geol. Survey Ann. Rept 1975, p. 62-70.

Plate: 25; Figure: 8

TENURE, ACCESS and POSSIBLE THREATS

In the National Park there are no general access problems or uncontained threats although two long-standing mining tenements MTRs 2614 H and 5980 H are in force. The headwaters of Badjirrajirra Creek where Oligocene type sections are found are part of Pastoral Lease 3114/996 of Exmouth Gulf Station, P.O. Box 241, Exmouth, WA 6707.

RECOMMENDATIONS

Cape Range is one of the great geological set-pieces of the State and it was not possible to select specific ground for a Geological Monument within the space of a short visit and accordingly an outline monument is recommended as shown on Figure 8 lying between Shot Hole Canyon and the west coast, and then south to a line from Mandu Mandu Creek to the east, to include the type sections in Badjirrajirra Creek beyond Cape Range's boundary; this extension beyond the Park is plotted on aerial photograph WA 1470 Ningaloo Run 2 No. 5112 held in the Records of the Survey.

- Protection : normal care; use of the Park is supervised.
- Proposal : a geological map of this part of Cape Range at a scale of 1:40,000 or larger with detail of the warped marine terraces would enhance interest and provide a basis for specifying a Geological Monument.
- Presentation : there is excellent potential here to heighten public enjoyment by notice boards explaining the marine terraces and other features.

The owner of Exmouth Gulf Station, the National Parks and Nature Conservation Authority, and the Shire of Exmouth would need to be consulted.

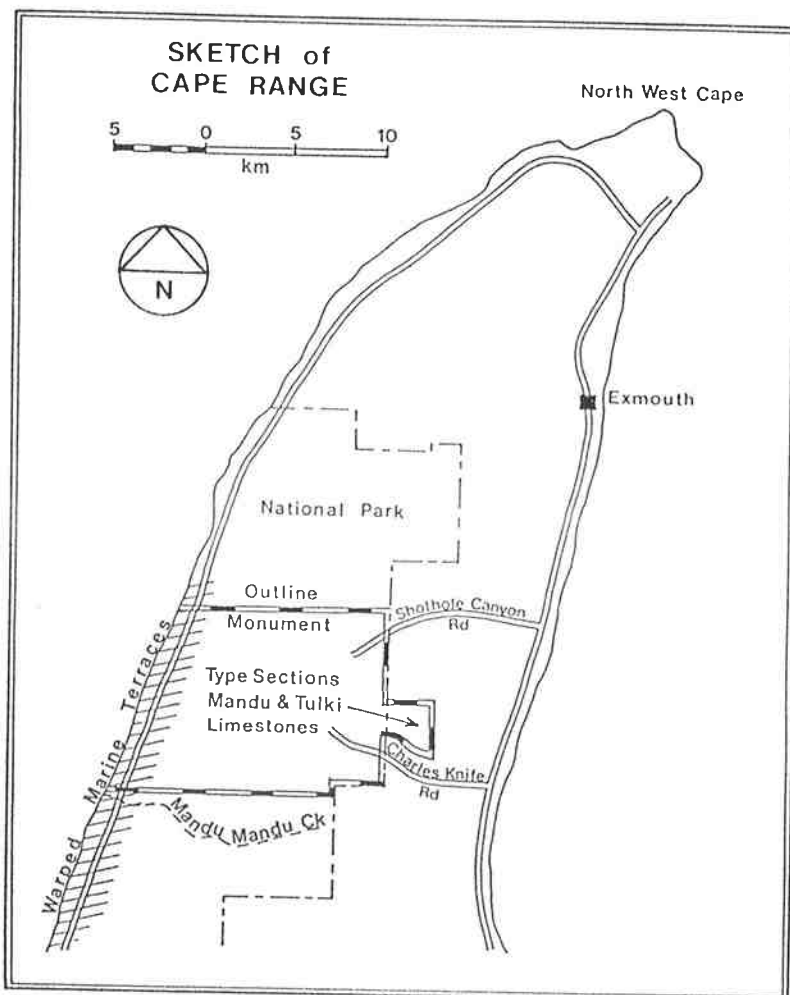


Figure 8

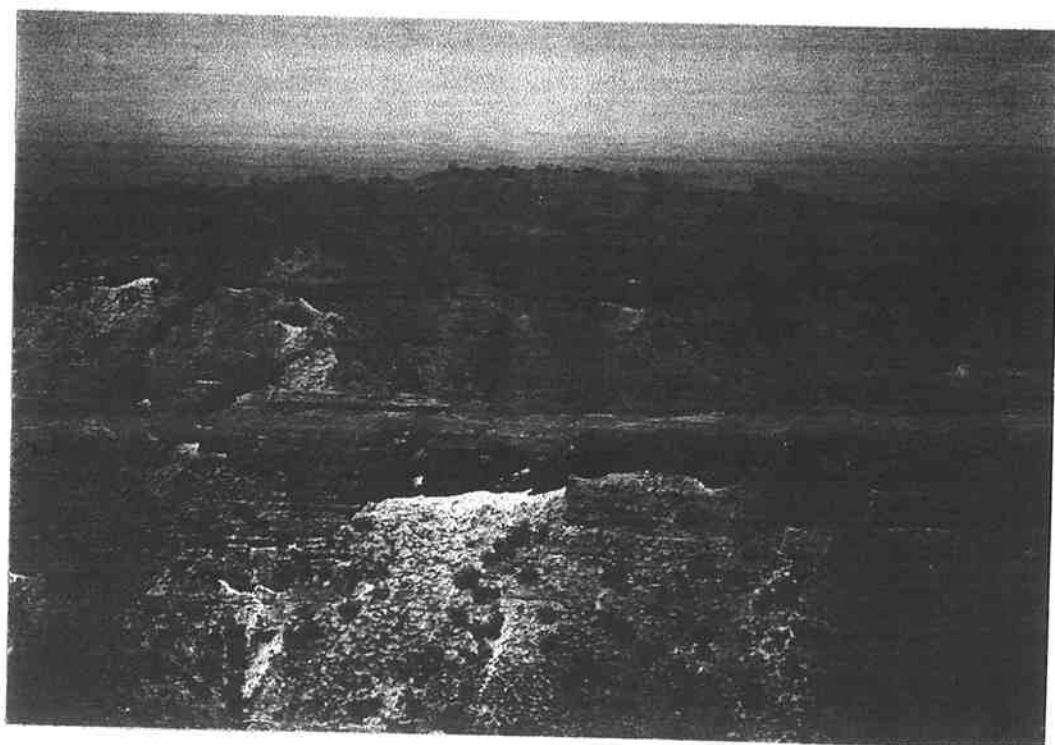


Plate 25 CAPE RANGE FROM CHARLES KNIFE ROAD Nigel Drake
Massive Tulki Limestone overlies well-bedded Mandu Limestone

OTHER LOCALITIES

Toothawarra and C-Y Creeks: Cretaceous and Tertiary type sections (Yanrey-Ningaloo 1:250,000 Geological Series); an access problem prevented the examination of Toothawarra Creek and the geology of C-Y Creek is understood to need further clarification. Both localities which lie a little north of Remarkable Hill (31) should be ear-marked for future consideration.

Cape Cuvier: Miocene Trealla Limestone (Quobba 1:250,000 Geological Series); inspection of this Cape which contains very thick Trealla Limestone was abandoned owing to access difficulties (locked gate and approach ground under salt stockpile).

North Kennedy Range Permian and Cretaceous type sections: (Kennedy Range 1:250,000 Geological Series); in general, access to many of these rather remote type sections is not good and the two examined, type sections of the Billidee and Coyrie Formations, are not well-exposed and lack more than ordinary geological interest and were rejected. Literature descriptions of others such as the Muderong Shale and Birdrong Sandstone type sections are not particularly stimulating.

Merlinleigh Sandstone type section: this Eocene sequence on the Kennedy Range 1:250,000 Geological Series sheet is mentioned in some papers but was not considered since during recent re-mapping the type section could not be satisfactorily identified.

Gascoyne Junction: partially exhumed karst in limestone of the Permian Callytharra Formation near Gascoyne Junction warrants attention (R.M. Hocking pers. comm. and see J.N. Jennings in *Helictite*, 1982, *Journal of Australasian Cave Research*, Vol. 20 (2) who describes this as 'The most remarkable exhumed karst yet recognized in Australia').

33.

CALLYTHARRA SPRING

STATEMENT OF INTEREST

One of the most celebrated Permian fossiliferous localities in the Carnarvon Basin is the 101 m thick type section of the Callytharra Formation half-a-kilometre west of Callytharra Spring on the south bank of the Wooramel River where limestones and interbedded calcareous sediments yield more than a hundred species of fossils. Many forms at this locality 200 km southeast of Carnarvon are common to the Fossil Cliff Member of the Holmwood Shale exposed at Coal Seam Park in the Geraldton Hinterland.

Also at Callytharra Spring and stratigraphically immediately below the Callytharra Formation, is the type section of the Carrandibby Formation, a 59 m thick unit of shale and sandstone with many marine fossils.

Location: 1:250,000 Geological Series Glenburgh and Wooramel
lat 25 53 S long 115 30 E
(Figure 7)

SIGNIFICANCE and VALUE

Class II : Permian Stratigraphy
Reference

GEOLOGICAL NOTE

The Carrandibby Formation is known only from this district and underlies the Callytharra Formation conformably. The latter is one of the most richly fossiliferous units in Western Australia, the most abundant forms being brachiopods, bryozoans and crinoids though bivalves, corals, gastropods and blastoids are common. Exposure of parts of this type section is poor (Plate 26) but lithologies can be satisfactorily identified.

Reference: Condon, M.A., 1967, The geology of the Carnarvon Basin, Western Australia, Part II: Permian stratigraphy: Australia Bur. Mineral Resources Bull. 77.

Plate: 26

TENURE, ACCESS and POSSIBLE THREATS

Callytharra Spring lies within Pastoral Lease 398/741 with owners at Curbur Station, via Mullewa, WA 6630.

From Gascoyne Junction take the southward road to Callytharra Springs homestead (118 km) to cross the Wooramel River and turn east after 2 km to follow a track for 17 km to a creek and small breakaway on the south bank of the Wooramel River where the type sections are found. Callytharra Spring is reached also from the North West Coastal Highway by taking the eastward Yalardy road a little distance north of the Overlander Roadhouse and finding a northern turn-off to Callytharra road.

Excessive fossil collecting is a threat.

RECOMMENDATIONS

A Geological Monument of 6.4 km² is recommended as shown on aerial photograph WA 2291 Glenburgh Run 13 No. 5457 (p.113).

Protection : high priority; fossils should be collected as sparingly as possible.

Presentation : not suitable; remote.

The owners of the Pastoral Lease and the Shire of Murchison should be consulted.

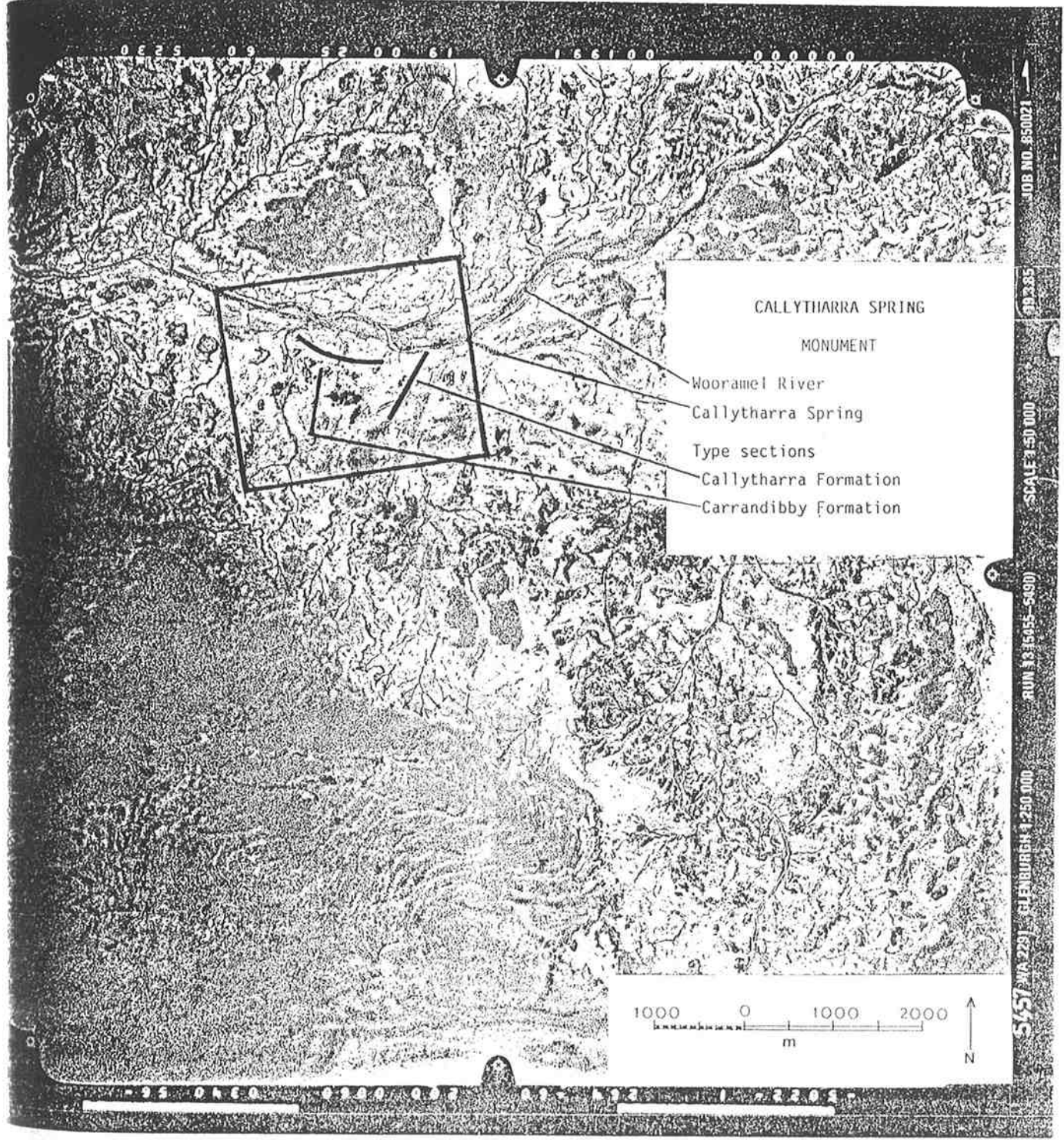


Plate 26

CALLYTHARRA SPRING

J.D. Carter

Type section of highly fossiliferous
Callytharra Formation



MURCHISON

In the Murchison a varied geology includes the western portion of the Archaean Yilgarn Block and Proterozoic sedimentary basins along the Block's northern margin. Initially two features were nominated though further localities were added with this result:

- | | |
|---------------------------------|------------------|
| 34. Mount Leake | Monument |
| 35. Don Well | Site |
| 36. Boogardie Orbicular Granite | outline monument |
| 37. Mulermurra Hill | Site |
| 38. Mount Singleton | outline monument |

Ancient Minerals and Rocks

- | | |
|-------------------|------------------|
| 39. Mount Narryer | Monument |
| 40. Jack Hills | outline monument |

Figure 9 shows these features. At Boogardie perhaps the most interesting granitic texture in Western Australia is seen while at Mount Singleton there is a magnificent exposition of unusually fresh igneous and sedimentary rocks of the Archaean, and geology of universal importance at Mount Narryer and Jack Hills incorporates the oldest terrestrial material known on Earth.

MURCHISON

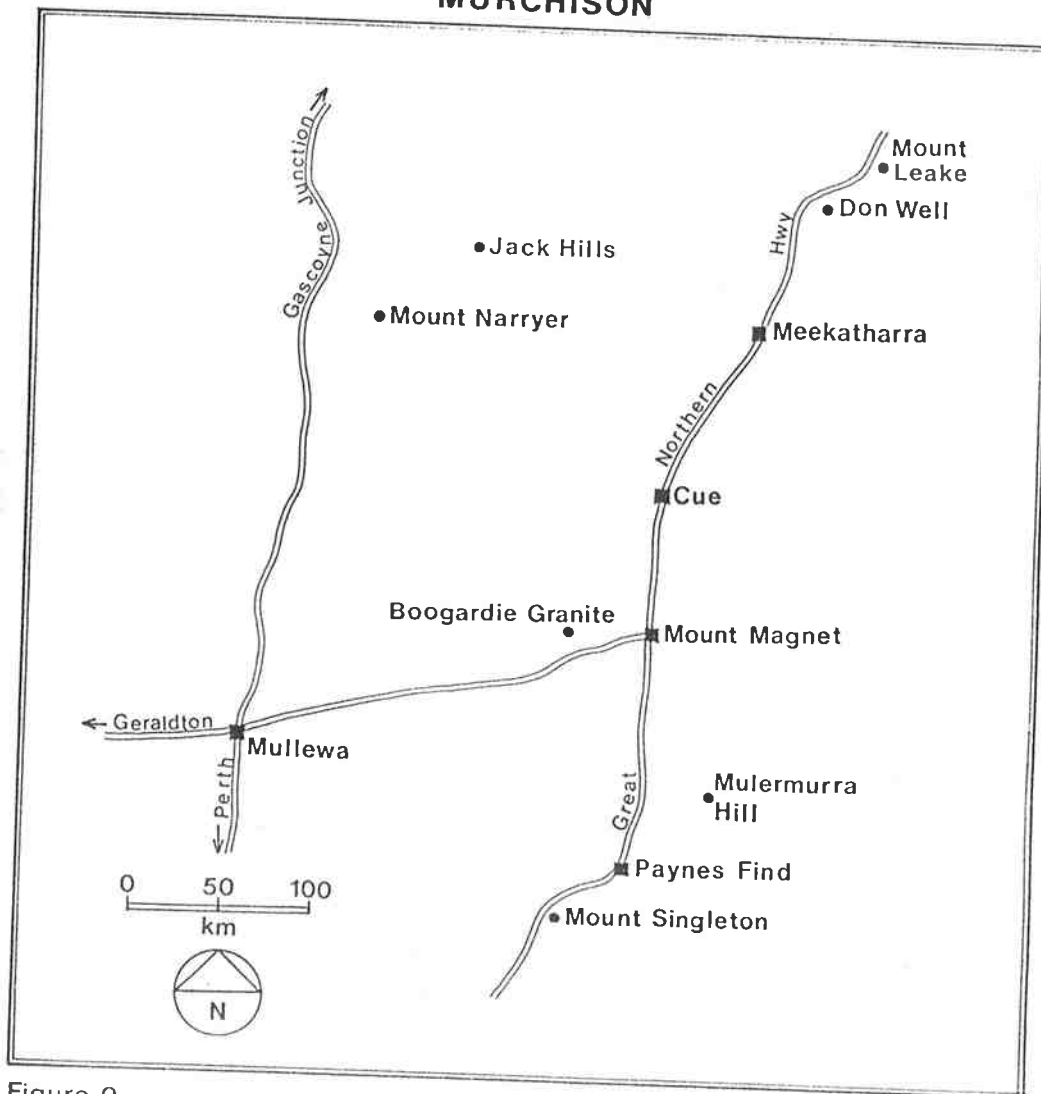


Figure 9

STATEMENT OF INTEREST

Distinctive stromatolites mark an angular unconformity between sandstones of the Lower and Middle Proterozoic exposed in Mount Leake, a flat-topped hill standing just east of the Great Northern Highway some 125 km north of Meekatharra. These early life-forms may prove to be of importance in correlating Proterozoic stratigraphy of the Nabberu region. Exposures at Mount Leake were examined by an international excursion in 1985.

Location: 1:250,000 Geological Series Peak Hill
lat 25 47 S long 119 10 E

SIGNIFICANCE and VALUE

Class III : Proterozoic Stromatolites
Research
Attractive Setting

GEOLOGICAL NOTE

At Mount Leake steeply dipping sandstone of the Doolgunna Formation of the c. 1800 m.y. Glengarry Group is overlain by gently dipping Mount Leake Sandstone for which an age of c. 1570 m.y. is reported.

Reference: Grey, K., 1985, in Glengarry Sub-Basin, Capricorn Orogen Excursion Notes: West. Australia Geol. Survey (unpublished).

TENURE, ACCESS and POSSIBLE THREATS

Mount Leake stands on Doolgunna Pastoral Lease 3114/1026 of Doolgunna Station via Meekatharra, WA 6642. A short track leaves the Great Northern Highway eastwards, abreast of Mount Leake about 125 km north of Meekatharra.

Stromatolitic material is not abundant and is at risk.

RECOMMENDATIONS

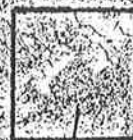
A Geological Monument of some 80 ha is recommended as shown on aerial photograph WA 1186 Peak Hill Run 14 No. 5173 (p.117).

Protection : high priority; stromatolites should be reserved for research and collected sparingly, if at all.

Presentation : not suitable; low visual appeal.

The owners of Doolgunna Pastoral Lease and the Shire of Meekatharra should be consulted.

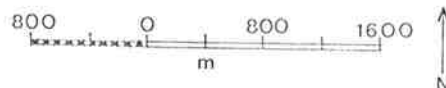
197



MOUNT LEAKE
MONUMENT

Unconformity with stromatolites
Mount Leake Sandstone

Doolgunna Formation
Great Northern Highway lies
a little west of Mount Leake



STATEMENT OF INTEREST

Proterozoic sedimentary textures and structures are clearly displayed by deeply weathered, turbiditic arkosic rocks of the Doolgunna Formation in breakaways some 80 km northeast of Meekatharra. Many of the structural components of a typical turbidite are seen including bottom scours, rip-up clasts, graded and convolute bedding, and wavy cross-bedding. These exposures were examined by an international excursion in 1985.

Location: 1:250,000 Geological Series Peak Hill
lat 25 58 S long 118 55 E

SIGNIFICANCE and VALUE

Class IV : Proterozoic Environment
Education
Attractive setting

GEOLOGICAL NOTE

The upper part of the Doolgunna Formation of the 1800 m.y. Glengarry Group of the Nabberu Province is a turbiditic arkose which probably originated as submarine fans.

Reference: Gee, R.D., 1985, Glengarry Sub-Basin in Capricorn Orogen Excursion Notes: West. Australia Geol. Survey (unpublished).

TENURE, ACCESS and POSSIBLE THREATS

Don Well breakaways are part of Pastoral Lease 3114/1134, Mount Padbury, via Meekatharra, WA 6642. This ground is held under mining tenements, principally E 51/117.

A track leaving the Great Northern Highway eastwards 7.7 km north of the 26th Parallel is taken. After 7.1 km Don Well is reached and bearing right a small creek is crossed. At 11.8 km follow a left fork and a faint track to the breakaways, some 14.2 km from the Highway (4WD).

There are no obvious threats.

RECOMMENDATIONS

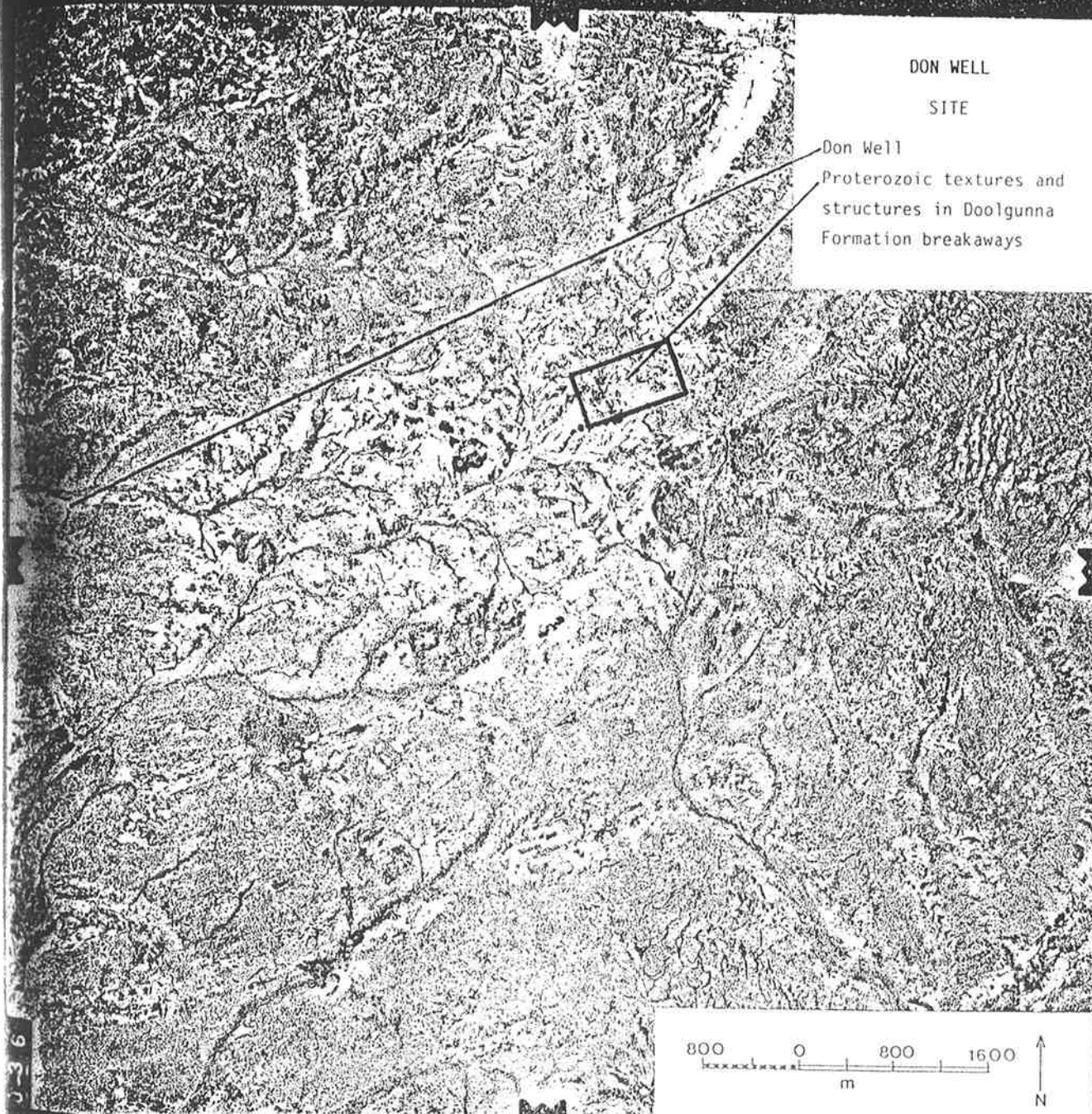
A Geological Site of about 45 ha is recommended as shown on aerial photograph WA 1186 Peak Hill Run 17 No. 5015 (p.119).

Protection : normal care.

Presentation : not suitable; remote.

The owners of Mount Padbury Pastoral Lease and mining tenements, and the Shire of Meekatharra should be consulted.

U-36



DON WELL

SITE

Don Well

Proterozoic textures and
structures in Doolgunna
Formation breakaways

800 0 800 1600
m

N

WA 1186 PEAK HILL Run 17 (5001-5048) 20,000' 152,56mm 16.9.69 Proj K 18

STATEMENT OF INTEREST

Perhaps the most arresting granitic texture in Western Australia is that of the orbicular granite some 37 km west of Mount Magnet on Boogardie Station. Here a patch of grey coarse-grained granite of the Archaean carries conspicuous oval orbs of dark minerals some more than 10 cm in diameter and many exhibit delicate rhythmic banding. Orbicular texture is rare throughout the world and the Boogardie occurrence is the best example known in the State.

Location: 1:250,000 Geological Series Kirkalocka
lat 28 2 S long 117 28 E
(aerial photograph: Records of the Survey)

SIGNIFICANCE and VALUE

Class III : Granitoid Texture
Education
Attractive Setting

GEOLOGICAL NOTE

Many of the famous orbicular granites occur in Finland and some are objects of outstanding petrological interest. Boogardie orbicular granite is very small in outcrop, perhaps not more than 100 m², and attempts have been made to exploit the rock for ornamental purposes (T.E. Johnston pers. comm.).

Plate: 27

TENURE, ACCESS and POSSIBLE THREATS

The orbicular granite is exposed within Boogardie Pastoral Lease 3114/956 with owners at Boogardie Station via Mount Magnet, WA 6638. It is held under mining tenement M 59/28 of Mr. K.C. Seivwright of Mount Farmer Station via Mount Magnet, WA 6638.

Access is from the Mount Magnet-Geraldton road by a track leaving the road northwards some 34 km west of the Great Northern Highway. Tracks sometimes very faint, leading north and northwest are taken for approximately 16 km to a low granitoid pavement incorporating orbicular texture (4WD).

This rare rock type could attract attention and as the occurrence is small, unauthorised collecting is an obvious threat.

RECOMMENDATIONS

Boogardie orbicular granite is of unusual petrological interest but no specific proposal is made as

there may be plans to exploit the granite as an ornamental stone when the accessible part of the outcrop could be removed,

and, publicity may generate unauthorised collecting since it is not evident that a normal form of reservation could effectively protect this isolated and small outcrop.

If the granite is not exploited, listing as a Class III Geological Monument with a 'high priority' protection status should be considered providing adequate safeguards could be introduced with examination restricted to supervised parties. The owners of Boogardie Pastoral Lease and the mining tenement, and the Shire of Mount Magnet would need to be consulted.

This orbicular granite should be better known and it is suggested that the owner of the mining tenement is approached and invited to donate specimens to public museums.

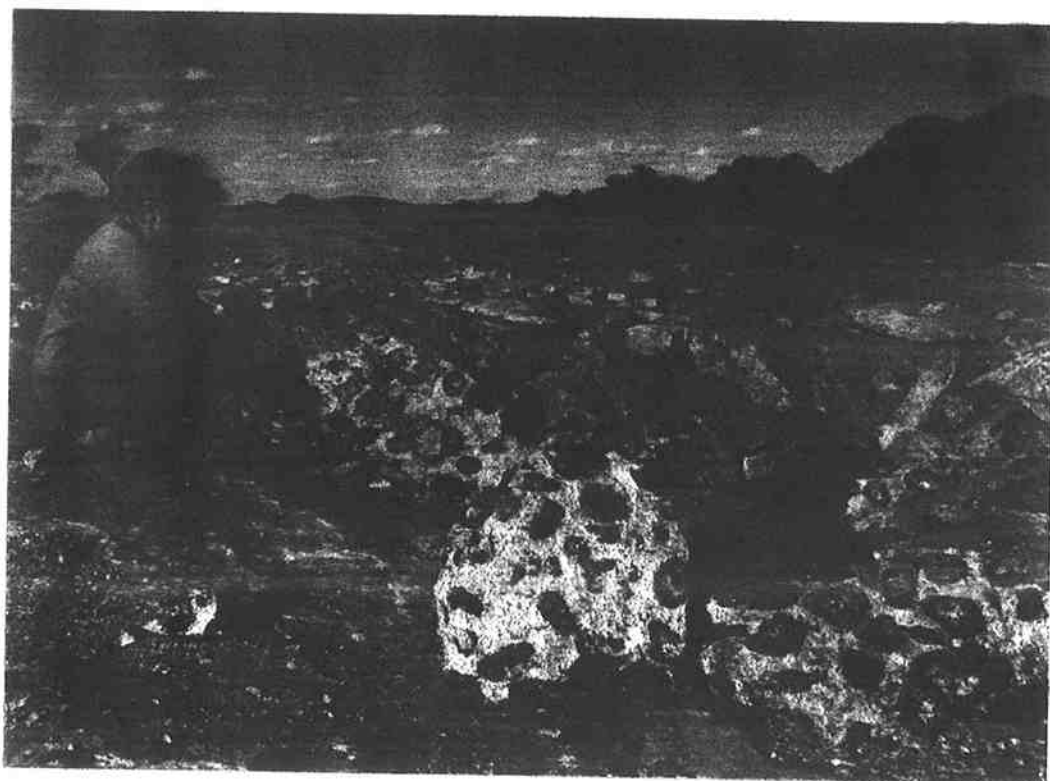


Plate 27

BOOGARDIE ORBICULAR GRANITE

J.D. Carter

STATEMENT OF INTEREST

A fresh and coarse textured intermediate agglomerate of the Archaean is well-exposed at Mulermurra Hill on Narndee Station. There is relatively easy access and though of local interest only, the agglomerate is a very good example of its kind.

Location: 1:250,000 Geological Series Kirkalocka
lat 28 53 S long 118 11 30 E

SIGNIFICANCE and VALUE

Class IV : Archaean Agglomerate
Education
Attractive Setting

GEOLOGICAL NOTE

Agglomerate at Mulermurra Hill is a member of the felsic volcanic and intrusive supracrustal rocks of the Yilgarn Block.

Reference: Baxter, J.L., Lipple, S.L. and Marston, R.J., 1983, Kirkalocka, W.A.: West. Australia Geol. Survey 1:250,000 Geol. Series Explan. Notes.

Plate: 28

TENURE, ACCESS and POSSIBLE THREATS

Mulermurra Hill lies within Pastoral Lease 3114/740 Narndee with owners contacted at Narndee Station via Mount Magnet, WA 6638. It is covered by mining tenement E 59/120.

Leave the Great Northern Highway eastwards some 97 km south of Mount Magnet by the Narndee Road. After 35 km Narndee Homestead is reached and 5.7 km beyond, a left fork is taken for about 1.5 km where the track skirts a low knoll of agglomerate (4WD).

These robust outcrops are unlikely to be threatened.

RECOMMENDATIONS

A Geological Site of some 80 ha is recommended as shown on aerial photograph WA 2345 Kirkalocka Run 13 No. 5495 (p.124).

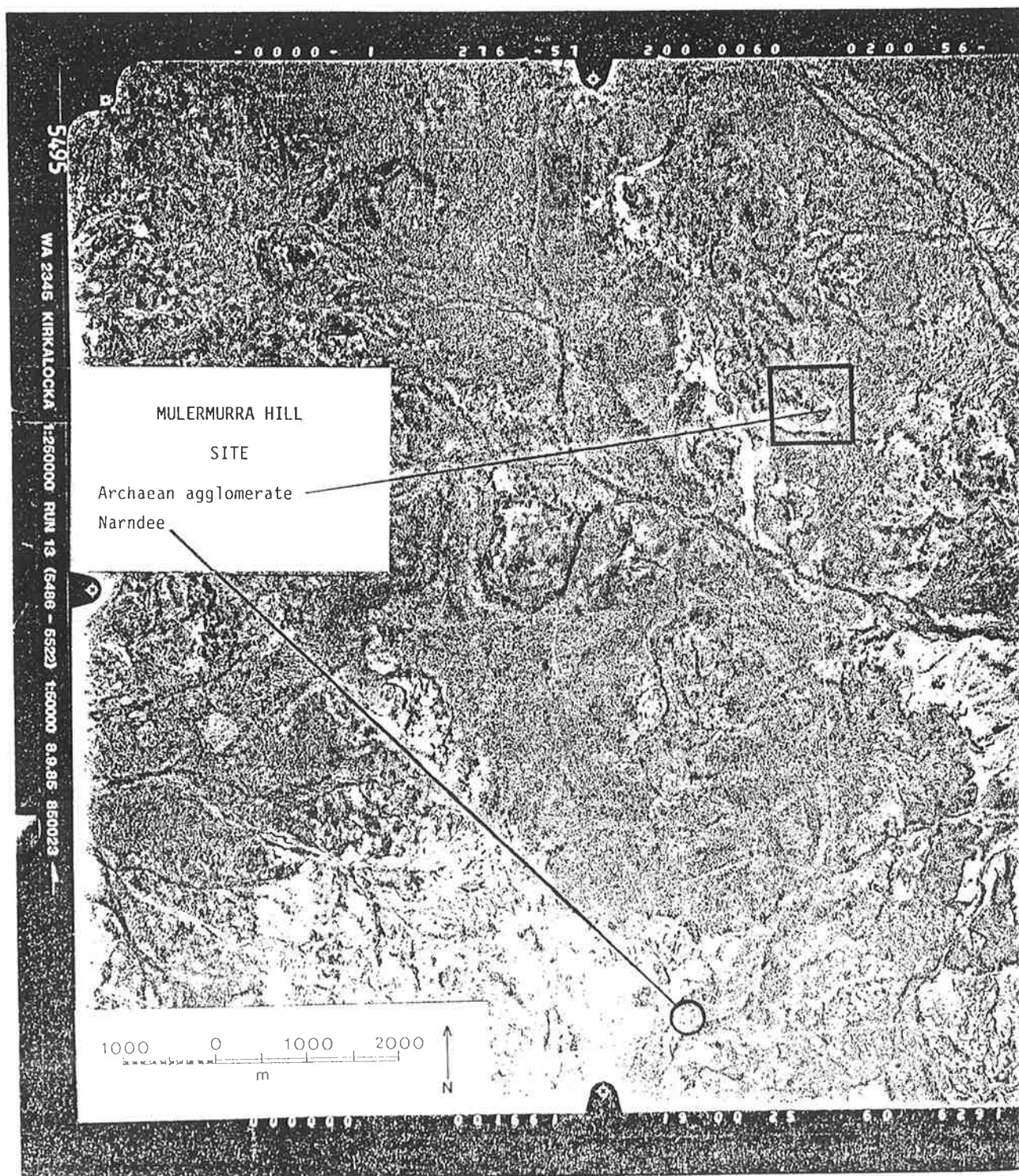
Protection : normal care.

Presentation : not suitable, remote.

The owners of Narndee Station and the mining tenement, and the Shire of Mount Magnet should be consulted.



Plate 28 ARCHAEOAN AGGLOMERATE, MULERMURRA HILL J.D. Carter



STATEMENT OF INTEREST

Bold outcrops in escarpments and gorges of Mount Singleton near Paynes Find mark an outstanding display of Archaean mafic and ultramafic rocks with exposures of unusual clarity revealing exquisitely preserved structures of volcanic and sedimentary origin. Although a typical greenstone sequence, the excellence of exposure and freshness of these barely deformed and little metamorphosed rocks set them apart from similar suites elsewhere in the Yilgarn Block.

Mount Singleton at nearly 700 m is the highest point of the Yilgarn Block and rises in a rugged wilderness with distant views of plains and great salt lakes and an endless scenery combines with compelling geology to create a field locale of high merit within relatively easy reach of Perth.

Mount Singleton is used for teaching at the tertiary level and is examined by excursions to the Murchison.

Location: 1:250,000 Geological Series Ninghan
lat 29 28 S long 117 18 E

SIGNIFICANCE and VALUE

Classes II and V : Archaean Mafic Volcanism
Research
Great Landscape Value

GEOLOGICAL NOTE

The many rock types and structural and textural features offered, occur in a large southeast-plunging syncline. Tuffaceous siltstone shows cross-bedding and scours, and basalt may be massive, variolitic or pillowed, and there is an outcrop of rare ultramafic agglomerate. Massive agglomerate with sharply defined components forms imposing escarpments and intrusive rocks include dolerite, gabbro, pyroxenite and peridotite.

Reference: Lipple, S.L., 1982, Geology of the Ninghan Fold Belt, Mount Singleton, Western Australia, in *Archaean Geology of the South Murchison*, Geological Excursion Guide compiled by J.L. Baxter: Geol. Soc. Aust., W.A. Division.

Plate: 29; Figure: 10

TENURE, ACCESS and POSSIBLE THREATS

The Mount Singleton syncline lies within Pastoral Leases 3114/602, Ninghan, and 398/616, Mount Gibson, with owners contacted via Wubin, WA 6612 and c/- P.O. Box 55 Dalwallinu, WA 6009, respectively. Mining tenements cover parts of this greenstone syncline, the principal tenement being E 59/161.

The entrance to Ninghan Station at the foot of Mount Singleton, is on the east of the Great Northern Highway some 380 km north of Perth. The station lies 7 km from the Highway and tracks enter different parts of the Mount Singleton range.

There is no obvious threat.

RECOMMENDATIONS

Mount Singleton is a particularly fine example of Western Australia's Archaean geology on the largest scale. Definition of a Geological Monument incorporating examples of each of the many phenomena could not be accomplished during a short examination and for the time being Mount Singleton is recommended as an outline monument as shown on Figure 10.

- Protection : normal care; rare rock types may need to be preserved and exposures of fine structures and textures taken care of.
- Proposal : to realise the potential of this compelling geology and its attractive setting, a guide with a map at a scale of 1:50,000 or larger is needed. Examples of all rock types, structures and textures should be located and shown, including the rare ultramafic agglomerate; the map should be used to define one or more Monuments.
- Presentation : there are excellent opportunities; Ninghan Station provides a variety of accommodation for station holidays, and geological trails with notice boards would attract interest.

The owners of Ninghan and Mount Gibson Stations and mining tenements, and the Shire of Yalgoo would be concerned.

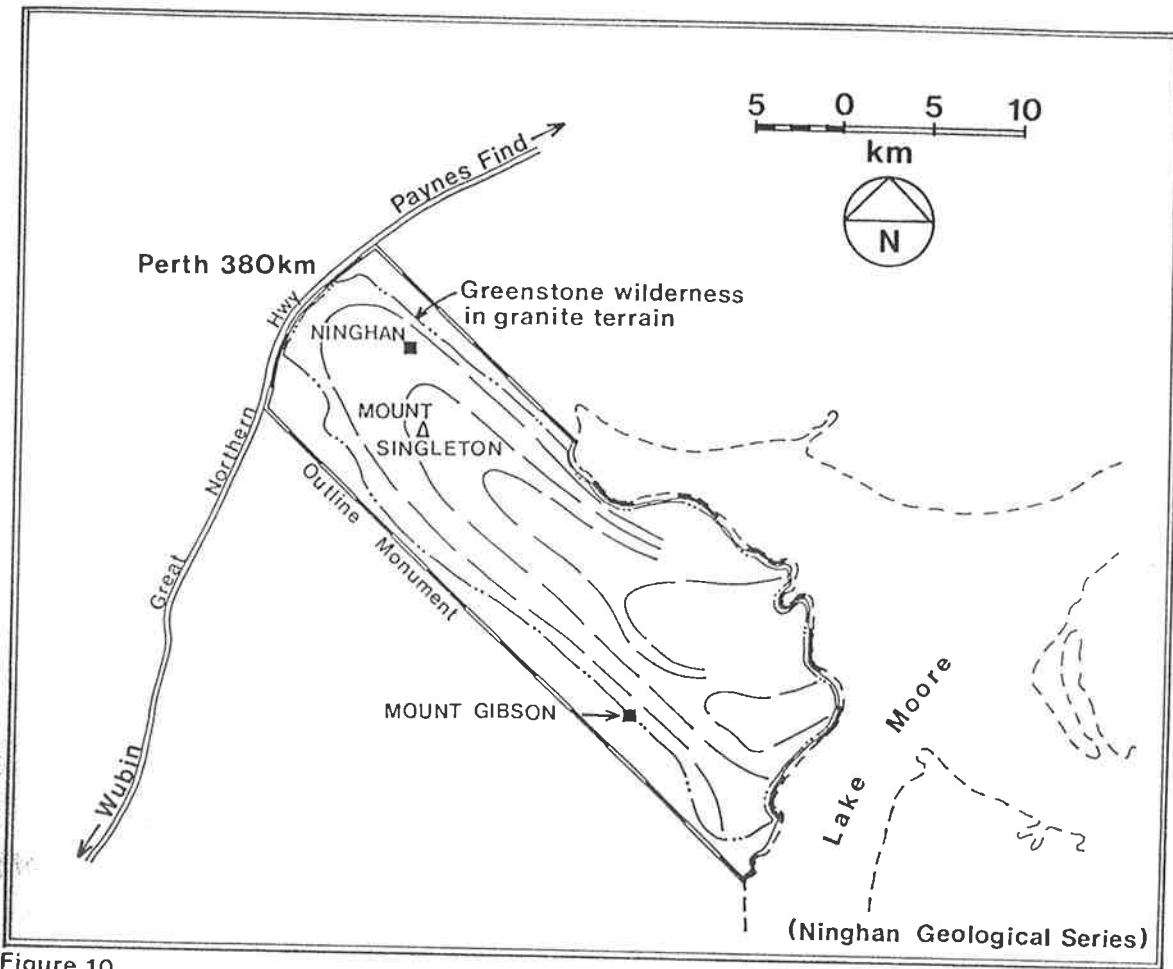


Figure 10

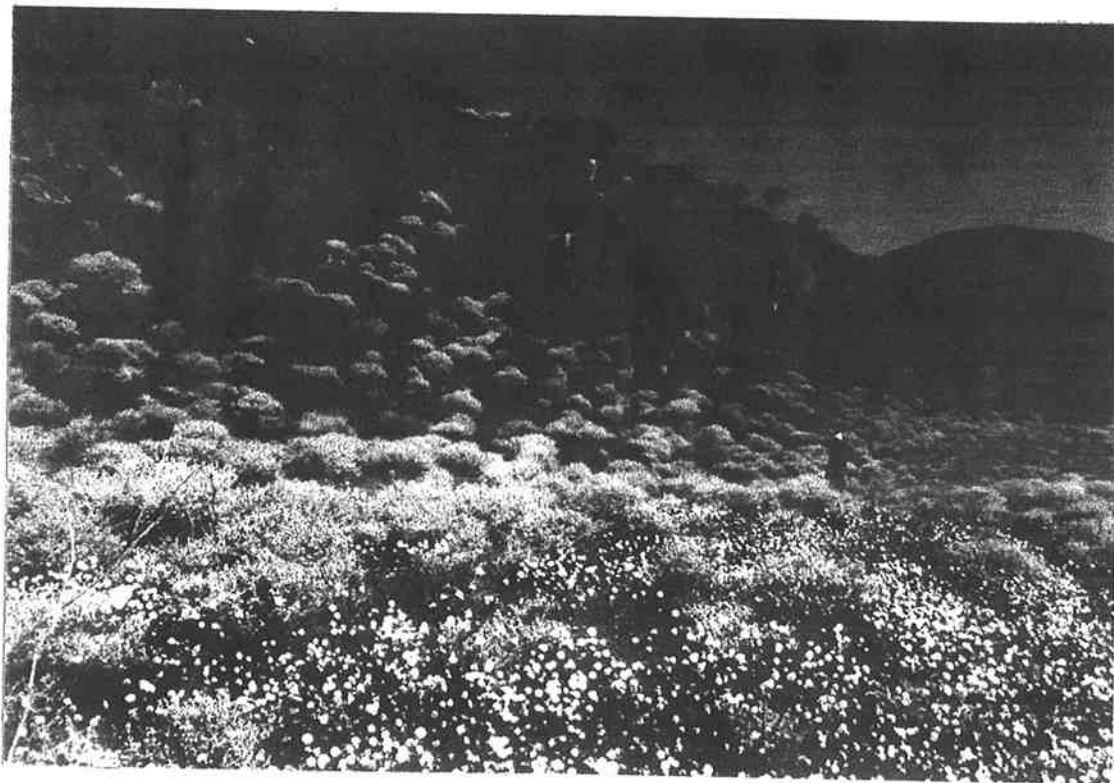


Plate 29

MOUNT SINGLETON

J.D. Carter

Exquisitely preserved structures are seen in these
Archaean agglomerate cliffs

39. - 40. ANCIENT MINERALS AND ROCKS
MOUNT NARRYER & JACK HILLS

STATEMENT OF INTEREST

Time worn relics from the beginnings of the Planet rise out of the plains of the Murchison 600 km north of Perth at Mount Narryer and Jack Hills where sandstone and conglomerate carry ancient detrital zircons with ages lying between 4300 and 4200 m.y. These minerals are the oldest terrestrial material known on Earth.

This country is part of the Western Gneiss Terrain of the Yilgarn Block and around Mount Narryer a very early crust of granitoids with ages from 3630 to 3540 m.y. is exposed as a gneiss complex and this is intimately associated with three unique groups of rocks. One is the remnant of a layered anorthosite-gabbro-ultramafic complex, the 3750 m.y. Manfred Complex which preserves the oldest known igneous layering in the world and is almost as old as the oldest known rocks on Earth - the Isua Supracrustal rocks of Greenland. Others are survivors of probably distinct sedimentary sequences and the more important, the 20 km length of Narryer Metasedimentary Rocks of some 3200 m.y. and a source of ancient detrital zircon, clearly preserves early sedimentary features including cross-bedding and graded bedding - conglomerates of this age at Jack Hills also yield ancient detrital zircon. The less important Mindle Metasedimentary rocks are of uncertain age.

Marching side-by-side with the ancient assemblages of Mount Narryer and traced by graceful stands of Mulga are small fault scarps formed most likely just over 100 years ago during the Geraldton-Northampton earthquake of 1885.

These clear expressions of the imponderable antiquity and recent activity of the Planet serve to distinguish this part of the Murchison as a natural history environment of universal importance.

(39.) MOUNT NARRYER

Location: 1:250,000 Geological Series Byro
lat 26 32 S long 116 23 E

SIGNIFICANCE and VALUE

Class I : Earliest Minerals and Ancient Rocks
Research
Attractive Setting

GEOLOGICAL NOTE

For the Mount Narryer region of the Western Gneiss Terrain and adjoining parts of the Yilgarn Block, the following is the general rock succession:

	m.y.
Orogenic granitoids	2600-2500
Greenstone sequences	3000-2700
Mount Narryer Range	
Narryer Metasedimentary Rocks	(?)3300-3200 with zircons of 4200 m.y.
Dugel Gneiss	3540 - 3400
Mindle Metasedimentary Rocks	(uncertain)
Meeberrie Gneiss	3630
Manfred Complex	3750

Much of the central portion of the Mount Narryer range consists of resistant highly metamorphosed quartzites of the Narryer Metasedimentary Rocks. Along the west and northern flanks Meeberrie Gneiss is exposed and to the northeast, Dugel Gneiss incorporates strips of the Manfred Complex layered intrusion some over 100 m thick and a kilometre long. Mindle Metasedimentary Rocks form smaller outcrops a little to the east.

Two tree-lined, curvilinear, recent fault scarps run northeastwards close to Mount Narryer. One of the small scarps is 11 km long and lies east of the quartzite range and the second a few kilometres west of the hills, is traced for nearly 33 km. Downthrows to the east are between 1 and 2 m, and splay faults and sag ponds are seen. Faulting of the hardpan produced favourable soil conditions for the growth of Mulga trees and dendochronology gave a maximum age of nearly 100 years for the trees and the fault scarps therefore could have been formed during the Geraldton-Northampton earthquake of 1885.

References: Williams, I.R., 1979, Recent fault scarps in the Mount Narryer area, Byro 1:250,000 sheet: West. Australia Geol. Survey Ann. Rept 1978 p.51-55.

Williams, I.R. and Myers, J.S., 1987, Archaean geology of the Mount Narryer region, Western Australia: West. Australia Geol. Survey Rept No. 22.

Plates: 30, 31 Figure: 11

TENURE, ACCESS and POSSIBLE THREATS

The Mount Narryer range runs across portions of three Pastoral Leases: 3114/406, Boolardy, c/- R.A. Long Rigby, Box B 79 GPO Perth, WA 6001; 3114/512, Meeberrie of Burton Nominees Pty. Ltd., Box 105, Morawa, WA 6623 and 3114/582, Mount Narryer of Oku Pty. Ltd., Mount Narryer Station via Mullewa, WA 6630. A greater part of the range is covered by mining tenement E 09/97.

Access is obtained from Mount Narryer Station on the Mullewa-Gascoyne Junction road where eastward tracks are taken for 50 km

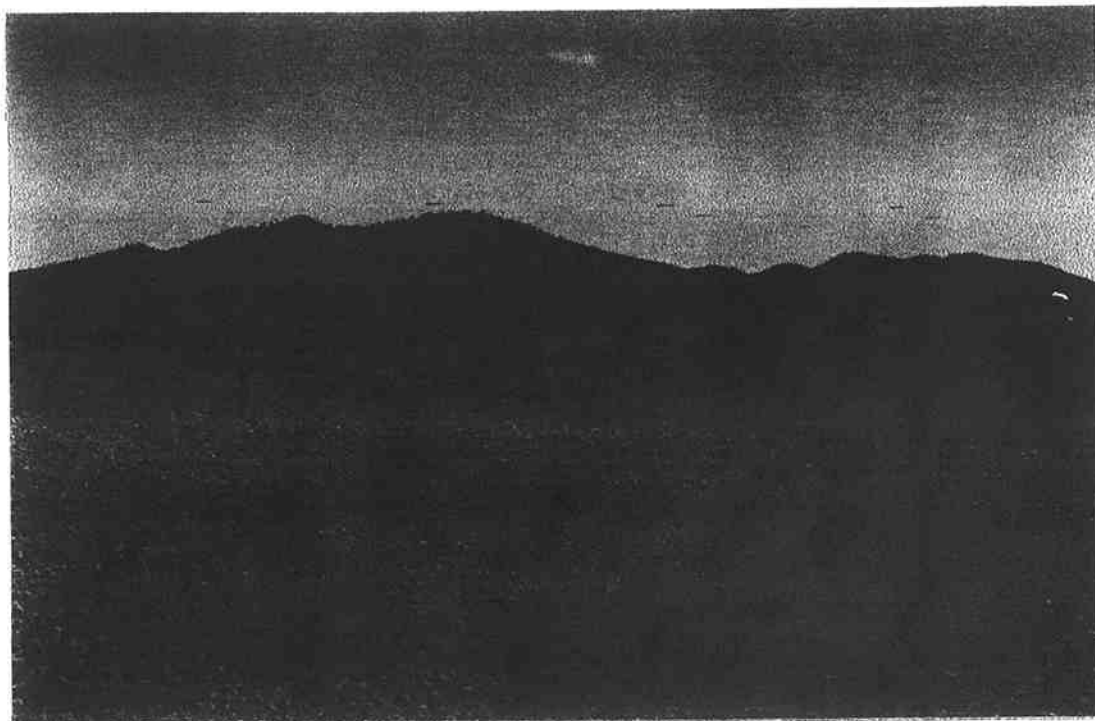


Plate 30 MOUNT NARRYER J.D. Carter
View from southeast: strips of Narryer metasedimentary rocks
(3200 m.y.) include conglomerate with detrital zircon
dated at 4200 m.y.



Plate 31 NARRYER METASEDIMENTARY ROCKS I.R. Williams
Cross-bedding in garnet-sillimanite gneiss
3200 m.y. old

MOUNT NARRYER

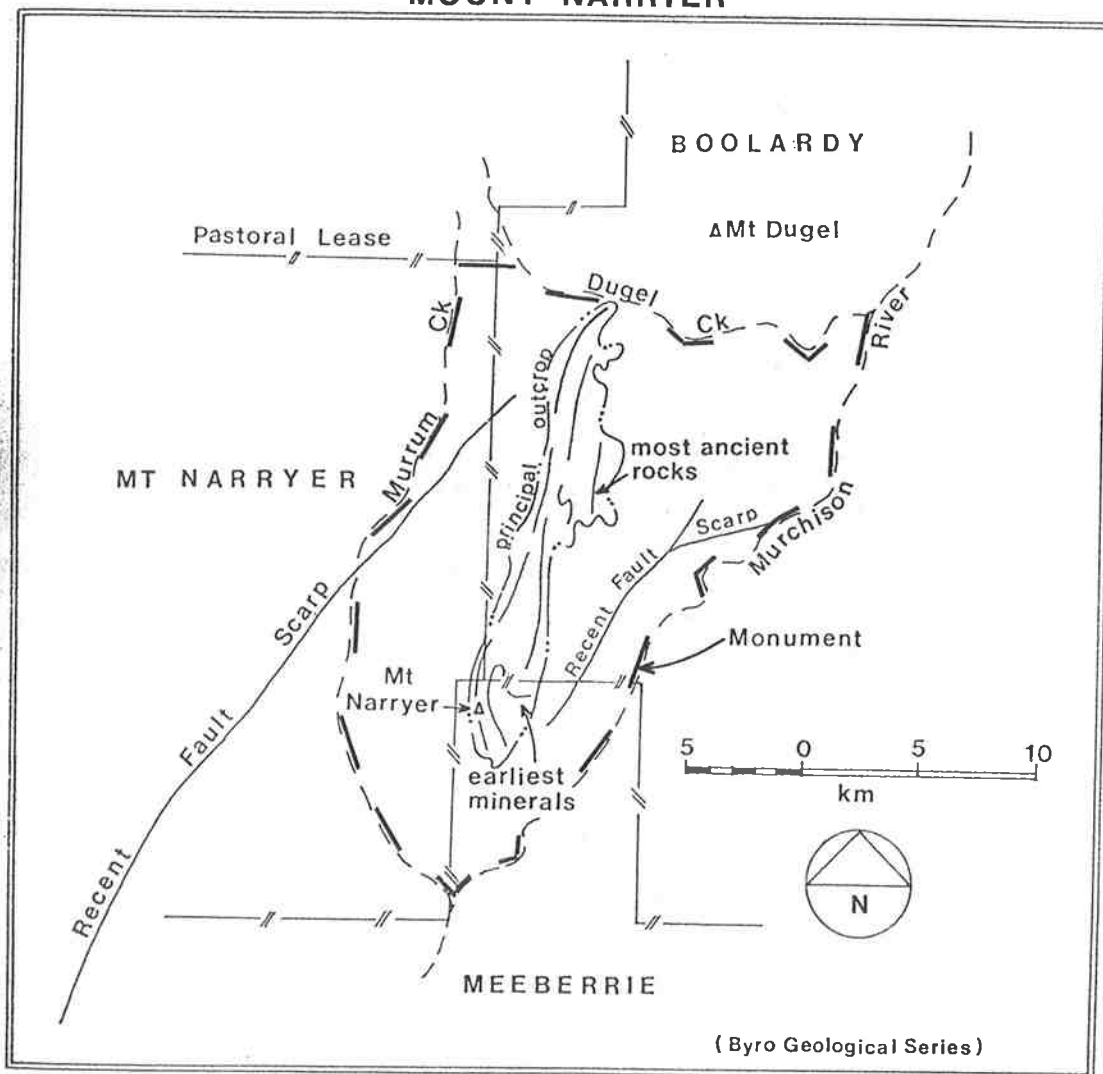


Figure 11

through Jailor Outcamp to reach Mount Narryer (4WD).

Examples of rocks showing ancient igneous layering and sedimentary structures, and rocks containing the oldest zircons will attract collectors.

RECOMMENDATIONS

Although geological studies of this part of the Murchison will continue for many years, it is unlikely that other sites of importance on the scale of Mount Narryer will be identified and there is little doubt this range will become known as one of the great geological localities of the world. A Geological Monument or reservation by means of a Class A Reserve or National Park with theme 'origins of the Planet' is warranted.

The terrain concerned includes the Mount Narryer range and surrounds, bounded by the Murchison River on the east, 'Mount Dugel creek' to the north and Murrumbidgee Creek on the west and south amounting to some 340 km² as shown on Figure 11. Locations of important geological features are shown on aerial photograph WA 2187 Byro Run 5 No. 5071 (Records of the Survey).

- Protection : high priority for exposures with ancient igneous and sedimentary textures and structures.
- Proposal : a guide to the geology with a 1:50,000 map is needed.
- Presentation : the Mount Narryer range, one of the great geological sites of the world, is reasonably accessible from Perth and controlled public presentation of this geology should be considered.

The owners of Pastoral Leases and the mining tenement, and the Shire of Murchison should be consulted.

(40.)

JACK HILLS

Location: 1:250,000 Geological Series Belele and Byro
lat 26 10 S long 117 E

SIGNIFICANCE and VALUE

Class I : Earliest Minerals
Research

GEOLOGICAL NOTE

The Jack Hills Metamorphic Belt lies in the Western Gneiss Terrain on the east of the Murchison River nearly 80 km northeast

of Mount Narryer and consists of a strip of metasedimentary rocks believed to be 3200-3100 m.y. in age, bounded to the north by gneissic granitoids of c.3500 m.y. and on the south by granites dated at 2600 m.y. Some 30 km east of the locality now considered, a rock, possibly a felsic volcanic, gave an age of nearly 3700 m.y.

Of great interest is the strip of metasedimentary rocks. These are low in metamorphic grade and display clear sedimentary structures, and conglomerates within them yield detrital zircons dated at almost 4300 m.y. and serve to amplify the extent of hosts of the Mount Narryer type preserving such zircons.

Reference: Baxter, J.L., Wilde, S.A., Pidgeon, R.T. and Fletcher, I.R., 1984, The Jack Hills Metasedimentary Belt - An extension of the early Archaean terrain in the Yilgarn Block, Western Australia in Geoscience in the development of natural resources, Abstracts, Seventh Australian Geological Convention: Geological Society of Australia Inc.

TENURE, ACCESS and POSSIBLE THREATS

Ground now considered lies within Pastoral Leases 3114/941, Beringarra of Mr. A. Blood, Beringarra Station via Cue, WA 6640 and 3114/575, Nookawarra of M.J. & J.R. Tomkins, Nookawarra Station also via Cue, WA 6640. It falls within mining tenement E 20/57.

Access is from the Cue-Beringarra road by crossing Jack Hills near Yarrameedie Gallery and north of the range, turning west at a creek with a 'concrete' crossing.

Conglomerate containing ancient zircons will attract collectors.

RECOMMENDATIONS

It was not possible to visit Jack Hills during the survey and for the time being an outline monument of 20 km² is recommended as shown on aerial photograph WA 2187 Byro Run 2 No. 5184 (p.134).

- Protection : high priority for zircon-bearing conglomerates.
- Proposal : this portion of Jack Hills should be included in conservation measures considered for Mount Narryer range.
- Presentation : not suitable, remote.

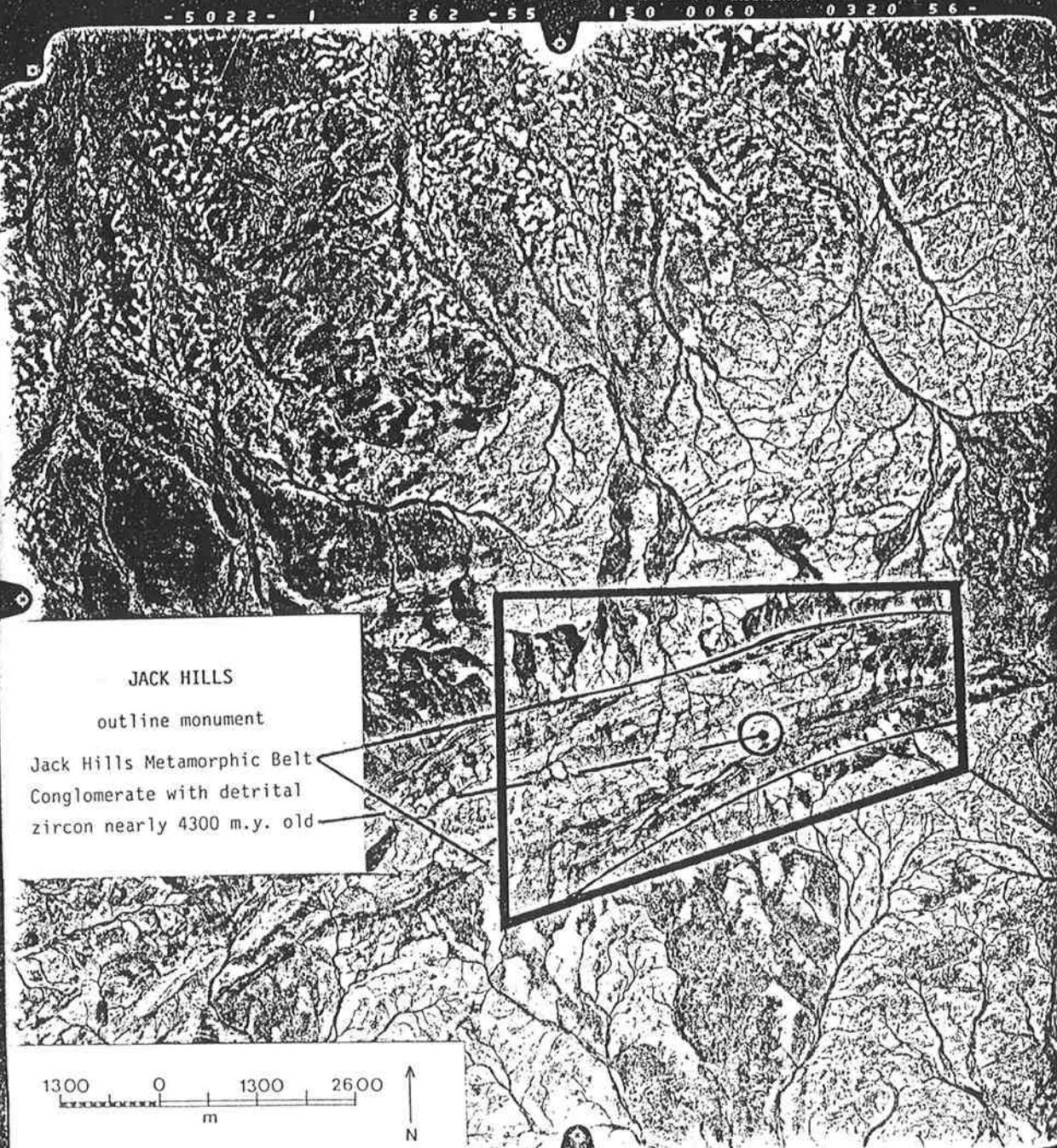
The owners of Pastoral Leases and mining tenements, and the Shire of Murchison should be consulted.

5184

WA 2187 BYRD 1:250 000

RUN 2 (5182-5210)

SCALE 1:65 000 14.12.83 JOB NO. 830471



JACK HILLS

outline monument

Jack Hills Metamorphic Belt
Conglomerate with detrital
zircon nearly 4300 m.y. old

1300 0 1300 2600
m

N

OTHER LOCALITIES

Carnarvon Range: spectacular and enigmatic cross-bedding in the Calyie Sandstone of the Bangemall Group (Nabberu 1:250,000 Geological Series); this feature is some 200 km northeast of Mount Leake and was too distant to visit during the 1986 traverse. It is recorded for future consideration; see Locality 18 in 'Excursion on the Nabberu Basin Area', 1979: West. Australia Geol. Survey (unpublished).

Crispin Conglomerate, Marker 'Quartzite' - Trig Hill and Labouchere Formation: (Peak Hill 1:250,000 Geological Series); these features, respectively stops G-16, G-17a and G-20 of the Capricorn Orogen Excursion, should be ear-marked for further examination - see Gee, R.D., 1985, Glengarry Sub-basin in Capricorn Orogen Excursion Notes: West. Australia Geol. Survey (unpublished).

Water Tank Hill and Trenton Hill, both at Cue: recommended for pillow basalt (Cue 1:250,000 Geological Series); no examples of pillow basalts suitable for listing were found on these hills.

Warrambo Hill at Mount Magnet: recommended for banded cherts (Kirkalocka 1:250,000 Geological Series); exposures at this public viewpoint overlooking Mount Magnet are too poor for the purpose of listing.

Extension Hill: recommended for banded cherts, etc. (Ninghan 1:250,000 Geological Series); this hill stands just east of the Great Northern Highway near the Perenjori turnoff but exposure is indifferent.

GERALDTON HINTERLAND

Close to Geraldton two major basins of the Phanerozoic, the Carnarvon and Perth Basins, with Proterozoic rocks to the east, come together to enclose the Northampton Block. This country includes the lower reaches of the Murchison River and the Greenough and Irwin Rivers and is well-known for a fine array of geological exposures, and many are used for teaching. Recommendations are made for the features shown on Figure 12:

North of Geraldton

41.	Pencell Pool	Site
42.-43.	Geraldine Lead Mine & Warribanno Chimney	Monuments
44.	Murchison River Gorge	Monument
45.	Stone Wall	Monument
46.	Shell House Coastal Cliffs	Monument
47.	Rocky Hill	Site
48.	Blue Hills	Monument

East and Southeast of Geraldton

49.	Billeranga Hills	Monument
50.	Enokurra Hill	Monument
51.	Wooderarrung River	Monument
52.	Bindoo Spring	Monument
53.	Coal Seam Park	Monument
54.	Bringoo Railway Cutting	Monument
55.	Moonyoonooka	Monument

Features north of Geraldton from Pencell Pool to Shell House, lie near or within Kalbarri National Park (Figure 13). Those to the east and southeast are arranged as a traverse over Proterozoic rocks and then principally Permian and Jurassic strata. The terrain lies in the wheat belt and is within easy reach of Perth, and over future years these features could attract many visitors.

GERALDTON HINTERLAND

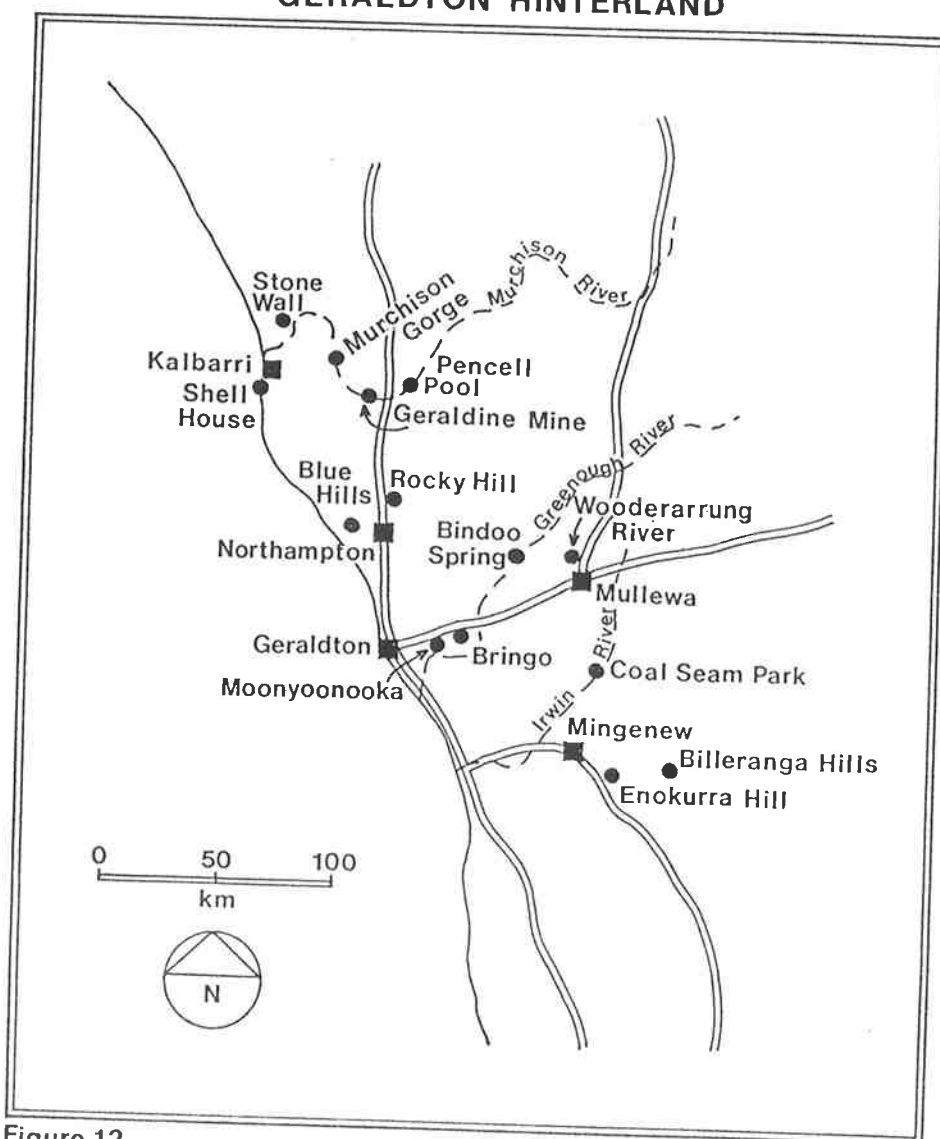
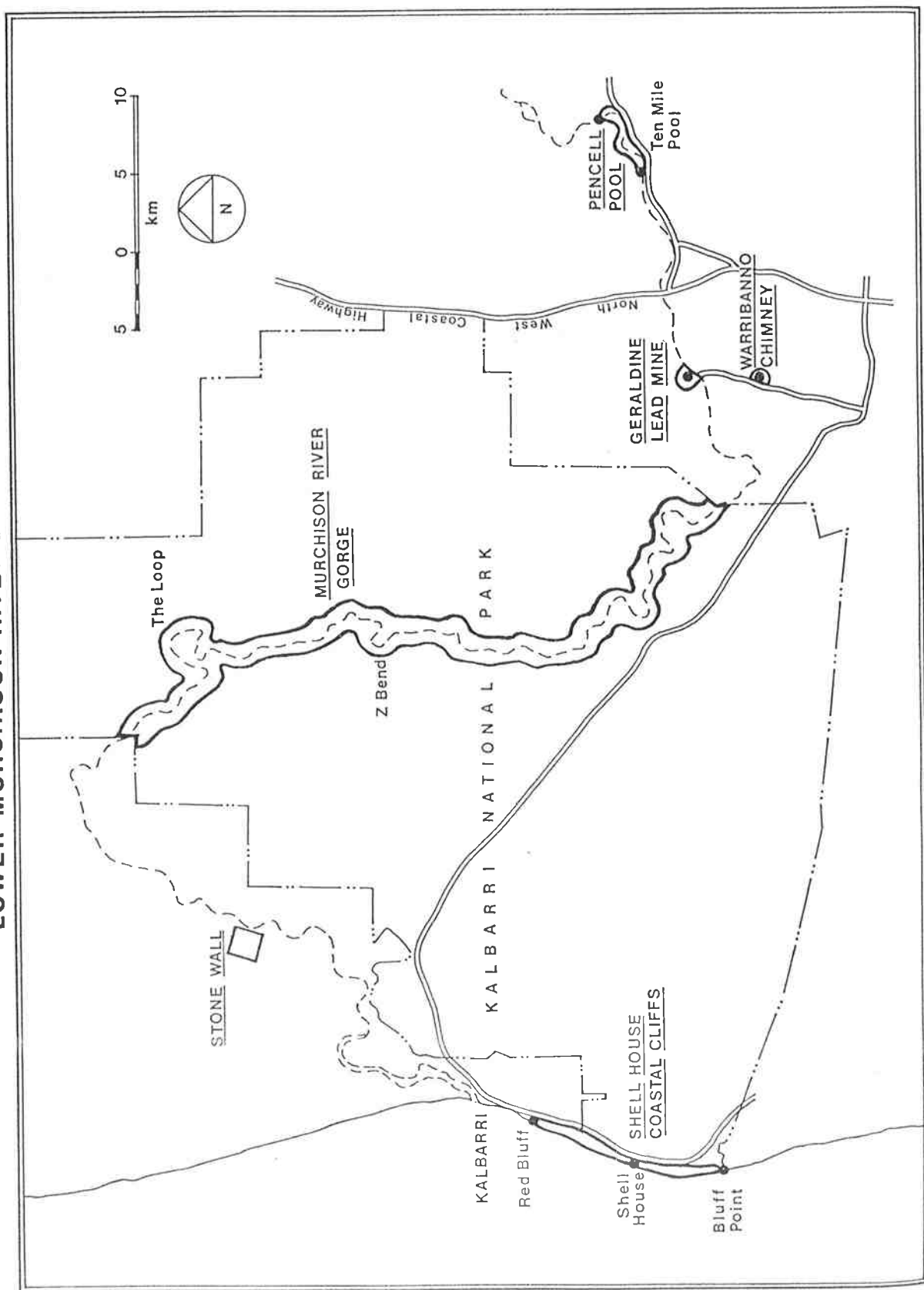


Figure 12

LOWER MURCHISON RIVER LOCALITIES



STATEMENT OF INTEREST

Brilliantly coloured Silurian strata of the red-bed Tumblagooda Sandstone stand in low cliffs at Pencil Pool on the Murchison River and in them a profusion of yellow, orange and vermillion sandstones are painted with deeper reds and browns marking trace fossils. Downstream at Ten Mile Pool, the unconformity between granulites of the Middle Proterozoic Northampton Block and the Tumblagooda Sandstone is seen.

Location: 1:250,000 Geological Series Ajana

lat 27 47 10 S long 114 48 E

Figure 13

SIGNIFICANCE and VALUE

Classes IV and V : Silurian Painted Sandstone
Education
Attractive Setting

GEOLOGICAL NOTE

Tumblagooda Sandstone at Pencil Pool some 13 km above the North West Coastal Highway crossing lies within the most northern part of the Perth Basin though the type section of the formation is in the Murchison River gorge in the Carnarvon Basin 30 km west of Pencil Pool. In the Perth Basin the rocks are essentially similar and although the red colour of the Tumblagooda Sandstone is a distinctive feature, at Pencil Pool there are also splendid orange, yellow and brown hues, best seen in the morning sun.

Reference: Playford, P.E., Cockbain, A.E. and Low, G.H., 1976, Geology of the Perth Basin, Western Australia: West. Australia Geol. Survey Bull. 124.

Plate: 32

TENURE, ACCESS and POSSIBLE THREATS

From Pencil Pool to Ten Mile Pool the Murchison River passes through Murchison Locations CG 71 and 72 and Victoria Locations CG 5140, 5142, 5144 and 5145, the property of Messrs. Porter, via Ajana, WA 6532. Ten Mile Pool lies within unvested Class C Reserve No. 1473 'Water for Travellers'. The river is bordered by a narrow belt of woodland and adjacent land is cropped or pasture.

Access is by the Coolcalalaya road which leaves the North West Coastal Highway eastward about 2.5 km south of the Murchison crossing. At 8.1 km a short track leads westward to Ten Mile Pool and the unconformity and Pencell Pool lies along faint 'duck shooter's tracks' at 13.8 km.

Defacement of 'painted sandstones' is a possible threat.

RECOMMENDATIONS

A Geological Site is recommended downstream from the Yandi boundary fence at the north end of Pencell Pool for some 8 km to include Pelican and Ten Mile Pools and Class C Reserve No. 1473, including 100 m of adjoining banks as shown on aerial photograph WA 2091 Ajana Run 12 No. 5154 (p.141).

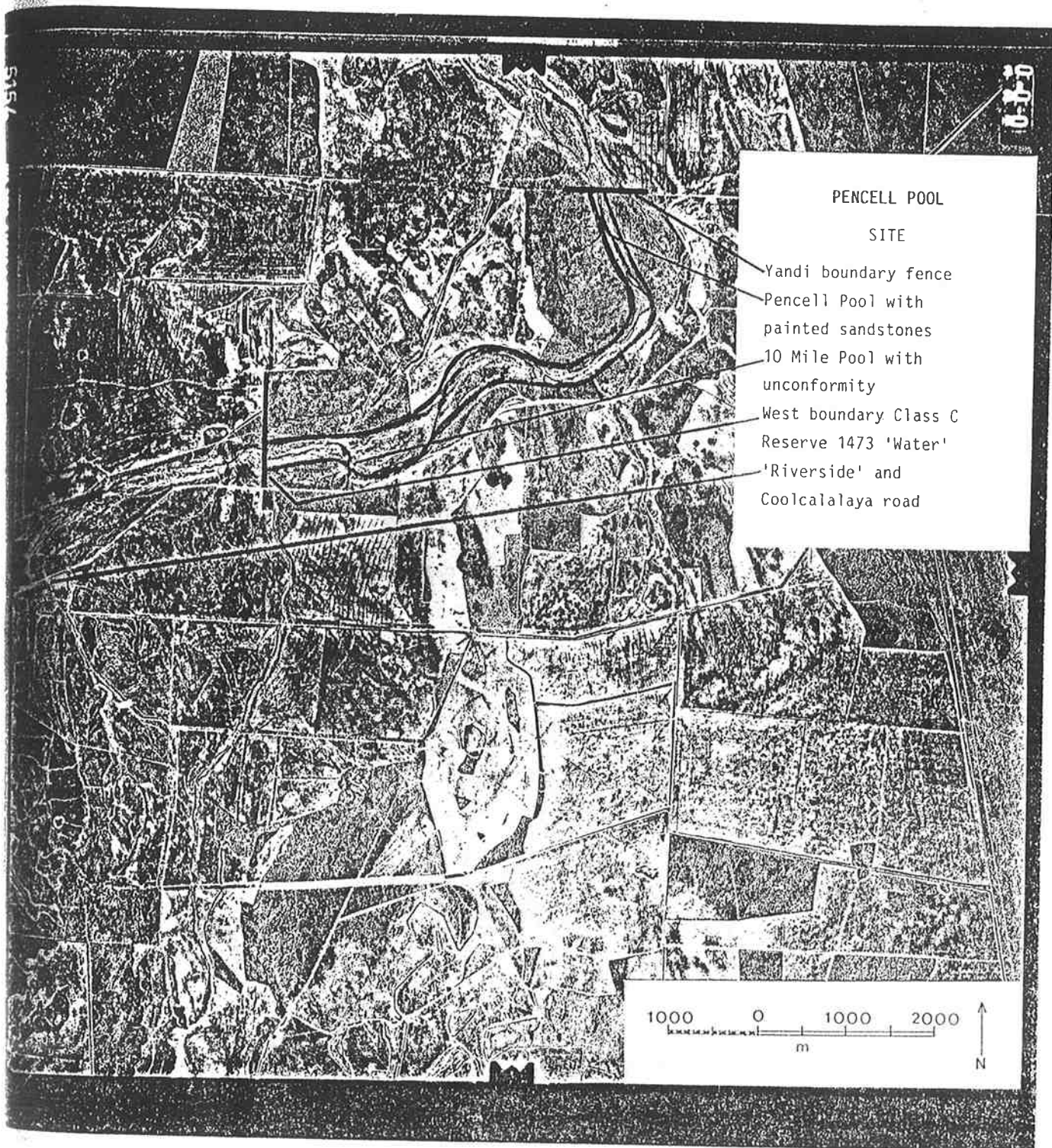
Protection : normal care; coloured cliffs could become targets for vandals.

Presentation : there is excellent potential; this picturesque reach of the Murchison River has easy access and is pleasant walking country where geological and natural history trails could be established.

Landowners and the Shire of Northampton should be consulted.



Plate 32 PAINTED SANDSTONES AT PENCELL POOL Nigel Drake
Trace fossil 'tubes' are picked out by reds and browns



42. - 43. GERALDINE LEAD MINE AND WARRIBANNO CHIMNEY

STATEMENT OF INTEREST

Appealing ruins including an imposing knapping floor mark the site of the State's earliest metal mining venture, the Geraldine Lead Mine on the Murchison River 14 km north of Ajana. At the Geraldine, mining on a commercial scale was first attempted in 1850 and between 1867 and 1878 there was important production of lead. Attractive vistas to the south take in Warribanno Chimney, the State's first metallurgical installation where lead ingots were smelted from Geraldine concentrates.

Location: 1:250,000 Geological Series Ajana

lat 27 51 S long 114 38 E

Figure 13

SIGNIFICANCE and VALUE

Mine and Chimney:

Classes III, V and VI : Mining
Education
Attractive Setting

GEOLOGICAL NOTE

A.C. Gregory's expedition of 1848 discovered the Geraldine lode cropping out in the bed of the Murchison River and it is one of many lead, zinc and copper deposits in the mineralised granulites of the Middle Proterozoic Northampton Block. Galena, sphalerite, chalcopyrite, cerussite and malachite are the principal ore minerals and mineralogical specimens are still found in waste heaps around the Geraldine's knapping floor.

Seven shafts (now filled) were sunk on the lode which was worked to a depth of about 100 m producing some 6500 tonnes of hand-cobbed concentrates. Ruins north of the river include the mine office and manager's house and the knapping floor, and on the south bank remains of huts and other simple accommodation. To the south, Warribanno Chimney is surprisingly well-preserved.

Reference: Blockley, J.G., 1971, The lead, zinc and silver deposits of Western Australia: West. Australia Geol. Survey Min. Resources Bull. 9.

Plates: 33, 34

TENURE, ACCESS and POSSIBLE THREATS

Murchison Location CG 1 used for grazing, contains the Geraldine Mine and owners are contacted through Messrs. Stone, Barr and Campbell, 115 The Esplanade, Mt. Pleasant, WA 6153. Warribanno Chimney stands in Murchison Lot 131 of Mr. R. Starling, Howatharra via Geraldton, WA 6530.

Access is from the Kalbarri road 3 km west of Ajana where a gravel road leads northward for about 8 km to Warribanno Chimney and 14 km to the Murchison River and the old mine, or westward from the North West Coastal Highway by tracks leaving the Highway a little south of the Murchison River.

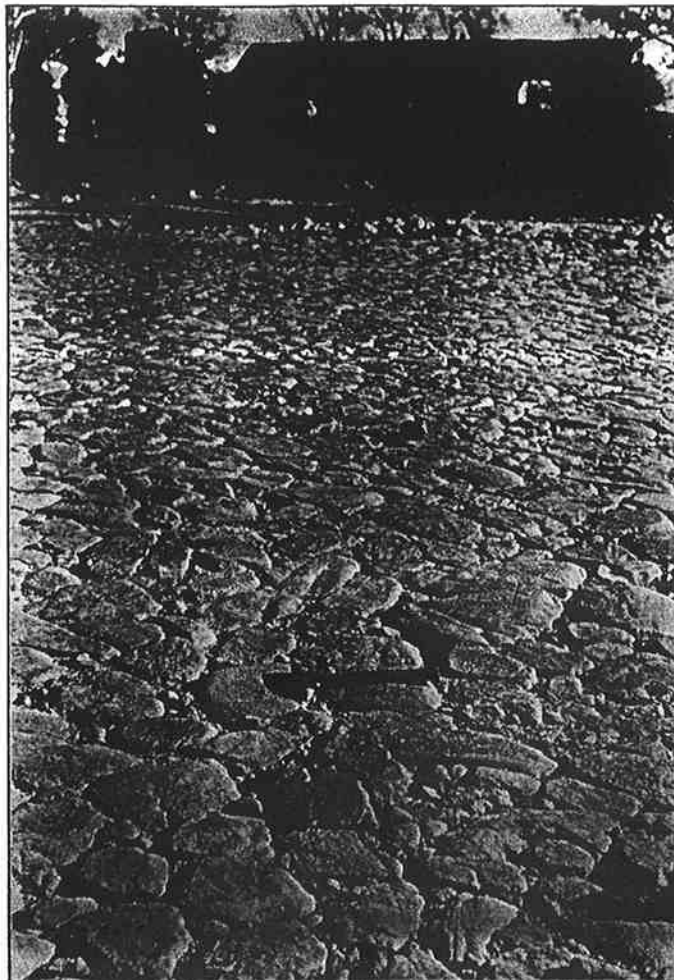
The Geraldine lode is unlikely to attract further mining attention. Ruins of consequence on the north of the river, particularly the buildings, are targets for vandalism and need protection now as without them much of the character of the old mine will be lost.

RECOMMENDATIONS

Geological Monuments are recommended for both the Geraldine Mine and Warribanno Chimney and for the former, the southern portion of Murchison Location CG 1 of some 35 ha would be involved as shown on aerial photograph WA 2091 Ajana Run 12 No. 5158 (p.145). About a hectare of ground with access around Warribanno Chimney would be needed.

- Protection : high priorities; these ruins are important vestiges of the State's mining history and both sites need complete protection and such rehabilitation as necessary to preserve and show them off.
- Proposals : a large-scale plan of the Geraldine mine should be constructed; it may be possible to restore Warribanno Chimney to a semblance of working order.
- Presentation : there is obvious and excellent potential to interest the public; the Monuments could become adjuncts of the Kalbarri National Park, and be incorporated in Park documentation.

Landowners, the Shire of Northampton and the National Parks and Nature Conservation Authority should be consulted.



GERALDINE LEAD MINE
The knapping floor

Plate 33

Nigel Drake

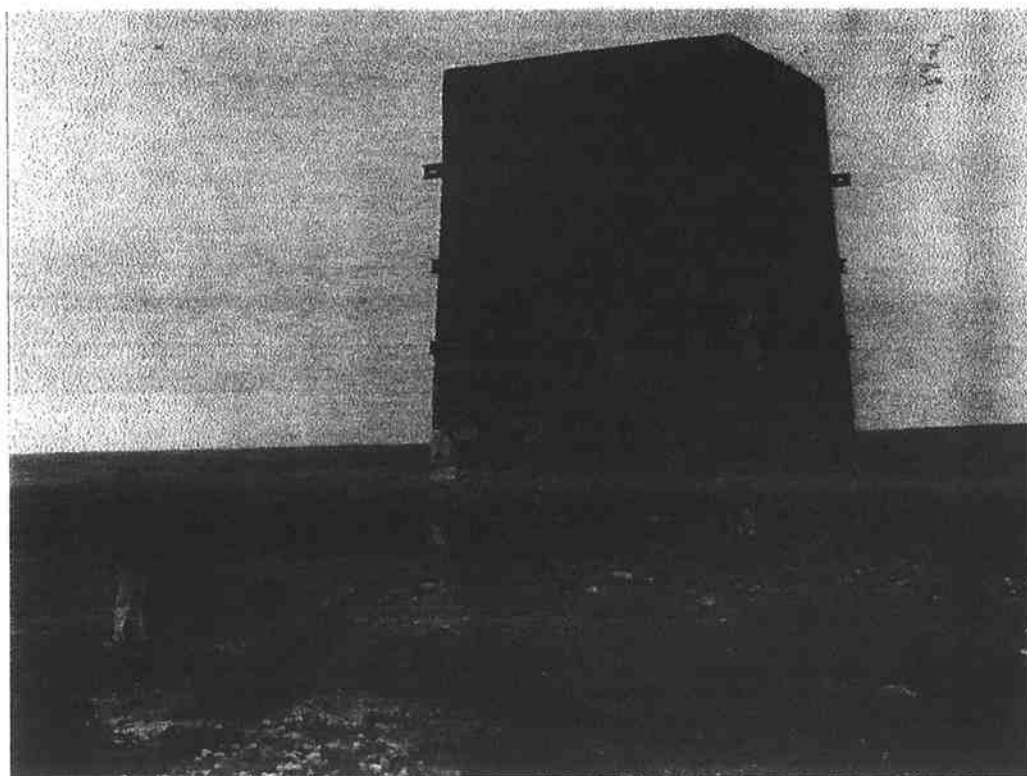
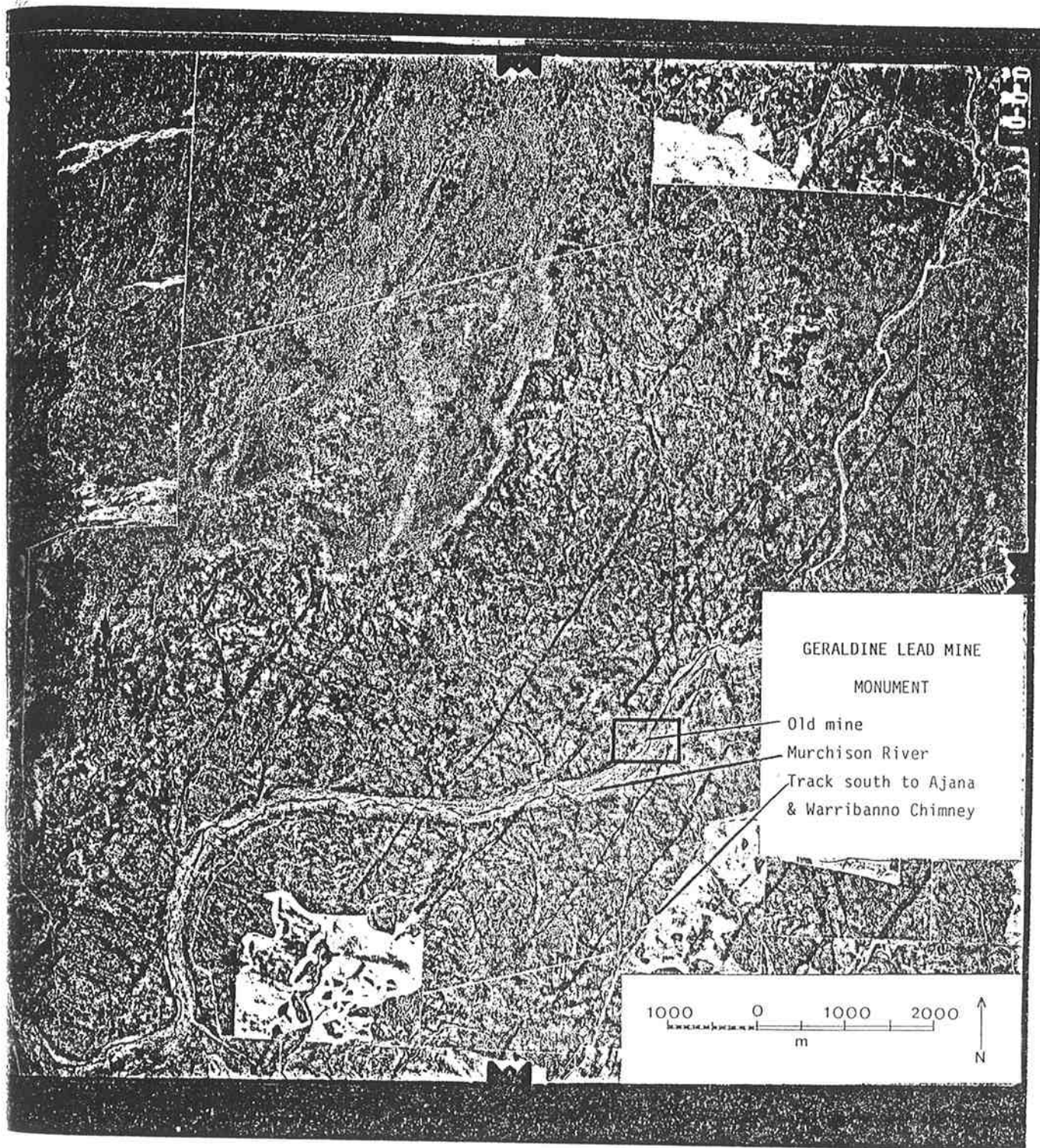


Plate 34
WARRIBANNO CHIMNEY
The first metallurgical installation in Western Australia

J.D. Carter



STATEMENT OF INTEREST

This remarkable young chasm on the lower course of the Murchison in the Kalbarri National Park is an outstanding example of an incised meandering river fathered by recent uplift and as such is of high interest to geologists quite apart from its fine scenic qualities. The gorge cuts the rolling Kalbarri sandplains to depths of 150 m over a distance of more than 80 km and contains the type section of a particularly fine example of a red-bed sequence, the Silurian Tumblagooda Sandstone and roseate cliffs of this formation form well-known features such as The Loop and Z Bend.

Giant scorpions known as eurypterids which grew to lengths of at least 2 metres crawled across the Silurian sands and their tracks are preserved on many rock surfaces in the gorge.

Location: 1:250,000 Geological Series Ajana
lat 27 50 S long 114 30 E
Figure 13

SIGNIFICANCE and VALUE

Classes III and V : Riverine Geomorphology
Reference
Outstanding Natural Beauty

GEOLOGICAL NOTE

The Murchison gorge contains the nineteen partial sections of the type section of the Tumblagooda Sandstone and four facies associations are recognised which include both fluvial and marine rocks.

Until late Tertiary times the lower reaches of the Murchison meandered across Tumblagooda Sandstone lowlands but possibly between the Miocene and Quaternary, uplift associated with reverse movement on the Hardabut Fault brought about a steady elevation of the land surface allowing the river to cut slowly down into the red-beds preserving meanders such as The Loop. The gorge however may be much more ancient since at Z Bend there are small patches of the Cretaceous Windalia Radiolarite at least 20 m below the highest Tumblagooda Sandstone exposures.

Reference: Hocking, R.M., 1979, Sedimentology of the Tumblagooda Sandstone (Silurian), Western Australia -- a preliminary interpretation: West. Australia Geol. Survey Ann. Rept. 1978, p.40-44.

TENURE, ACCESS and POSSIBLE THREATS

The Geological Monument now recommended lies within the Kalbarri National Park and roads to principal geomorphological features such as The Loop have signposts.

There are no obvious threats; use of the ground is supervised.

RECOMMENDATIONS

The Murchison River gorge lying within the National Park is recommended as a Geological Monument (Figure 13): this section contains The Loop and Z Bend, and many partial sections of the type section of the Tumblagooda Sandstone.

Protection : normal care; ground lies within a National Park.

Presentation : geomorphological attractions are self-explanatory; the public should be able to see the unusually clear scorpion tracks at 'Fourways'.

The National Parks and Nature Conservation Authority should be consulted.

STATEMENT OF INTEREST

A magnificent escarpment overlooking the Murchison River gorge 17 km northeast of Kalbarri exposes rugged red-beds of the Silurian Tumblagooda Sandstone overlain by a thick white mantle of marine Cretaceous rocks in which four formations are displayed with unusual clearness.

A geological excursion examined this section in 1983.

Location: 1:250,000 Geological Series Ajana
lat 27 34 20 S long 114 15 E
Figure 13

SIGNIFICANCE and VALUE

Class III : Cretaceous Stratigraphy
Education
Great Landscape Value

GEOLOGICAL NOTE

At 'section gully' near Stone Wall, current-bedded, red sandstones of the Tumblagooda Sandstone include a widespread marker horizon of pebbles above which the trace fossil *Skolithos* is found.

The white-weathering mantle is formed by the Lower Cretaceous Winning Group and Toolonga Calcilutite. At its base, poorly bedded sandstones of the Birdrong Sandstone are overlain by dark radiolarian siltstones of the Windalia Radiolarite and then by dark claystones of the Alinga Formation. Capping the escarpment and disconformably overlying the Winning Group is the fossiliferous Toolonga Calcilutite of Upper Cretaceous age.

Reference: Hocking, R.M., 1983, in Ajana Excursion Notes: West. Australia Geol. Survey (unpublished).

Plate: 35

TENURE, ACCESS and POSSIBLE THREATS

Stone Wall lies within Murchison House Pastoral Lease 3114/969 with owners at P.O. Box 399, WA 6005.

Access is by very sandy tracks calling for competent four-wheel driving. Murchison River is crossed at Murchison House Station and after 500 m a track to the north-east is taken for about 8 km to the second open valley where an ill-defined trail leads westward to a small dam at the foot of the escarpment with a low stone wall set up to keep stock off the hills (4WD).

An Exploration Licence (E 70/182) encroaches on the area of interest; if pursued, quarrying would improve exposure but it should be planned to maintain the integrity of escarpment panoramas.

RECOMMENDATIONS

A Geological Monument of 60 ha is recommended as shown on aerial photograph WA 2091 Ajana Run 9 No. 5040 (p.150).

Protection : normal care.

Presentation : not suitable owing to difficult access; because of the difficult access (very sandy tracks), use of this Geological Monument should be restricted to parties with experienced leadership.

The owners of Murchison House Pastoral Lease and the mining tenement, and the Shire of Northampton should be consulted.



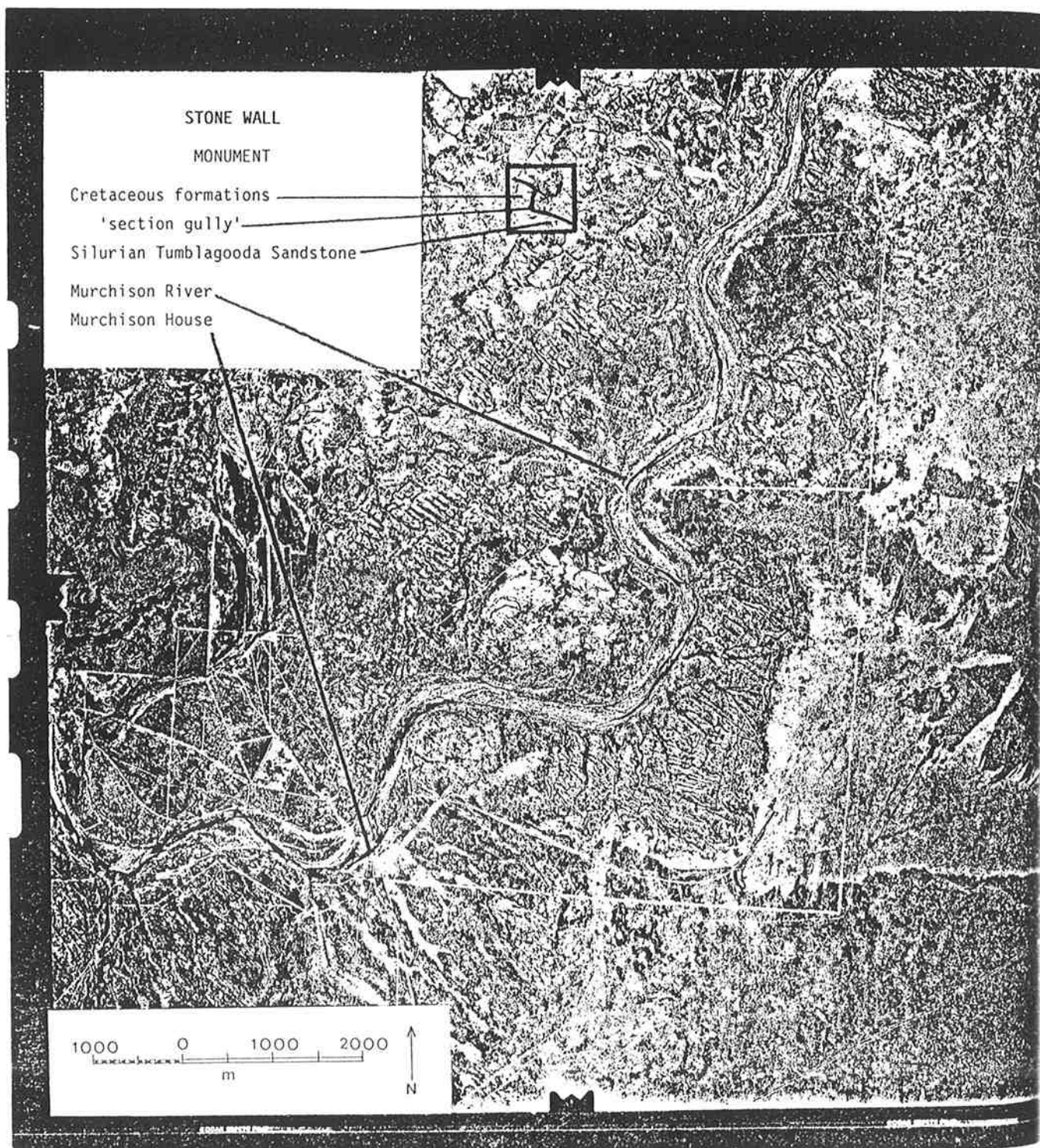
Plate 35

STONE WALL

Nigel Drake

Red-beds of the Silurian Tumblagooda Sandstone are overlain by a white mantle of Cretaceous marine sediments.

The notch in the red-bed cliff (centre, right) marks 'section gully'



STATEMENT OF INTEREST

Multicoloured strata in attractive coastal cliffs and gorges south of Kalbarri are formed by sediments of the Silurian, Triassic and Pleistocene and there is good access to many features of geological and scenic interest. On the north stands Red Bluff where an especially fine red-bed sequence of Silurian Tumblagooda Sandstone is capped by creamy Tamala Limestone of the Pleistocene. In the cove Shell House some 8 km to the south, the type section of the Triassic Wittecarra Sandstone rests on the Silurian red-beds and is conformably overlain by Kockatea Shale with Tamala Limestone completing the sequence.

These sections are examined by geological excursions.

Location: 1:250,000 Geological Series Ajana

lat 27 48 S long 114 7 E

Figure 13

SIGNIFICANCE and VALUE

Classes III and V : Triassic Stratigraphy
Reference
Great Landscape Value

GEOLOGICAL NOTE

At Shell House the 8 m type section of Wittecarra Sandstone consists of conglomerate, sandstone and siltstone and is overlain by thin clayey siltstone of Kockatea Shale.

The particularly good exposures of Tumblagooda Sandstone at Red Bluff include among many sedimentary features, a widespread pebble marker horizon and numerous examples of tubes of the trace fossil *Skolithos*.

Reference: Hocking, R.M., 1983, in Ajana Excursion Notes: West. Australia Geol. Survey (unpublished).

Plate: 36

TENURE, ACCESS and POSSIBLE THREATS

The Geological Monument recommended falls within Kalbarri National Park and roads to Shell House and Red Bluff are shown by signposts from Kalbarri township.

No threats are foreseen.

RECOMMENDATIONS

A Geological Monument is recommended for the coastline of approximately 14 km extending southwards from Red Bluff to the southern limit of the Kalbarri National Park bounded to the east by the coastal access road (Figure 13).

Protection : normal care; use of the ground is supervised.

Presentation : public enjoyment of the geology of the coastal cliffs would be enhanced by explanatory notice boards.

The National Parks and Nature Conservation Authority should be consulted.



Plate 36

SHELL HOUSE

J.D. Carter

This cove contains the type section of the
Triassic Wittecarra Sandstone

47.

ROCKY HILL

STATEMENT OF INTEREST

A contact zone between garnet granulite of the Proterozoic and coarse porphyritic granite is unusually well-exposed in the low rounded boss of Rocky Hill some 8.5 km north of Northampton. Contacts are marked by coarse minerals including very large garnet and excellent examples of migmatite are seen.

Rocky Hill stands alongside the North West Coastal Highway and is used for teaching at the tertiary level.

Location: 1:250,000 Geological Series Geraldton-Houtman Abrolhos
lat 28 16 35 S long 114 37 30 E

SIGNIFICANCE and VALUE

Class IV : Intrusive Relationship
Education
Attractive Setting

GEOLOGICAL NOTE

At Rocky Hill, migmatite formed during Middle Proterozoic granite intrusion is displayed very clearly in the central portion of the hill with garnet granulite on the west and coarsely garnetiferous granite cropping out along the eastern flanks.

Reference: Peers, R., 1971, The Proterozoic of the Geraldton-Northampton area: West. Australia Geol. Survey Ann. Rept. 1970, p. 50-56.

Plate: 37

TENURE, ACCESS and POSSIBLE THREATS

Victoria Lot CG 22 (Wibi) contains Rocky Hill and is the property of Mr. W.R. Patrick, P.O. Box 22, Northampton, WA 6535. The ground is cropped and grazed.

Rocky Hill stands immediately east of the North West Coastal Highway 8.5 km north of Northampton and this Rocky Hill paddock is shown as such on Lands and Surveys plan 160 D/4 but the 1:250,000 Geological Series sheet places a 'Rocky Hill' 2 km to the northeast.

Surfaces with coarse garnet should be protected.

RECOMMENDATIONS

A Geological Site of approximately 55 ha is recommended as shown on aerial photograph WA 1709 Geraldton Run 5 No. 5467 (p.155).

Protection : normal care; clean exposures of coarse euhedral garnet should not be sampled.

Presentation : not suitable: this is private land and is used periodically for crops.

The landowner and the Shire of Northampton should be consulted.

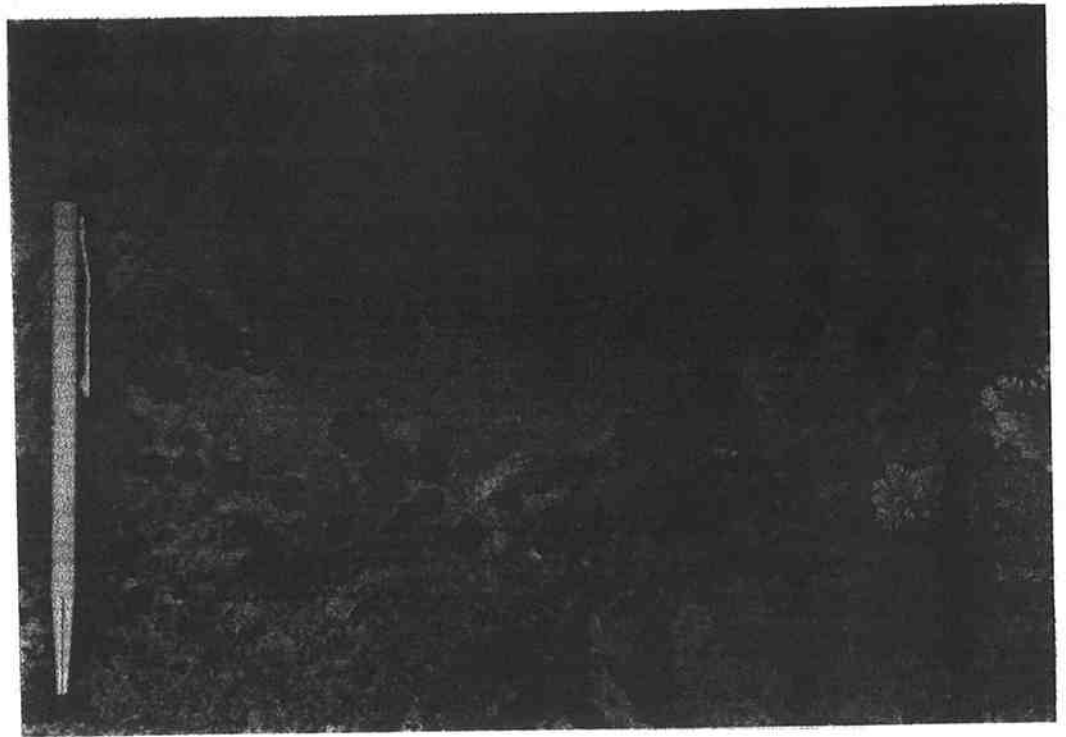


Plate 37

COARSE GARNET AT ROCKY HILL

J.D. Carter



STATEMENT OF INTEREST

A horizon corresponding to the lowest strata of the European Mesozoic follows the crest of an imposing escarpment at Blue Hills 15 km west of Northampton. Here red-beds of Tumblagooda Sandstone of the Silurian are capped by thin algal coatings at the base of bleached siltstones of the Triassic Kockatea Shale and this escarpment of gently dipping sediments straddles Proterozoic crystalline rocks of the Northampton Block. Two unconformities and the distinctive rocks they separate make Blue Hills an area of unusual geological interest.

Blue Hills is visited by teaching parties at the tertiary level.

Location: 1:250,000 Geological Series Geraldton-Houtman Abrolhos
lat 28 22 S long 114 29 30 E

SIGNIFICANCE and VALUE

Class III : Mesozoic Unconformity
Reference
Attractive Setting

GEOLOGICAL NOTE

Blue Hills lies near the northwest margin of the Perth Basin and the principal unit of interest here, marine Kockatea Shale, is up to 30 m thick and yields a varied flora and fauna of early Triassic age. At its base a thin irregular pebble band is draped by algal coatings and some are moulded around quartz pebbles and irregularities on Silurian sandstone to form small ferruginised bioherms. Thinly laminated, bleached siltstone and clay overlie the algal structures.

Reference: Karajas, J., 1969, A geological investigation of an area between Mount Minchin and the Bowes River, Western Australia: Univ. West. Australia Science Hons. thesis (unpublished).

TENURE, ACCESS and POSSIBLE THREATS

This part of Blue Hills lies within Victoria Location CG 2792 of Mr. W.J. Suckling, P.O. Box 77, Northampton, WA 6535. Surrounding paddocks are under crops.

From Northampton the Port Gregory road is taken for 10.3 km before turning north at the signpost 'Port Gregory 42' and taking the left fork 300 m along the gravel road. At 4.6 km beyond the fork, the road reaches the summit of the Tumblagooda Sandstone scarp where there is parking in a gravel pit. Algal structures are exposed on the scarp crest some 400 m to the southwest.

To preserve algal coatings, hammers should not be used on solid rock along the scarp crest.

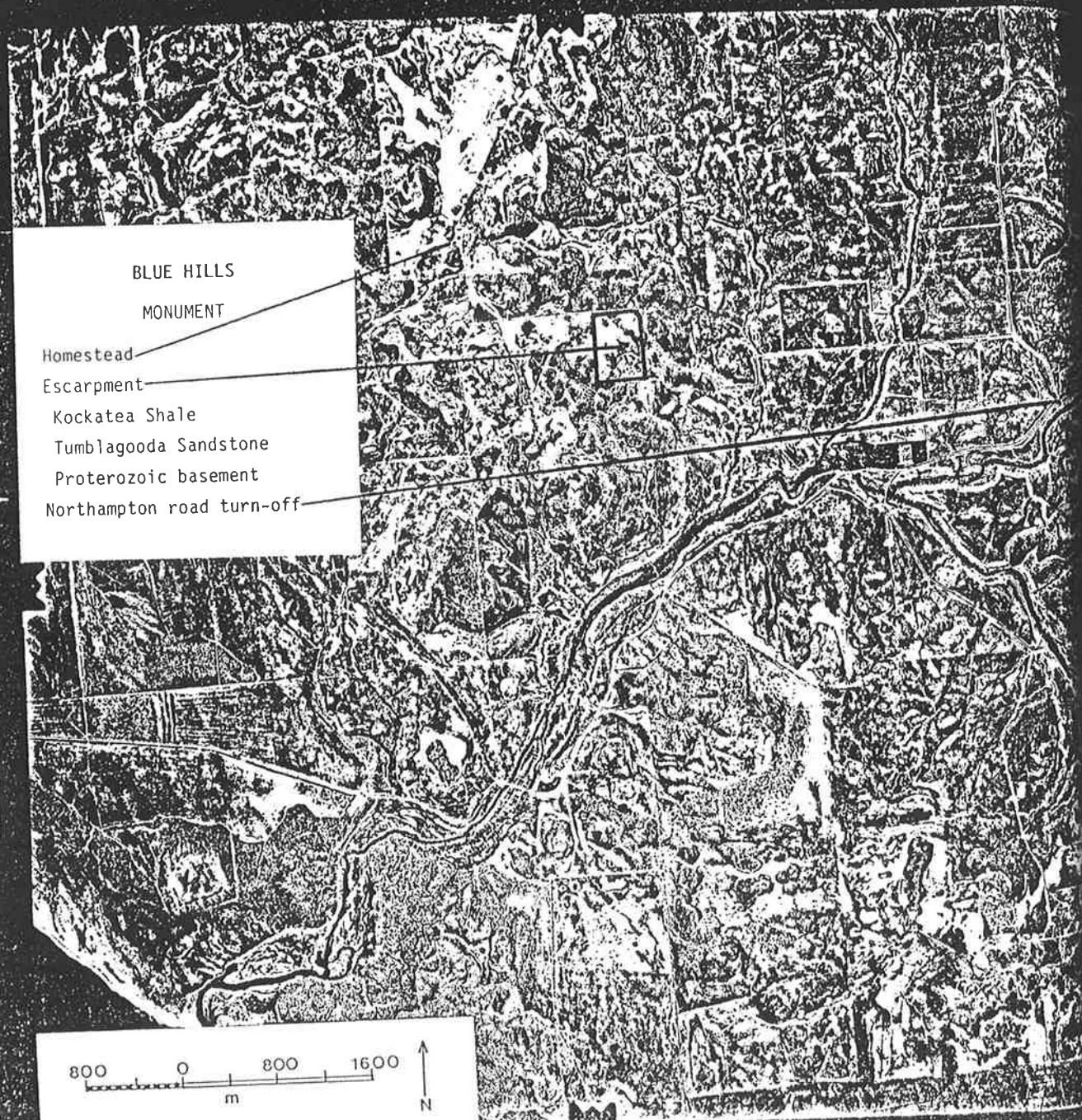
RECOMMENDATIONS

A Geological Monument of some 25 ha is recommended as shown on aerial photograph WA 1709 Geraldton Run 7 No. 5530 (p.158).

Protection : high priority; algal structures could be easily destroyed and need to be examined with care. Use of the Monument should be restricted to research workers and supervised geological parties.

Presentation : not suitable; the geology is not readily appreciated and this is private land used for cropping.

The landowner and the Shire of Northampton should be consulted.



STATEMENT OF INTEREST

A large-scale palaeogeographic display including river channels of the Proterozoic is seen in the east face of the Billeranga Hills 24 km southwest of Morawa. The ancient river channels were cut into Archaean gneiss and filled by Proterozoic Neereno Sandstone and then draped by Morawa Lavas, and thus the exposition presents a sequence of gneiss, sandstone and lavas with a regional unconformity separating gneiss from sandstone and lavas, and a disconformity between the river infills of sandstone and overlying lavas.

These exposures have obvious educational value and are visited by teaching parties at the tertiary level.

Location: 1:250,000 Geological Series Perenjori
lat 29 19 S long 115 53 E

SIGNIFICANCE and VALUE

Class III : Proterozoic Relationships
Education
Attractive Setting

GEOLOGICAL NOTE

The Proterozoic rocks were formerly assigned to a thin Billeranga Group, a sequence of gently dipping sandstone, siltstone, chert and trachytic to andesitic lavas overlying the Archaean some 14 km east of the Darling Fault. They are now placed in the Billeranga Subgroup of the Moora Group.

Reference: Baxter, J.L. and Lipple, S.L., 1985, Perenjori, WA: West. Australia Geol. Survey 1:250,000 Geol. Series Explan. Notes.

Plate: 38; Figure: 14

TENURE, ACCESS and POSSIBLE THREATS

This part of the Billeranga Hills lies within Victoria Location 2018, Lot M1315, the property of Mr. and Mrs. F.J. & P.G. Lane,

P.O. Box 172, Morawa, WA 6623. Adjacent paddocks are cropped.

'Old Three Springs Road 19' runs below the hill face which is situated a little northeast of Mount Campbell. From Morawa the Wubin road is taken for 2 km before turning west on the Three Springs Road for 20 km and then north on Road 19 for 1.5 km.

There are no obvious threats.

RECOMMENDATIONS

A Geological Monument of some 45 ha is recommended as shown on aerial photograph WA 1951 Perenjori Run 5 No. 5417 (p.161).

Protection : normal care.

Presentation : not suitable; remote.

Landowners and the Shire of Morawa should be consulted.

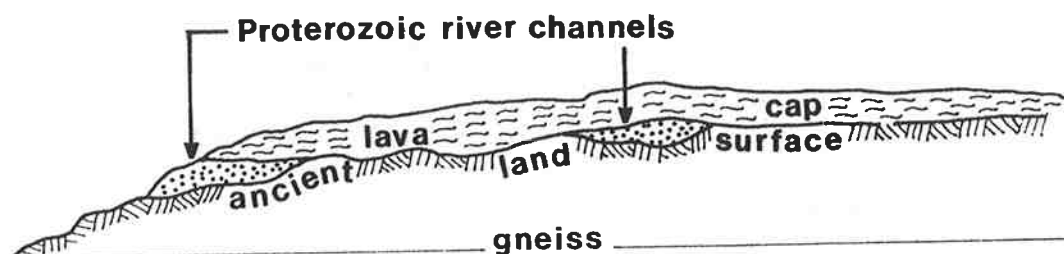


Figure 14

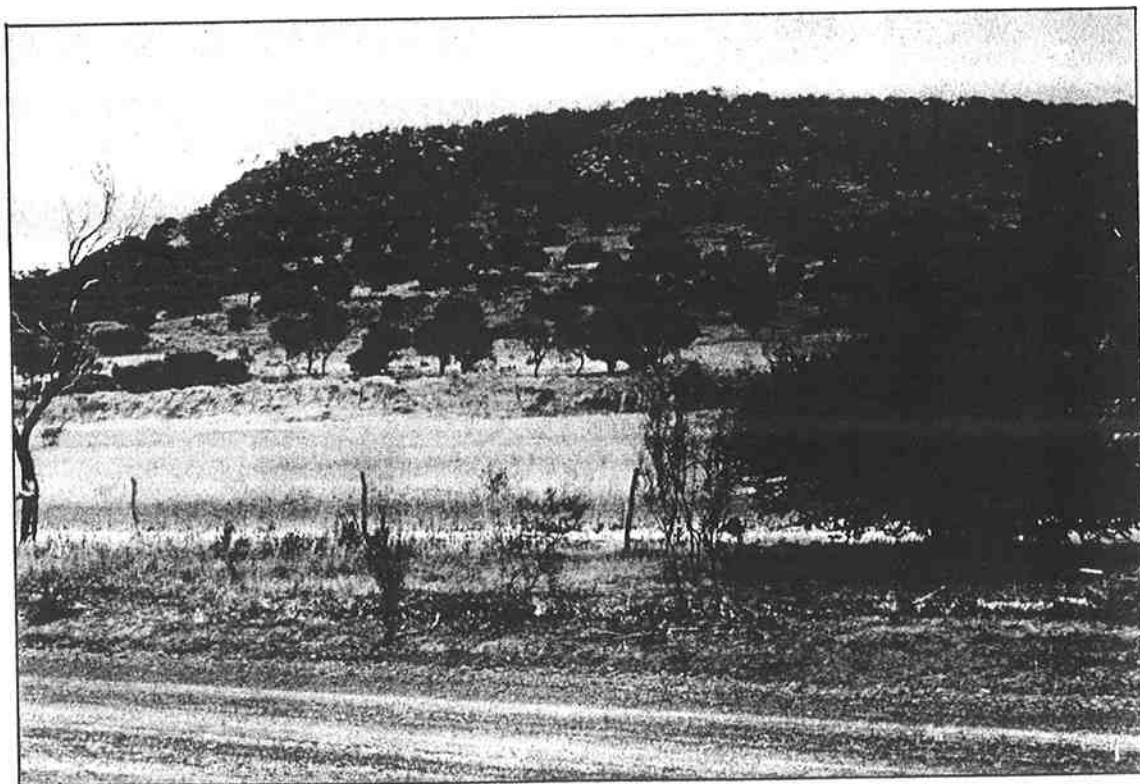


Plate 38

BILLERANGA HILLS

J.D. Carter

The prominent canoe-shaped outcrops mark Proterozoic river channels



STATEMENT OF INTEREST

This rugged sandstone hill contains the type section of the Enokurra Sandstone of the Proterozoic Yandanooka Group and is part of a low range lying amid pleasant countryside 25 km southeast of Mingenew visited by teaching excursions.

Location: 1:250,000 Geological Series Perenjori
lat 29 19 20 S long 115 35 18 E

SIGNIFICANCE and VALUE

Class III : Proterozoic Stratigraphy
Reference
Attractive Setting

GEOLOGICAL NOTE

The Enokurra Sandstone is one of five formations of the Yandanooka Group, a thick sequence of clastic sediments resting on the metamorphic Mullingar Inlier and underlying Permian rocks of the Irwin Sub-basin.

Reference: Playford, P.E., Cockbain, A.E. and Low, G.H., 1976, Geology of the Perth Basin, Western Australia: West. Australia Geol. Survey Bull. 124.

TENURE, ACCESS and POSSIBLE THREATS

Enokurra Hill lies within Victoria Location 1929 Lot CG 107 owned by the Mantinea Pastoral Company, Yandanooka via Mingenew, WA 6522. It is referred to as 'Granite Hill' also.

Access from Mingenew is by the Three Springs road south for 20 km, turning east at Yandanooka and taking a right-fork gravel road with signpost 'Enokurra' for 3 km.

There is no obvious threat.

RECOMMENDATIONS

A Geological Monument of about 80 ha is recommended as shown on aerial photograph WA 1951 Perenjori Run 5 No. 5424 (p.163).

Protection : normal care.

Presentation : not suitable; remote.

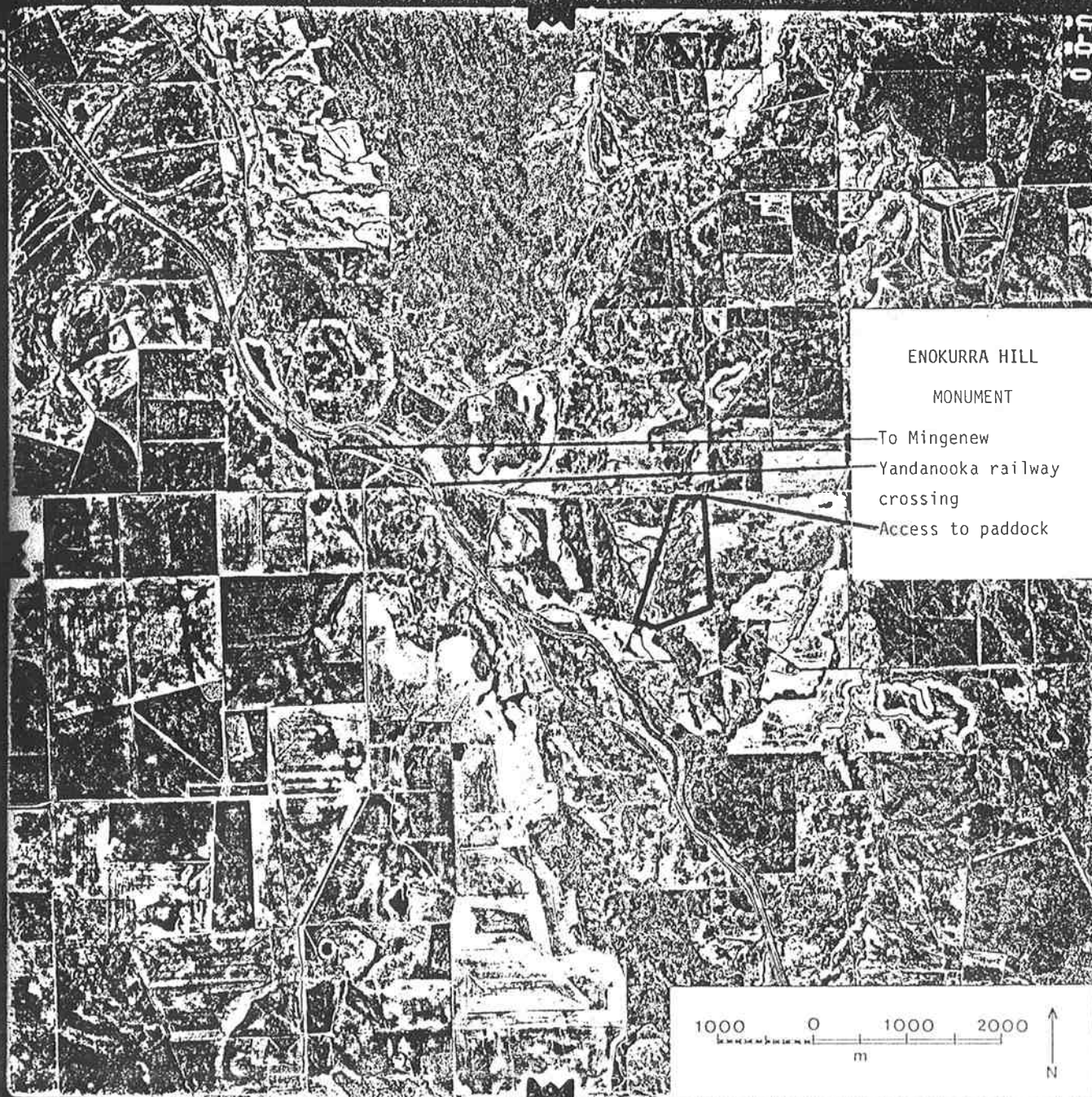
Landowners and the Shire of Mingenew should be consulted.

5626

WA 1951 PERTH 1:25000

RUHS 15071-6391

SCALE 1:25000 100 500m 212.00 100 NO. 600013



STATEMENT OF INTEREST

One of the major structural features of Earth's crust, the Darling Fault, is exposed in the Wooderarrung River 10 km north of Mullewa with the type section of the Wenmillia Formation of the Proterozoic and rarely found in Western Australia, glacial varves in the Permian Nangetty Formation.

The Darling Fault brings together Archaean granite and phyllitic shale and spilitic lava of the Wenmillia Formation, and although the fault has no physiographic expression, the river section is unusually good as the crystalline rocks outcrop well and the contrast between pale coarse granitoid and dark fine-grained Proterozoic rocks enables the disposition and complexity of the fault zone to be seen quite clearly.

Location: 1:250,000 Geological Series Geraldton-Houtman Abrolhos
lat 28 28 45 S long 115 27 45 E

SIGNIFICANCE and VALUE

Class III : Darling Fault
Research

GEOLOGICAL NOTE

About 290 m of steeply dipping Wenmillia Formation form a strip immediately west of the fault. These are overlain with angular unconformity by the basal unit of the Permian sequence, the Nangetty Formation and this among other glaciogene rocks, contains varves standing in a low cliff. Each varve cycle is some 2 to 3 mm thick and the sequence is estimated to represent approximately 40,000 years of sedimentation within a glacial lake.

Reference: Playford, P.E., Cockbain, A.E. and Low, G.H., 1976, Geology of the Perth Basin, Western Australia: West. Australia Geol. Survey Bull. 124.

TENURE, ACCESS and POSSIBLE THREATS

This river section lies within Victoria Location CG 3834 of Daisy Downs Station, via Mullewa, WA 6630.

A wire gate 0.4 km south of Wenmillia Creek on the west side of Nubberoo Road provides access to the river, a rough track being followed for 2 km westward to a ford about 100 m below the varve cliff. Surrounding paddocks are cropped or pasture (4WD).

There are no obvious threats other than mindless hammering particularly of the varve cliff.

RECOMMENDATIONS

A Geological Monument is proposed for 1500 m of the Wooderarrung River including 100 m of adjoining banks extending southwards from the varve cliff to the southern boundary of Victoria Location CG 3834 as shown on aerial photograph WA 1711 Geraldton Run 9 No. 5603 (p.166).

- Protection : normal care, though particular care should be taken when examining the varve cliff.
- Proposal : the well-exposed Darling Fault zone extends south beyond Location CG 3834 and offers opportunities for student research; a Monument could be extended southwards to include any interesting features disclosed by future work.
- Presentation : as the Darling Fault zone is clearly seen there is potential for public presentation though rough track access through paddocks poses problems.

Landowners and the Shire of Mullewa should be consulted.

5603

WA 1711 GERALDTON 1:250000 SHEET

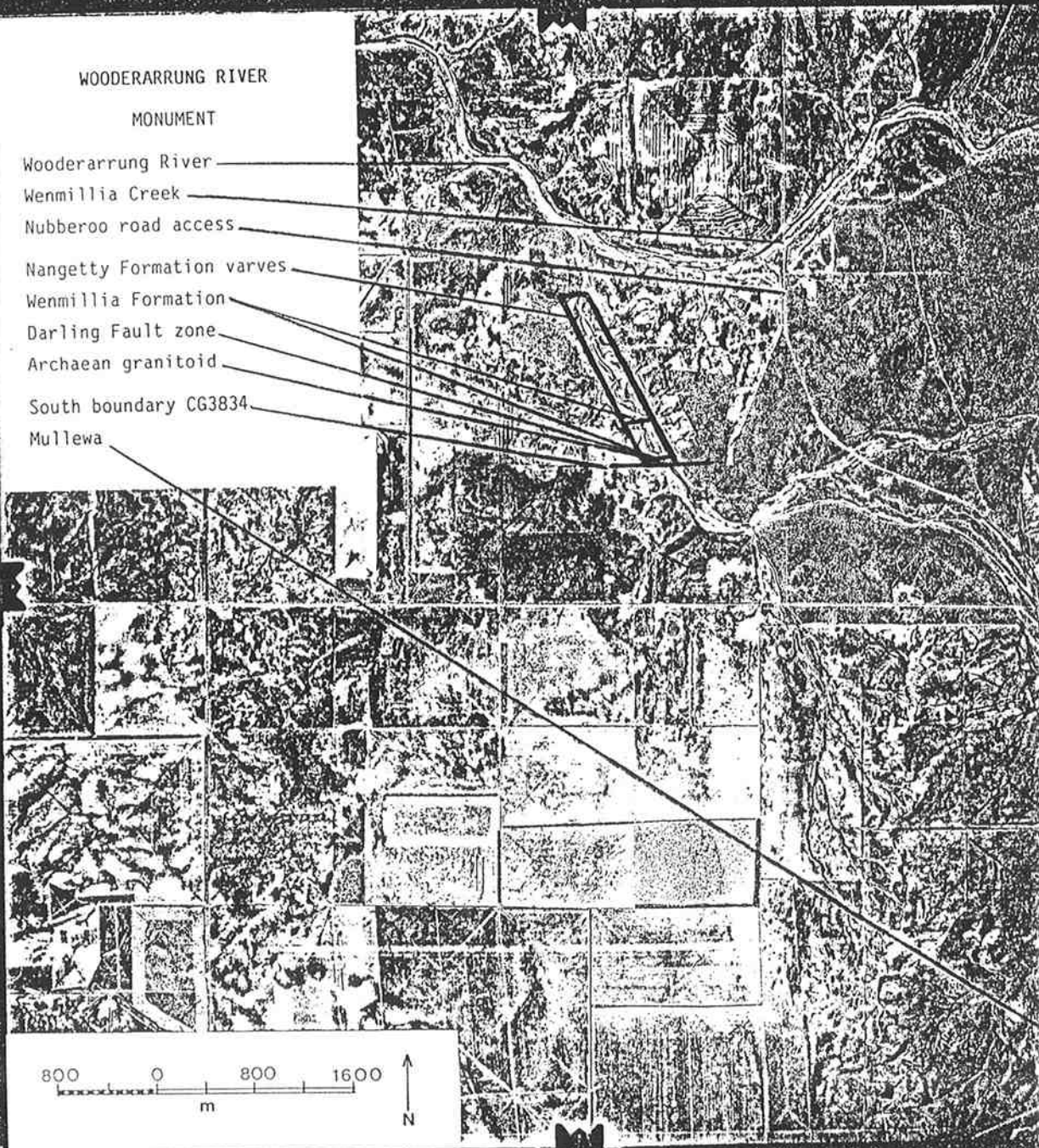
RUN 9 (5601-5630)

SCALE 1:40000 152576mm 14.9.77 JOB NO. 770012

WOODERARRUNG RIVER

MONUMENT

- Wooderarrung River
- Wenmillia Creek
- Nubberoo road access
- Nangetty Formation varves
- Wenmillia Formation
- Darling Fault zone
- Archaean granitoid
- South boundary CG3834
- Mullewa



52.

BINDOO SPRING

STATEMENT OF INTEREST

One of the best exposures of glacial rocks of the Permian in the Perth Basin occurs in the south bank of the Greenough River near Bindoo Spring about 30 km due west of Mullewa where a tillite cliff of Nangetty Formation contains an interesting range of erratic cobbles and boulders scattered through a clay matrix.

Teaching parties visit Bindoo Spring.

Location: 1:250,000 Geological Series Geraldton - Houtman Abrolhos
lat 28 29 50 S long 115 12 E

SIGNIFICANCE and VALUE

Classes III and V : Permian Glacigene Lithology
Education
Attractive Setting

GEOLOGICAL NOTE

The Nangetty Formation consists of marine and continental, glacial and fluvioglacial deposits of the Lower Permian and incorporates tillite, shale, sandstone and conglomerate.

Tillite, a clay with unsorted erratic cobbles and boulders, is excellently exposed at Bindoo Spring where a wide variety of erratics includes Precambrian rocks with representatives from every formation of the Yandanooka Group and examples of Moora Group and Tumblagooda Sandstone.

Reference: Playford, P.E., Cockbain, A.E. and Low, G.H., 1976, Geology of the Perth Basin, Western Australia: West. Australia Geol. Survey Bull. 124.

TENURE, ACCESS and POSSIBLE THREATS

Mullewa Shire has developed Bindoo Spring for public recreation as the 'Bindoo Glacier Bed' and from the Shire car park there is access to the Greenough River and a foreshore reserve incorporating the tillite cliff. The cliff adjoins Victoria Location CG 6058 of Mr. S.B. Burton, P.O. Box 1045, Geraldton, WA 6530.

From Mullewa the Geraldton road is taken for 18 km before turning north onto the Yunna Road (signpost: 'Bindoo Glacier Bed') for 24 km, where the Shire car park is on the left or west of the road.

Senseless hammering of rare erratics has taken place.

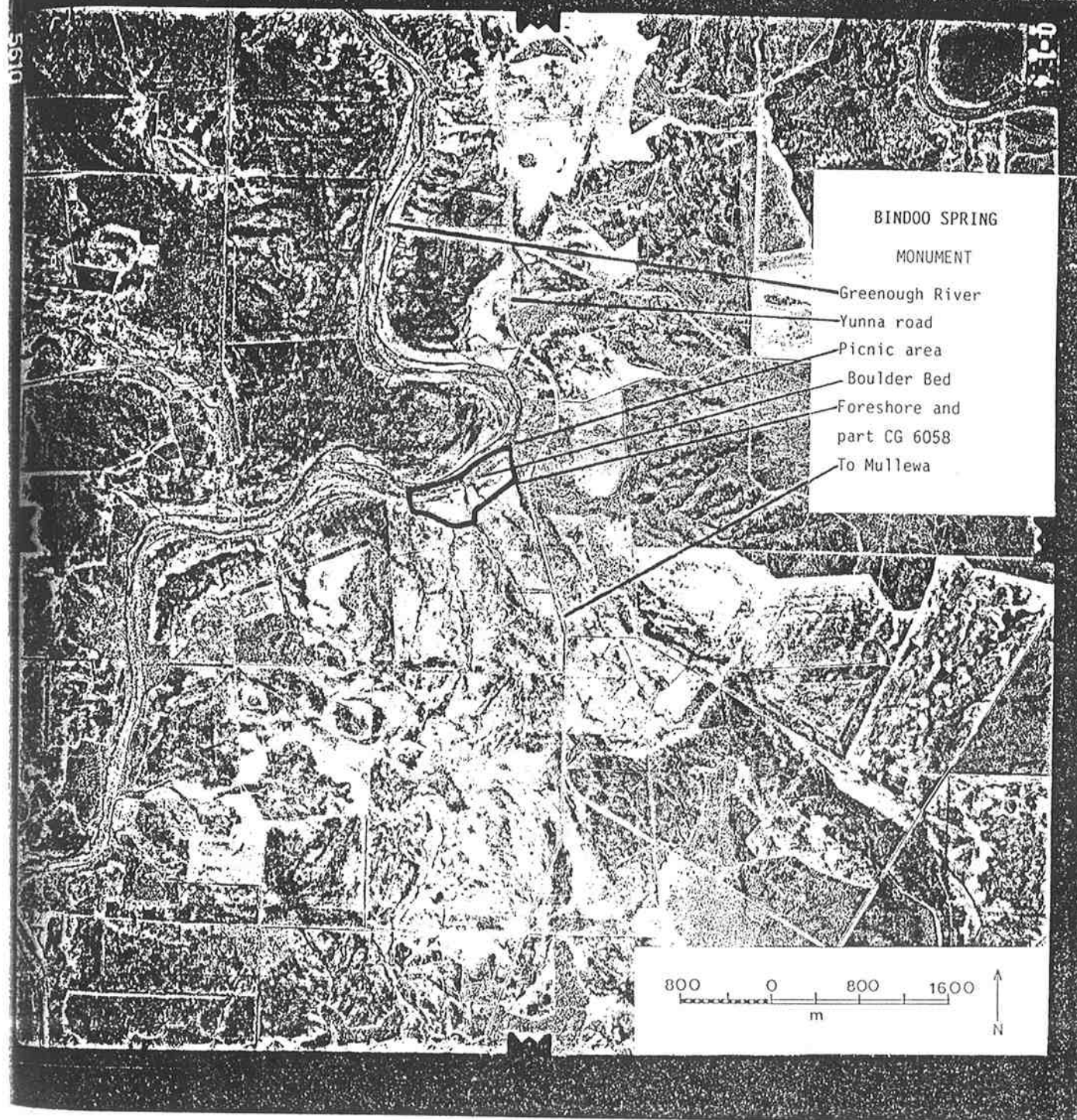
RECOMMENDATIONS

A Geological Monument of some 35 ha is recommended as shown on aerial photograph WA 1711 Geraldton Run 9 No. 5610 (p.169).

Protection : normal care; rare erratics should not be damaged.

Presentation : Bindoo Spring possibly lacks ready visual appeal for the untrained eye and to foster general appreciation of the feature, a pamphlet explaining the geology with particular reference to the provenance of erratics is needed. A display of fallen erratics recovered from the Greenough River bed could be considered with explanations of lithologies and localities of derivation.

The owner of Victoria Location CG 6058 and the Shire of Mullewa should be consulted.



STATEMENT OF INTEREST

A famous geological sequence of the Permian is found along the North Branch of the Irwin River 35 km north of Mingenew and it was here in 1846 that the Gregory brothers made the first discovery of coal in the State. This classic succession includes two type sections, those of the High Cliff Sandstone and the richly fossiliferous Fossil Cliff Member of the Holmwood Shale, and is set in handsome surrounds of flat-topped hills and breakaways.

The clear exposures of the Irwin River sequence provide a valuable and attractive locale for geological education.

Location: 1:250,000 Geological Series Yalgoo
lat 28 57 S long 115 33 E

SIGNIFICANCE and VALUE

Classes II and V : Permian Stratigraphy
Research
Great Landscape Value

GEOLOGICAL NOTE

At the base of the succession is black pyritic Holmwood Shale, a marine shale some 560 m thick. This is followed by its 27 m Fossil Cliff Member composed of marine limestone and siltstone, the former being richly fossiliferous in foraminifera, brachiopods, bryozoans, crinoids, bivalves and other forms, many identical to those of the Callytharra Formation of the Carnarvon Basin. The fossiliferous rocks pass upwards into 24 m of cross-bedded sandstone of the High Cliff Sandstone and Irwin River Coal Measures with 63 m of sandstone, siltstone, shale and thin coal seams carrying a rich **Glossopteris** flora. Marine shales of the Carynginia Formation are the uppermost rocks.

Coals of the Irwin River Coal Measures are too poor in quality to be exploited.

Reference: Playford, P.E., Cockbain, A.E. and Low, G.H., 1976, The geology of the Perth Basin, Western Australia: West. Australia Geol. Survey Bull. 124.

Plate: 39

TENURE, ACCESS and POSSIBLE THREATS

This part of the Irwin River lies within Class A Reserve No. 900 vested in the Shire of Mingenew for the 'Protection of Natural Features' and the Reserve is managed as the tourist attraction Coal Seam Park.

Access is by road from Mingenew or Mullewa, and within the Park a network of gravel roads connect features of interest, lookouts and picnic sites.

Over-collecting fossils is an obvious threat.

RECOMMENDATIONS

Class A Reserve No. 900, Coal Seam Park, of some 6.4 km² should be deemed a Geological Monument. The principal features of the geology of the Park are shown on aerial photograph WA 2100 Yalgoo Run 14 No. 5034 (p.172).

Protection : high priority; fossiliferous sections could be spoiled. The public should be educated to look after Coal Seam Park and interested palaeontologists may take a lead here.

Presentation : notice boards explaining the geology should enhance public enjoyment.

The Shire of Mingenew should be consulted.

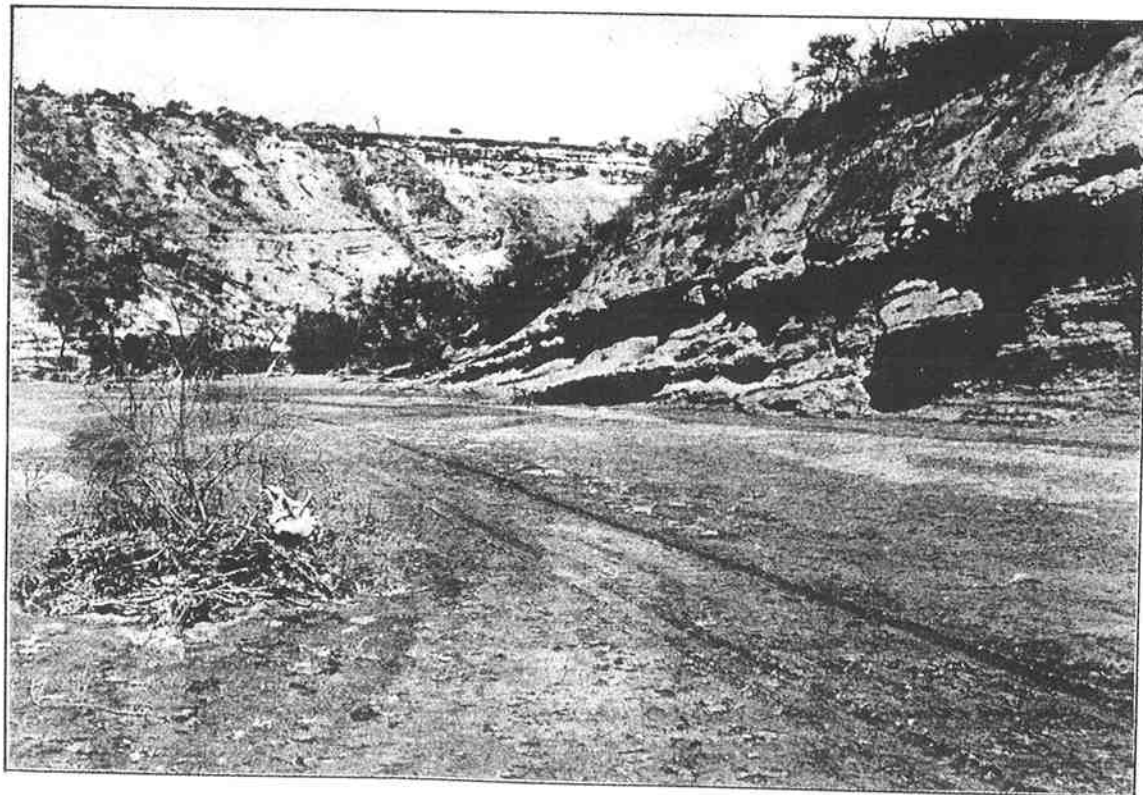


Plate 39

COAL SEAM PARK

J.D. Carter

On the right stands Fossil Cliff and in the background High Cliff

5037

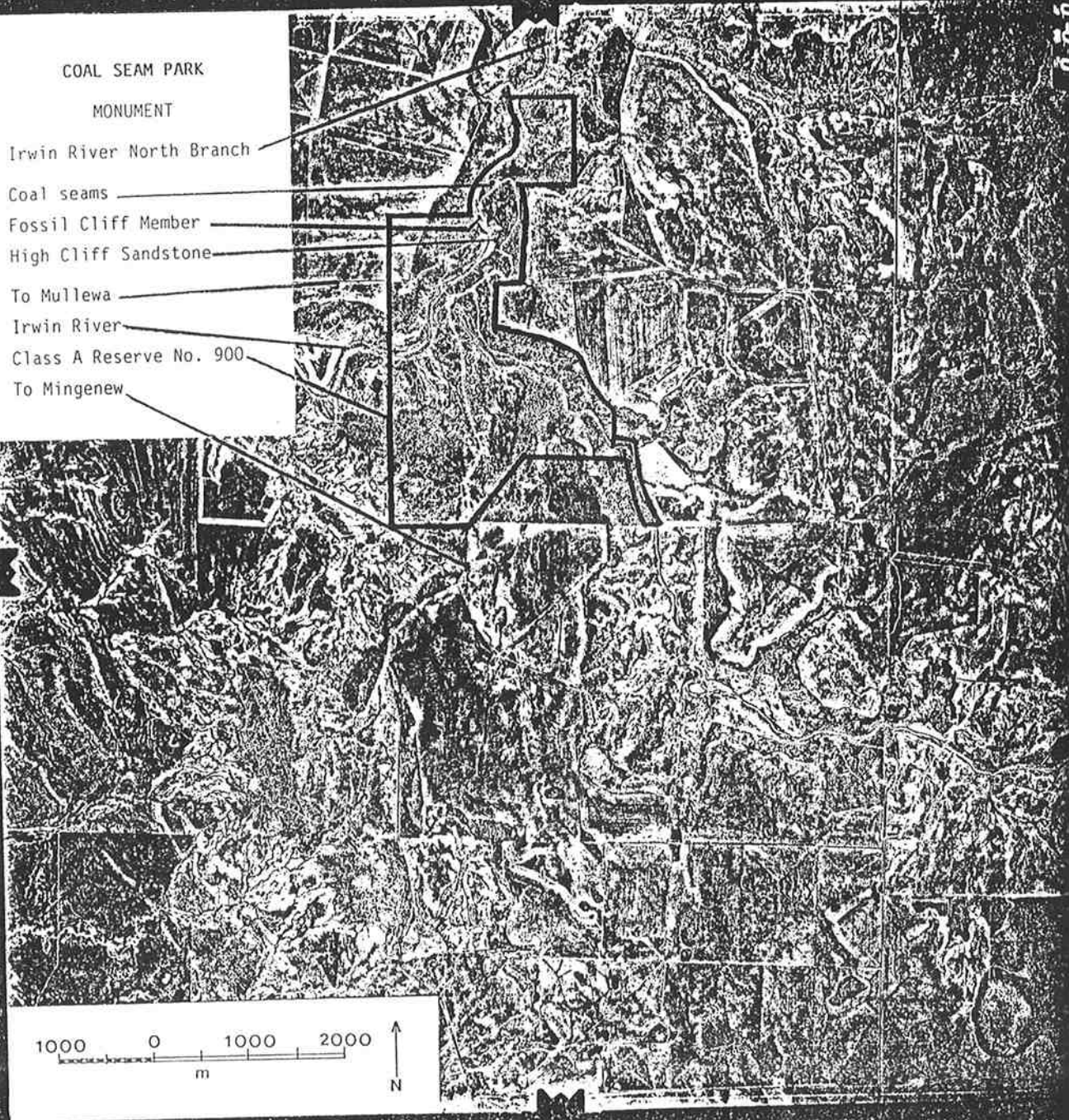
WA 2100 VALG00 1:250 000

RUN 14 (5001-5036)

SCALE 1:50 000 152.5mm 17.1182 JOB NO. 800034

COAL SEAM PARK MONUMENT

- Irwin River North Branch
- Coal seams
- Fossil Cliff Member
- High Cliff Sandstone
- To Mullewa
- Irwin River
- Class A Reserve No. 900
- To Mingenew



54.

BRINGO RAILWAY CUTTING

STATEMENT OF INTEREST

Six formations of the Lower and Middle Jurassic are exposed in the Bringo Railway Cutting 28 km east of Geraldton including two type sections, those of the Bringo Shale and Kojarena Sandstone. This sequence is an attenuated variant of the Perth Basin succession resulting from deposition on an elevated surface of the Northampton Block.

The cutting is used for teaching at the tertiary level.

Location: 1:250,000 Geological Series Geraldton - Houtman Abrolhos
lat 28 44 50 S long 114 51 E

SIGNIFICANCE and VALUE

Class III : Jurassic Stratigraphy
Reference

GEOLOGICAL NOTE

The gently dipping succession consists of:

top			
Yarragadee Formation	m	Bringo Shale	m
Kojarena Sandstone	16	Colalura Sandstone	2.1
Newmarracarra Limestone	10.1	Moonyoonooka Sandstone	c.0.5
	c.10	bottom	(few)
		Proterozoic gneiss	

Continental Moonyoonooka Sandstone of the Chapman Group of Lower Jurassic age is overlain disconformably by Middle Jurassic marine formations of the Champion Bay Group: the Colalura Sandstone passes into thin Bringo Shale and this is followed by Newmarracarra Limestone but in the cutting the limestone is ferruginised; Kojarena Sandstone is disconformably overlain by fluviatile sandstone and siltstone of the reference section of the Yarragadee Formation.

Reference: Playford, P.E., Cockbain, A.E. and Low, G.H., 1976, The geology of the Perth Basin, Western Australia: West. Australia Geol. Survey Bull. 124.

Plate: 40

TENURE, ACCESS and POSSIBLE THREATS

A Railway Reserve extending from the mid-point of the cutting for between 15 and 25 m is vested in The Secretary, Western Australian Government Railways Commission, Box S1 422, GPO, Perth. Parties visiting the cutting should notify the Station Master, Geraldton.

Access is obtained at the northern end of the cutting where the Geraldton-Mullewa highway swings north out of a major eastward curve some 28 km from Geraldton (with parking on an old bitumen road just east of the highway).

In October 1985 exposures in the cutting were in a fairly good condition and natural deterioration apart, there is no threat.

RECOMMENDATIONS

A Geological Monument is recommended for a 900 m length of the Railway Reserve as shown on aerial photograph WA 1708 Geraldton Run 13 No. 5111 (p.175).

Protection : normal care.

Presentation : not suitable; a railway cutting.

The Western Australian Government Railways Commission (Westrail) and the Shire of Greenough should be consulted.

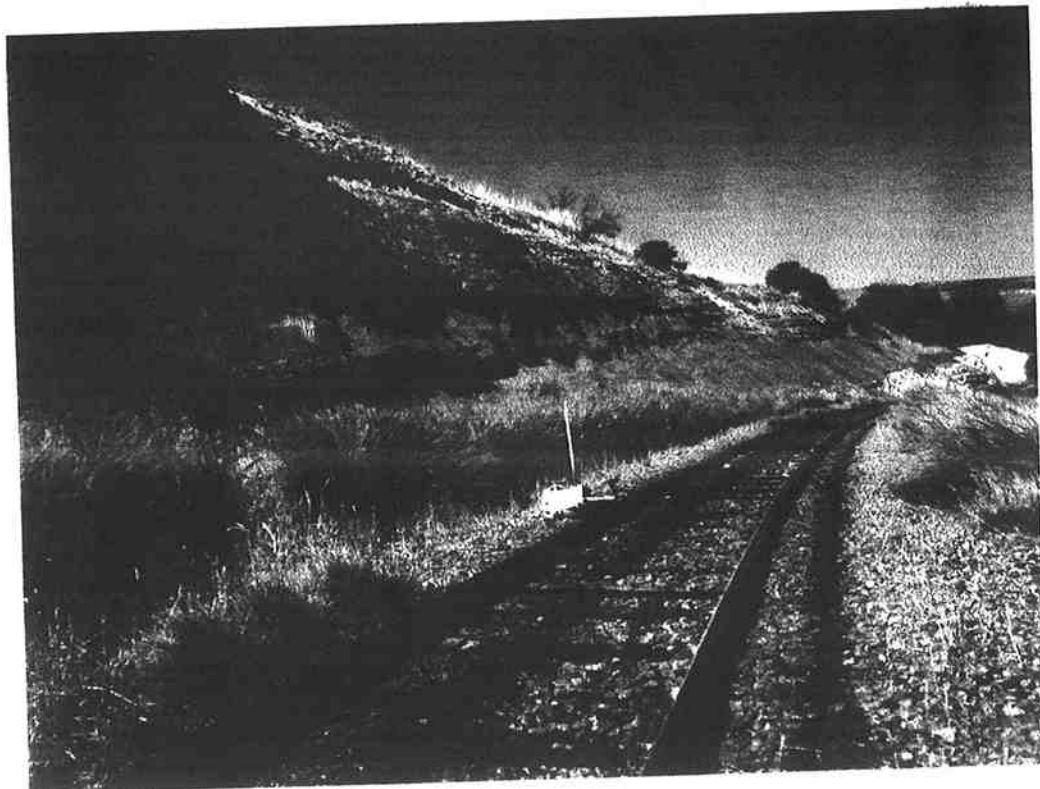
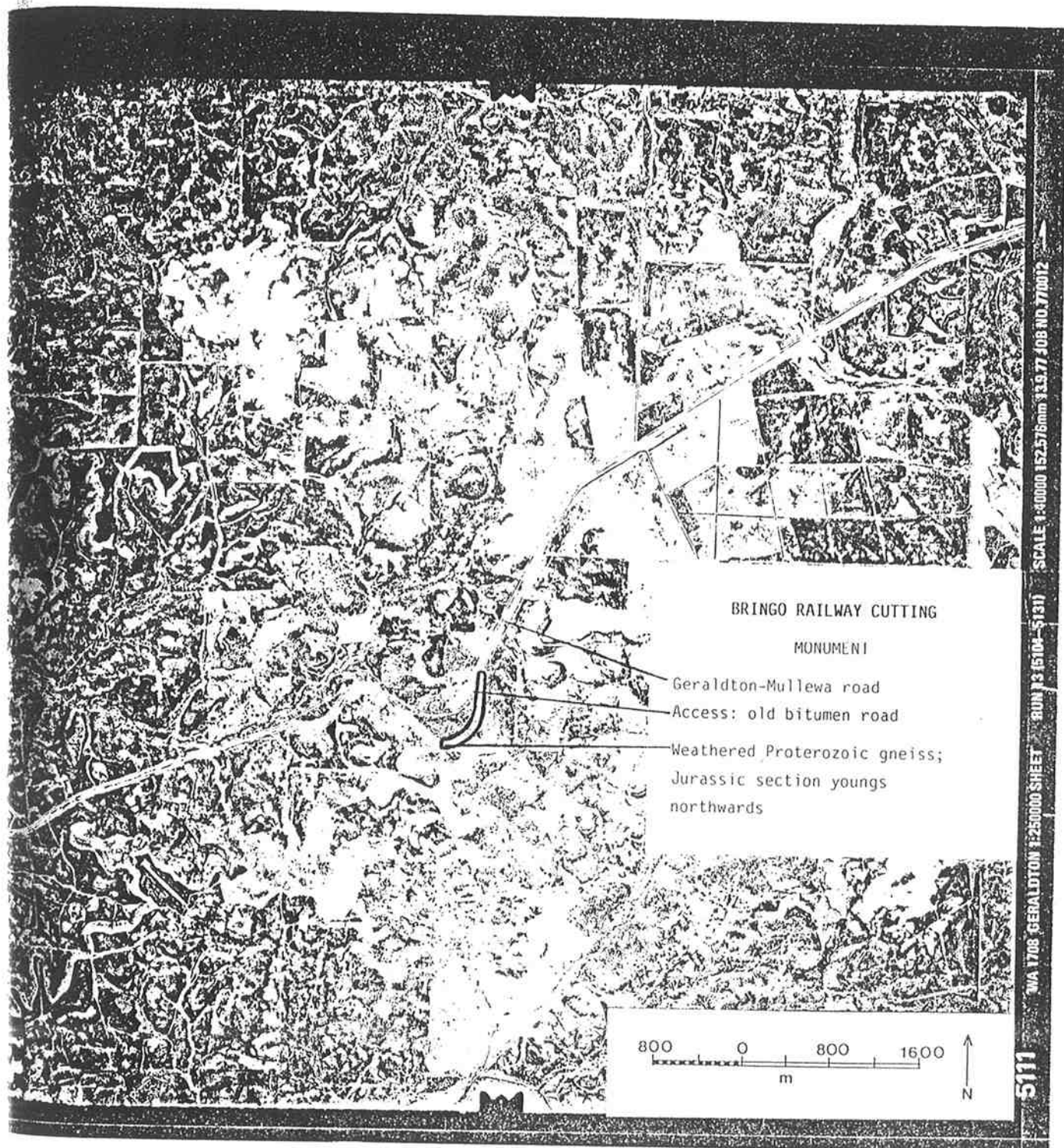


Plate 40

BRINGO RAILWAY CUTTING

J.D. Carter

Thin gently dipping strata of the Jurassic overlies white weathered gneiss of the Northampton Block seen in the background.



STATEMENT OF INTEREST

Attractive hills and escarpments at Moonyoonooka 20 km east of Geraldton reveal Triassic rocks and strata of the Lower and Middle Jurassic including the type sections of the Greenough, Moonyoonooka and Colalura Sandstones, and particularly fine outcrops of the richly fossiliferous Newmarracarra Limestone.

Moonyoonooka is used for teaching at the tertiary level.

Location: 1:250,000 Geological Series Geraldton - Houtman Abrolhos
lat 28 46 45 S long 114 48 E

SIGNIFICANCE and VALUE

Class III : Jurassic Stratigraphy
Research
Attractive Setting

GEOLOGICAL NOTE

At Moonyoonooka the section consists of :

top	m		m
Newmarracarra Limestone	11.5	Greenough Sandstone	19
Colalura Sandstone	c.3	Kockatea Shale	8.5
Moonyoonooka Sandstone	31	bottom	
		Proterozoic gneiss	

The sequence is best exposed between Spion Kop and the escarpment 2 km southwest of this hill: Kockatea Shale of the Triassic overlies Proterozoic gneiss of the Northampton Block and to the west the shales are overlain unconformably by the type sections of the Greenough and Moonyoonooka Sandstones of the Lower Jurassic Chapman Group. The escarpment contains thin Colalura Sandstone and is capped by Newmarracarra Limestone.

Reference: Playford, P.E., Cockbain, A.E. and Low, G.H., 1976, Geology of the Perth Basin, Western Australia : West. Australia Geol. Survey Bull. 124.

TENURE, ACCESS and POSSIBLE THREATS

Ground of interest is part of Victoria Location CG 1815 owned by Mr. J. Grant, Moonyoonooka, via Geraldton, WA 6530. Land is under crop and pasture. Access is by a road which leads southward from the Geraldton-Mullewa road 20.5 km east of Geraldton.

This attractive and interesting geological venue may be visited a number of times annually for teaching purposes and careless use would bring about degradation.

RECOMMENDATIONS

A Geological Monument of some 3.3 km² is recommended as shown on aerial photograph WA 1708 Geraldton Run 14 No. 5096 (p.178).

Protection : high priority; fossils should be collected sparingly and when possible sampling of Newmarracarra Limestone should be confined to the regolith to avoid unsightly scarring of its attractive outcrop.

Presentation : not suitable; off the beaten track.

The landowner and the Shire of Greenough should be consulted.

5096

WA 1708 GERALDTON 1:250000 SHEET

RUN 14 (5075-5103)

SCALE 1:40000 152.576mm 139.77 JOB NO. 770012

MOONYOONOOKA

MONUMENT

Geraldton-Mullewa

road turn-off

Homestead

Spion Kop

Section youngs to
southwest from

gneiss in stream bed



SHARK BAY AND OTHER LOCALITIES

The modern sedimentary environment of **Shark Bay** excluded from the study (p.5), is of universal geological importance for living algal stromatolites and unusual sediments, and should be mentioned. Its broad marine indentations shown on Figure 1, lie 300 km north of Geraldton where shallow loops, pools, bays and bights, the home of dugong and friendly dolphins, extend over 8000 km². Shark Bay's geology is described in the Shark Bay-Edel and Yaringa 1:250,000 Geological Series.

In a remarkable environment created by recent marine flooding of Pleistocene landscapes of red and yellow sand dunes during interglacial high sea levels, tidal flow is reduced by sea grass covered banks and highly saline waters are now trapped in Hamelin Pool and Lharidon Bight with dramatic biological and geological consequences for normal marine competition is restricted by the saline conditions allowing examples of the earliest forms of life, stromatolites, to flourish in the absence of algal predators. Restricted competition triggers also a population explosion of the small bivalve **Fragum** whose remains are marked by long white shell beaches.

Unvested Class A Reserve No. 30885 'Preservation of Sedimentary Deposits' covers the intertidal zone of Hamelin Pool. Stromatolites there would attract Class I Monument status and the better **Fragum** deposits, Class II Monuments. Stromatolites are too fragile for casual presentation. **Fragum** deposits have immediate and excellent appeal but those at Shell Beach in Lharidon Bight need protection from vehicles. Supervised parties should have the rare experience of seeing a rock quarry in this contemporary shell sediment.

These 'other localities' were rejected.

Bringo District and Ellendale Pool (Geraldton 1:250,000 Geological Series); Bringo district suggested for the Jurassic Newmarracarra Limestone is no better exposed than nearby Moonyoonooka where a Monument is proposed. At Ellendale Pool Jurassic sediments of the Chapman and Champion Bay Groups in a precipitous cliff are difficult to examine; both Groups are seen in sections at Bringo Railway Cutting (54) and Moonyoonooka (55).

Beckett Gully and Beaconsfield Conglomerate (Perenjori 1:250,000 Geological Series); exposures of the type sections of Permian Holmwood Shale in Beckett Gully and Proterozoic Beaconsfield Conglomerate near Yandanooka are too poor for listing.

Nangetty/Tillite Creek (Geraldton and Dongara 1:250,000 Geological Series); the glaciogene Nangetty Formation of the Permian was proposed but no acceptable exposures were found at locations suggested.

EASTERN GOLDFIELDS KALGOORLIE

This is typical Archaean granitoid-greenstone country and despite a complex geology, a broad stratigraphy is recognised with mafic and ultramafic, volcanic and intrusive rocks low in the sequence followed by felsic volcanic rocks and clastic sedimentary rocks. The layered sequence has an age of some 2700 m.y. and was intruded by granitoids and then at about 2400 m.y., by very large mafic dykes including the Binneringie Dyke, one of the largest true dyke occurrences in the world.

Originally a dozen localities were proposed, all lying within the Wiluna-Norseman Belt from near Menzies to beyond Norseman. However certain proposals considered the same feature and others recommended rather far-flung teaching sites without outstanding geological merit and rather than follow up this pot-pourri (recorded under Other Localities), a decision was made to investigate features within easy reach of Kalgoorlie frequently visited by geological excursions to the Eastern Goldfields (Figure 15). Field inspections were marred by rain but this result was achieved:

Mount Hunt - Lake Douglas Dam Layered Sequence Traverse

56. Mount Hunt	Monument
57. Tramlines Gabbros	Site
58. Gibson-Honman Rock	Monument
59. Lake Douglas Dam	Site

Kanowna Felsic Volcanic Complex

60. Kanowna Lake	Monument
61. Alunite Amphitheatre	Monument
62. Robinson Mine	outline site
63. Four Mile Hill	Monument
64. Kanowna Town Dam	Monument
65. Perkolili Conglomerate	outline site

Kambalda - Norseman Area

66. Merougil Creek	Site
67. Binaronca Rock	Monument
68. Lake Cowan Causeways	Monument

Complex groupings of mining tenements cover most of these recommendations; the tenements have not been completely investigated but relevant Mines Department plans are specified.

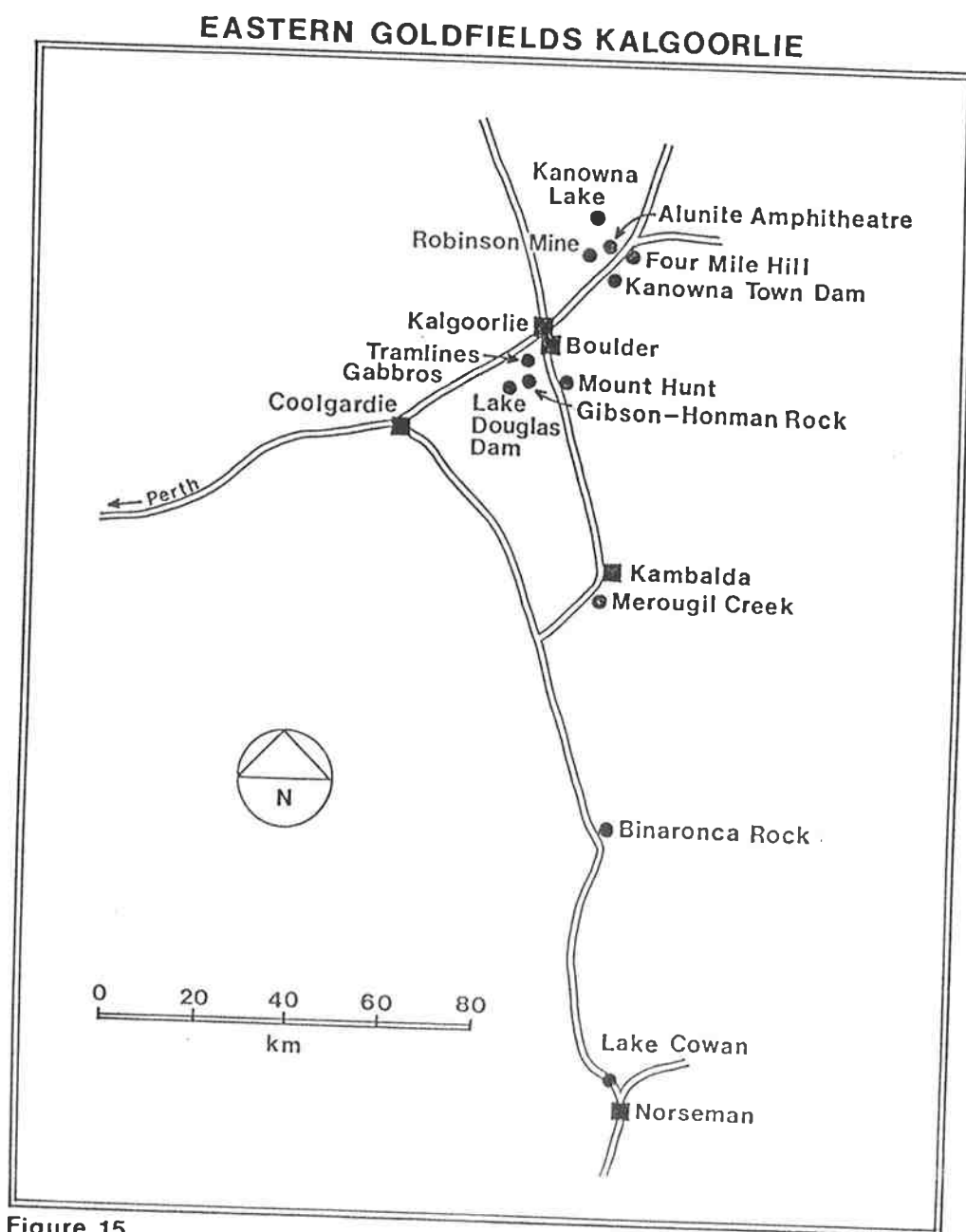


Figure 15

56. - 59. MOUNT HUNT - LAKE DOUGLAS DAM

LAYERED SEQUENCE TRAVERSE

STATEMENT OF INTEREST

A well-known traverse of an Archaean layered succession of the Eastern Goldfields incorporating clear exposures of the Golden Mile sequence lies between Mount Hunt on the southern outskirts of Boulder and Lake Douglas Dam some 12 km to the west. Here examples of the principal lithologies of the layered rocks are exposed with a relatively high proportion of fresh outcrop.

The four-stage traverse commences at Hannan Lake just east of **Mount Hunt** where the oldest members of the succession, mafic and ultramafic rocks, are examined before crossing the many lithologies exposed around the low hill. Five kilometres to the northwest, differentiated intrusives are seen at **Tramlines Gabbros** and a few kilometres further west, a dacitic complex is magnificently displayed at **Gibson-Honman Rock**. The traverse terminates near **Lake Douglas Dam** where the youngest representative of the sequence, polymictic conglomerate, appears in hills of low relief.

Geological excursions follow this traverse which is recorded on aerial photographs held in the Records of the Survey.

Reference: Mount Hunt-Lake Douglas Dam Layered Sequence Traverse
Griffin, T.J., Hunter, W.M., Keats, W. and Quick,
D.R., 1983, in Eastern Goldfields geological field conference
abstracts and excursion guide: Geological Society of Australia
Inc., W.A. Division and the Eastern Goldfields Geological
Discussion Group.

(56.)

MOUNT HUNT

Location: 1:250,000 Geological Series Kalgoorlie and Kurnalpi
lat 30 51 S long 121 30 E

SIGNIFICANCE and VALUE

Class 1 : Archaean Stratigraphy
Research
Attractive Setting



Plate 41

MOUNT HUNT KAPAI SLATE
This is a chert marker horizon

J.D. Carter

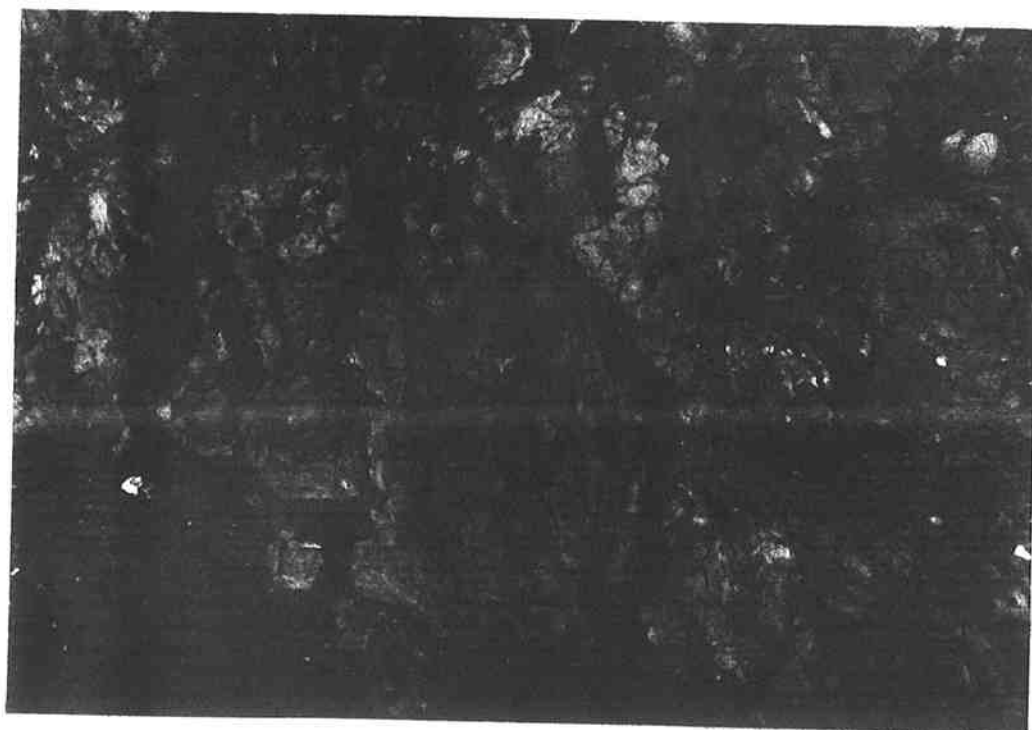


Plate 42 MOUNT HUNT PILLOWS IN DEVON CONSOLS BASALT J.D. Carter

GEOLOGICAL NOTE

Near Mount Hunt the well-established sequence consists of:

top	
Black Flag Beds	tuffaceous metasediments with conglomerate;
Paringa Basalt	tholeiitic and high Mg-basalt with pillows;
Williamstown Dolerite	layered mafic and ultramafic sills;
Kapai Slate	thin cherty slate;
Devon Consols Basalt)	the two lowest units include mafic and ultramafic extrusives such as peridotitic komatiite showing spinifex texture and high Mg-basalt with pillows.
Hannan Lake Serpentine)	
bottom	

From fine exposures of komatiite flows at Serpentine Bay on the west of Hannan Lake, one moves to the eastern slopes of Mount Hunt where overlying pillow lavas are seen in a creek immediately below prominent outcrops of Kapai Slate and the slate, repeated by tight folding, encloses rubbly outcrops of Williamstown Dolerite. The summit and west flank of Mount Hunt are underlain by Paringa Basalt and immediately west of the Kambalda road, Black Flag Beds form low outcrops and platform exposures.

Plates: 41, 42

TENURE, ACCESS and POSSIBLE THREATS

The western shore of Hannan Lake lies within Woolibar Pastoral Lease 3114/981 of Mr. B. Crook, P.O. Box 371, Kalgoorlie, WA 6430 and the lease adjoins unvested Class C Reserve No. 8767, 'Common', which includes Mount Hunt. The western part of the Monument now recommended lies within unvested Class C Reserve No. 8168 'Parklands' and many mining tenements are involved (Mines Department plans, Golden Ridge NW and Boulder NE).

Access is obtained from the Kambalda road 12 km south of the Hannan and Maritana Streets intersection; a track leads eastward to Serpentine Bay on the shores of Hannan Lake.

No threats are foreseen apart from hammering, especially of basalt pillows.

RECOMMENDATIONS

A Geological Monument (7 km²) is recommended as shown on aerial photograph WA 1838 Kalgoorlie Run 12 No. 5558 (p.189).

Protection : a high priority especially for structures such as the well-preserved but rare pillows on the east flank of Mount Hunt.

Proposal : an illustrated guide to the geology with a map at 1:5,000 would assist geologists.

Presentation : not suitable; this geology is not readily appreciated.

The owners of Woolibar Pastoral Lease and mining tenements, and the nearby Shire of Boulder should be consulted.

(57.) TRAMLINES GABBROS

Location: 1:250,000 Geological Series Kalgoorlie
lat 30 48 S long 121 27 E

SIGNIFICANCE and VALUE

Class IV : Mafic Intrusions
Education

GEOLOGICAL NOTE

A short distance west of a Readymix Quarry (fresh felsic and intermediate volcanics of Black Flag Beds) low parallel ranges containing differentiated gabbros can be followed (like 'tramlines') to the south. Basal rocks are pyroxenite and these pass westwards into quartz-gabbro and gabbro with fine layering.

TENURE, ACCESS and POSSIBLE THREATS

This ground lies within unvested Class C Reserve No. 8767 'Common'; mining tenements are shown on Mines Department plan Boulder NE.

Access is by the westward 'SEC Pylon' track from the Kambalda road 6.6 km south of Hannan and Maritana Streets intersection (or 5.4 km north of the Mount Hunt access track). The pylon track is followed for 2.4 km where the Readymix Quarry lies 0.5 km south with rubbly gabbro outcrop just west of the workings. Better exposures of Tramlines Gabbros are reached by proceeding 0.7 km along the pylon track past the Readymix turn-off to turn left and after 400 m bear left for 200 m (4WD).

No threats are foreseen.

RECOMMENDATIONS

A Geological Site of some 40 ha is recommended as shown on aerial photograph WA 1838 Kalgoorlie Run 12 No. 5558 (p.189).

Protection : normal care.

Presentation : not suitable; poor visual appeal.

Owners of mining tenements and the nearby Shire of Boulder should be consulted.

(58.) GIBSON-HONMAN ROCK

Location: 1:250,000 Geological Series Kalgoorlie
lat 30 51 S long 121 26 E

SIGNIFICANCE and VALUE

Class III : Dacite Volcanism
Reference

GEOLOGICAL NOTE

A low rounded hill rising from salt lakes reveals unusually fine examples of structures associated with dacite flows, breccias and waterlain crystal tuffs, including bottom scouring, graded bedding and cross-bedding.

Plate: 43

TENURE, ACCESS and POSSIBLE THREATS

Gibson-Honman Rock lies within unvested Class C Reserve No. 8767, 'Common', and is held under mining tenement M 26/22 (Mines Department plan Boulder NE).

For access along the 'SEC Pylon' track leaving the Kambalda road westward 6.6 km south of Hannan and Maritana Streets intersection, follow the pylon track for 4.1 km and turn left at a cross-road for a further 4.3 km (4WD).

There is no obvious threat.

RECOMMENDATIONS

A Geological Monument of 37 ha is recommended as shown on aerial photograph WA 1838 Kalgoorlie Run 12 No. 5556 (p.188).

Protection : normal care.

Presentation : not suitable; difficult access.

Mining tenement owners and the nearby Shire of Boulder should be consulted.



Plate 43

GIBSON-HONMAN ROCK

This low hill reveals well-preserved
volcanic and sedimentary structures

J.D. Carter

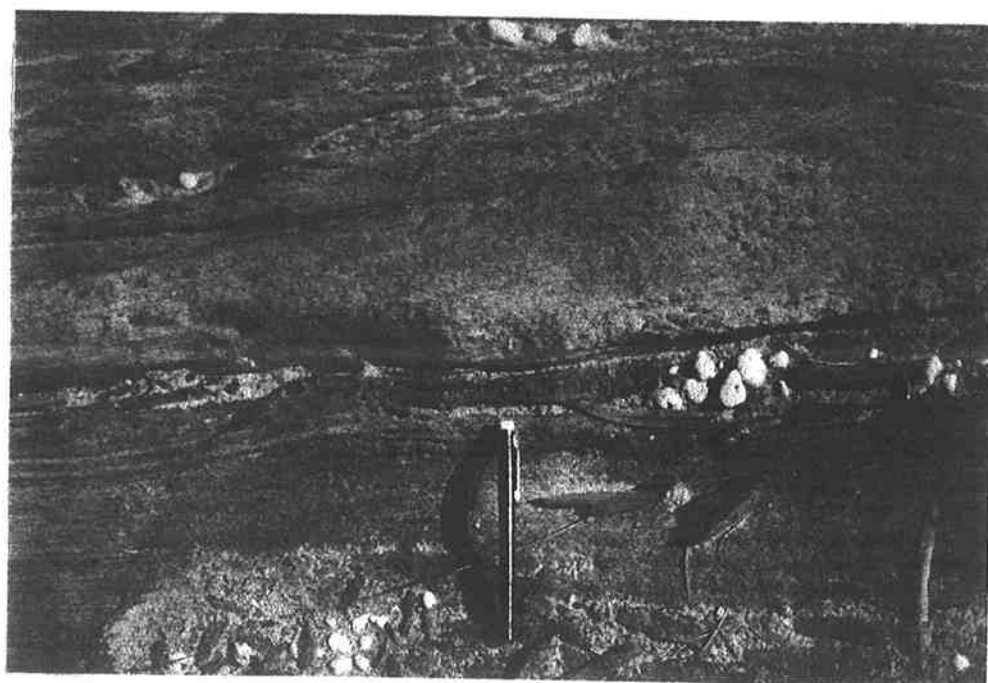
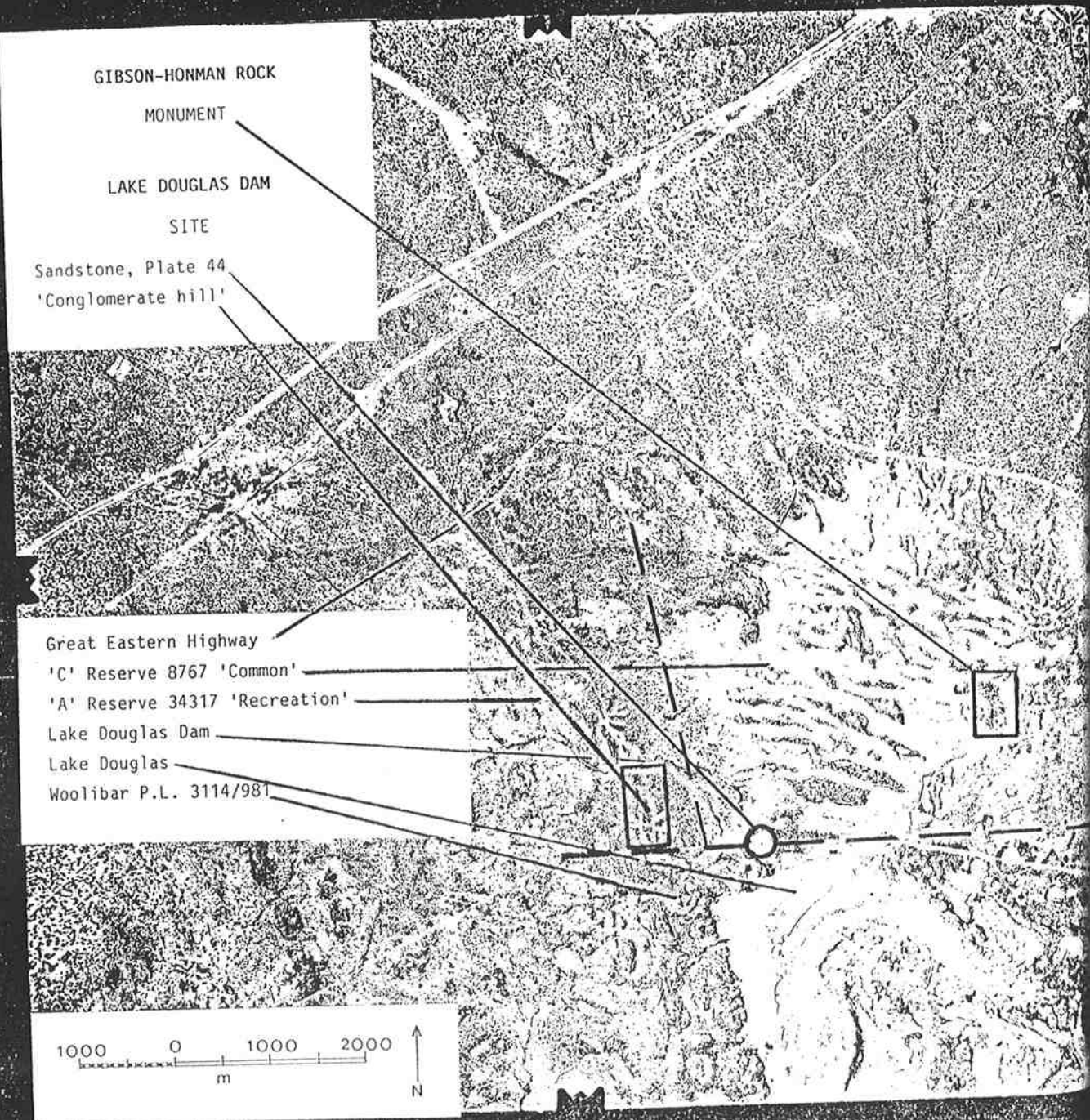


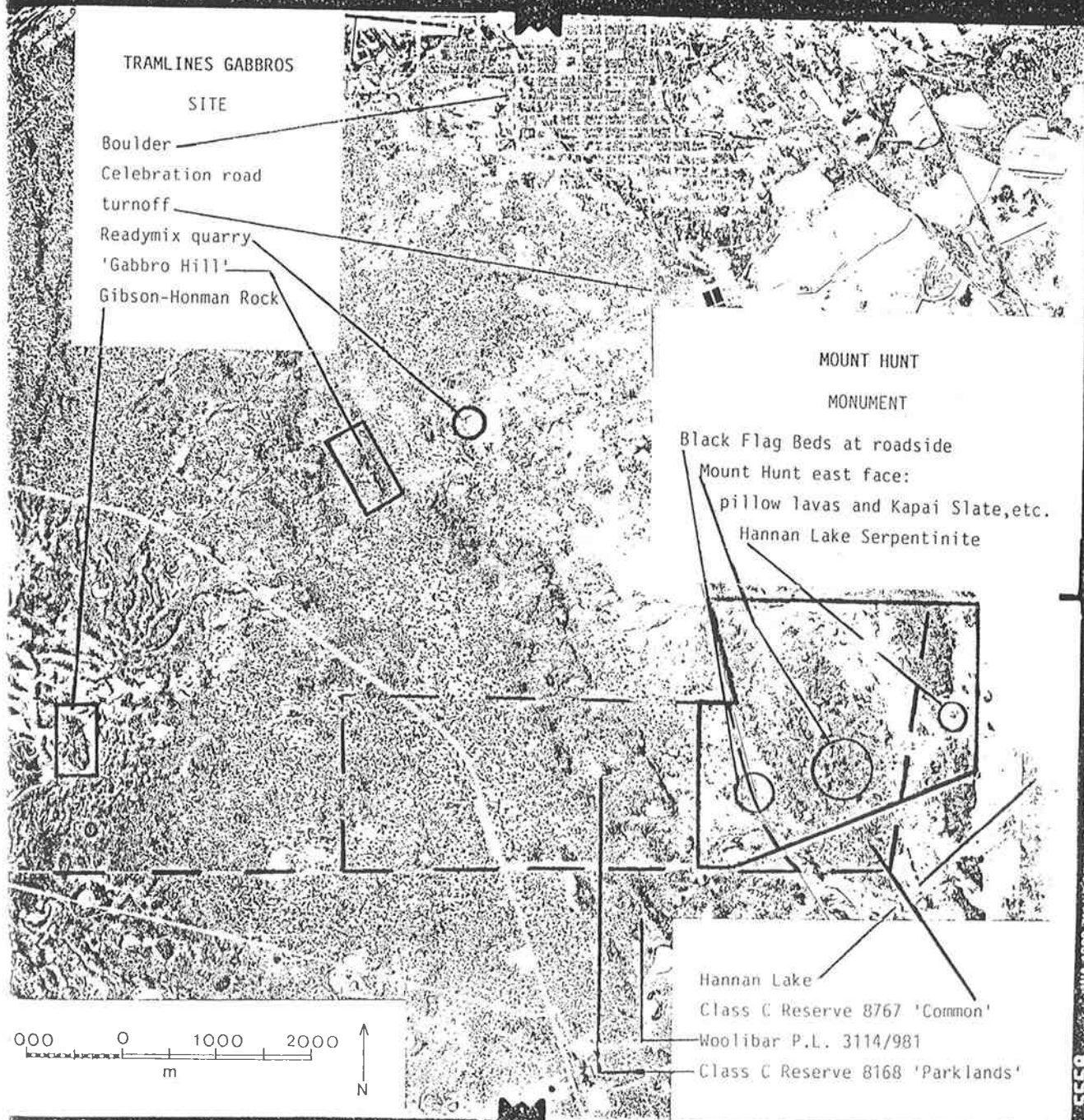
Plate 44

ARCHAEAN SANDSTONE, LAKE DOUGLAS DAM

Current bedded sandstone in the Kurrawang syncline

J.D. Carter





5558 VIA 1838 KALGOORLIE 1:250 000 RUN 12 (5526-5560) SCALE 1:50000 152.6mm 21.10.79 JDB NO. 790017

(59.)

LAKE DOUGLAS DAM

Location: 1:250,000 Geological Series Kalgoorlie
lat 30 51 S long 121 23 E

SIGNIFICANCE and VALUE

Class IV : Polymictic Conglomerate
Reference

GEOLOGICAL NOTE

The highest stratigraphic unit consists of conglomerate with sandstone and occurs in the Kurrawang syncline in the Lake Douglas area where characteristic lithologies are seen in a lakeshore sandstone exposure and low hills with outcrops of 'Kurrawang conglomerate'. The well-bedded sandstone preserves sedimentary structures (p.187) and the conglomerate hosts a wide range of clasts including chert, basalt, dacite and granite.

Plate: 44

TENURE, ACCESS and POSSIBLE THREATS

Ground with conglomerate hills lies within Class A Reserve No. 34317 'Recreation' vested in the Shire of Boulder and falls largely within mining tenement P 15/1273 (Mines Department plan Boulder NE).

From Gibson-Honman Rock follow the track southwest for 1.8 km to a haul road and turn right for 1.2 km where sandstone outcrops on the shore of Lake Douglas. Continue for 0.8 km and turn right over a grid and follow a track to a picnic area near Lake Douglas Dam (1.1 km) where a telegraph line leads to a hill summit with good exposures of conglomerate (0.4 km; 4WD). This locality is reached also from Kalgoorlie by taking the Coolgardie road and turning left in a road cutting 8.3 km beyond the airport turnoff to follow the Lake Douglas road southward for 3.1 km to the dam.

There are no obvious threats.

RECOMMENDATIONS

A Geological Site of 45 ha is recommended for the conglomerate hills as shown on aerial photograph WA 1838 Kalgoorlie Run 12 No. 5556 (p.188) on which the lake shore sandstone outcrop is also located.

Protection : normal care.

Presentation : not suitable; low visual appeal.

Holders of mining tenements and the Shire of Boulder should be consulted.

60. - 65. KANOWNA FELSIC VOLCANIC COMPLEX

STATEMENT OF INTEREST

Singular geological phenomena are offered by the felsic volcanic complex of the Archaean around the ghost town of Kanowna some 20 km northeast of Kalgoorlie:

to the north, **Kanowna Lake** has fine exposures of pillowed basalt and ultramafic rocks of probably the lowest unit;

at **Alunite Amphitheatre** where conglomerates and boulder beds with stromatolites, the sole life-forms known from the Yilgarn Block, are carried in olistostromes, strikingly coloured rocks reveal a profusion of structural complexities;

near the old **Robinson Mine** a short distance southwest of the Amphitheatre, carbonate rocks with spinifex texture deny a seafloor origin proposed for similar lithologies in the same setting elsewhere;

northeast, near Lake Gwynne, **Four Mile Hill** shows off a dacitic complex in excellent exposure,

and to the south at **Kanowna Town Dam**, volcaniclastic rocks display exquisite sedimentary and volcanic structures formed 2700 m.y. ago.

A wealth of information gained during recent studies of the close-spaced Kanowna features allows these to be proposed as a multipartite field laboratory suitable for students at every level. They are regularly used by geological excursions.

General Reference: Kanowna Felsic Volcanic Complex
Taylor, T., 1984, The palaeoenvironment and tectonic setting of Archaean volcanogenic rocks in the Kanowna district near Kalgoorlie, Western Australia : Univ. West. Australia Science M.Sc. thesis (unpublished).

(60.)

KANOWNA LAKE

Location: 1:250,000 Geological Series Kurnalpi
lat 30 31 S long 121 35 E

SIGNIFICANCE and VALUE

Class III : Mafic Volcanism
Reference
Attractive Setting

GEOLOGICAL NOTE

The lowest stratigraphical unit of the volcanic complex at Kanowna consists of mafic and ultramafic rocks erupted in deep water with very little clastic sedimentation. At the lake, amygdaloidal basalt flows contain pillows.

Reference: Williams, I.R., 1970, Kurnalpi, W.A.: West. Australia Geol. Survey 1:250,000 Geol. Series Explan. Notes.

TENURE, ACCESS and POSSIBLE THREATS

Kanowna Lake lies within Kanowna Pastoral Lease 3114/1000 of Mount Vettors Station, Bardoc via Kalgoorlie, WA 6430 and mining tenement E 27/32 (Mines Department plan Kanowna NW).

At Kanowna find the Gordon track (300 m south of the Townsite monument) and drive north for 10.5 km passing through two gates to arrive at a lake shore with a basalt islet and ultramafic rocks standing in a bluff.

No threats are foreseen providing pillow lavas are spared hammers.

RECOMMENDATIONS

A Geological Monument of 70 ha is recommended as shown on aerial photograph WA 1849 Kurnalpi Run 8 No. 5652 (p.201).

Protection : normal care.

Presentation : not suitable; remote.

The owners of the Pastoral Lease and mining tenement, and the Shire of Boulder should be consulted.

(61.)

ALUNITE AMPHITHEATRE

Location: 1:250,000 Geological Series Kurnalpi
lat 30 34 S long 121 37 E

SIGNIFICANCE and VALUE

Classes I and V : Archaean Stromatolites and Structures
Research
Attractive Setting

GEOLOGICAL NOTE

No finer geology was seen in the Eastern Goldfields than this multicoloured amphitheatre formed by breakaways enclosing more than a square kilometre of strikingly coloured, deeply weathered sedimentary and volcanic rocks where alunite is found. In the floor of the amphitheatre (Figure 16), two olistostromes are seen. The lower more than 100 m thick carries pale yellow dacitic conglomerate with green komatiite fragments, basalt pillows and chert blocks with stromatolites, the only life-forms known so far in the Yilgarn Block, and the upper incorporates great exotic blocks of siltstone. To the southwest, the olistostromes are overlain by magnificent dacite boulder beds and in breakaway faces, by komatiite flows.

The high energy sedimentary phenomena represented here by conglomerate, boulder beds and olistostromes contrast with lower energy sedimentary structures found at Town Dam to the south. Deeply weathered komatiite clasts are recognised by brilliant green colours although basalt pillows either a rich chocolate or leached white belie colour as a criterion for rock identification.

Reference: Grey, K., 1981, Small conical stromatolites from the Archaean near Kanowna, Western Australia: West. Australia Geol. Survey Ann. Rept. 1980, p.90-94.

Plates: 45, 46, 47, 48; Figure: 16

TENURE, ACCESS and POSSIBLE THREATS

The amphitheatre falls within Class C Reserve No. 4459, 'Common', vested in the Shire of Boulder where a special lease for grazing (332/2068) is sought, and is covered principally by mining tenement E 27/3 Sec. 1 of Seltrust Mining Corp. Pty. Ltd. (Mines Department plan Kanowna NW).

The Gordon road (which leaves the Kalgoorlie road northward 300 m south of the Townsite monument) is taken for 2.1 km before turning right to negotiate mine dumps and to follow a track northeast for about 3 km and then to swing right to breakaways overlooking the southwest face of the amphitheatre (4WD).

There are threats here. The unique stromatolite blocks are rare and are sought by collectors. These should be preserved in situ. The highly coloured soft rocks may attract vandals.

RECOMMENDATIONS

Here a Geological Monument of 1.7 km² is proposed as shown on aerial photograph WA 1849 Kurnalpi Run 8 No. 5652 (p.201).

Protection : high priority; development should be steered away from the locality.

ALUNITE AMPHITHEATRE

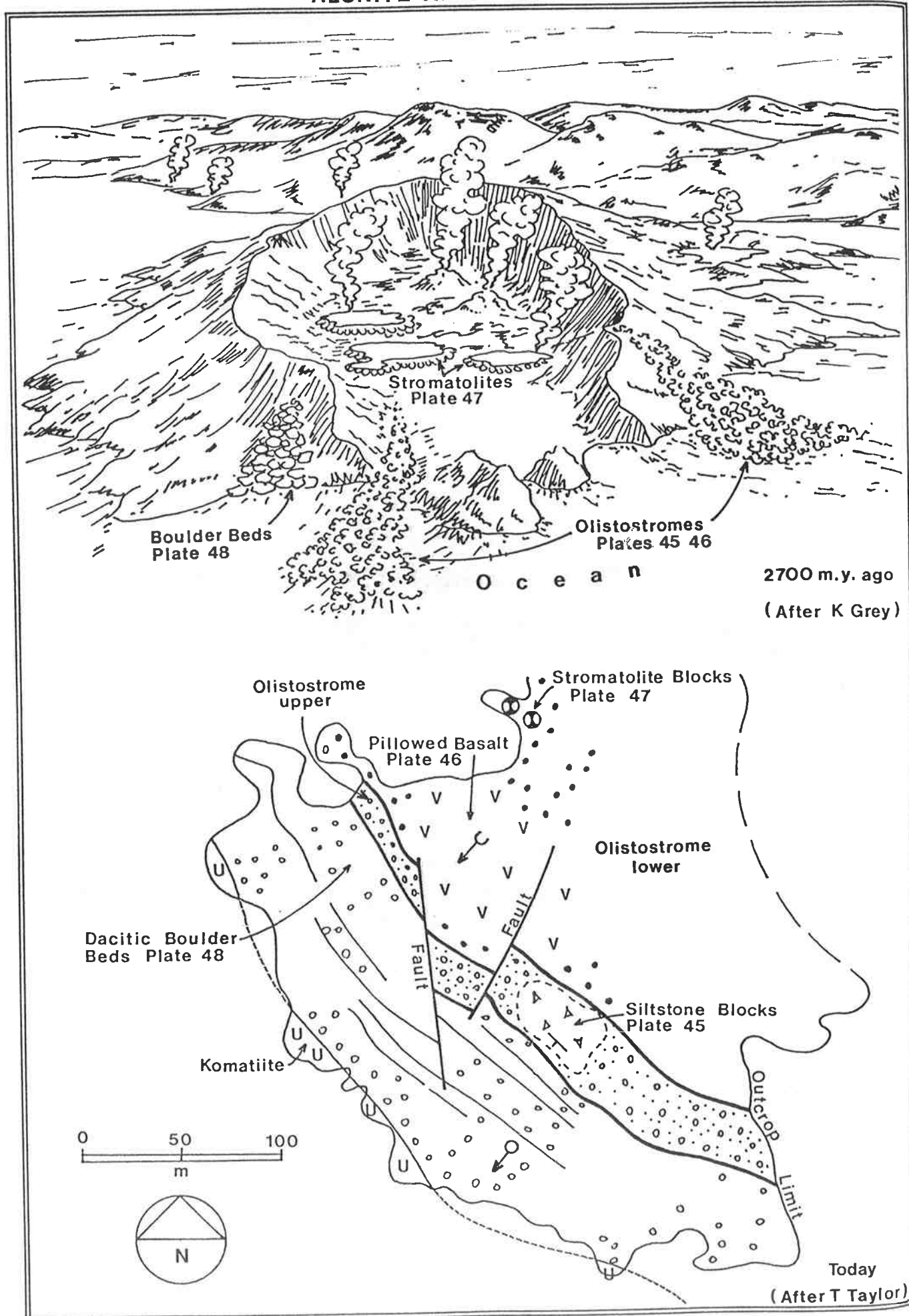


Figure 16

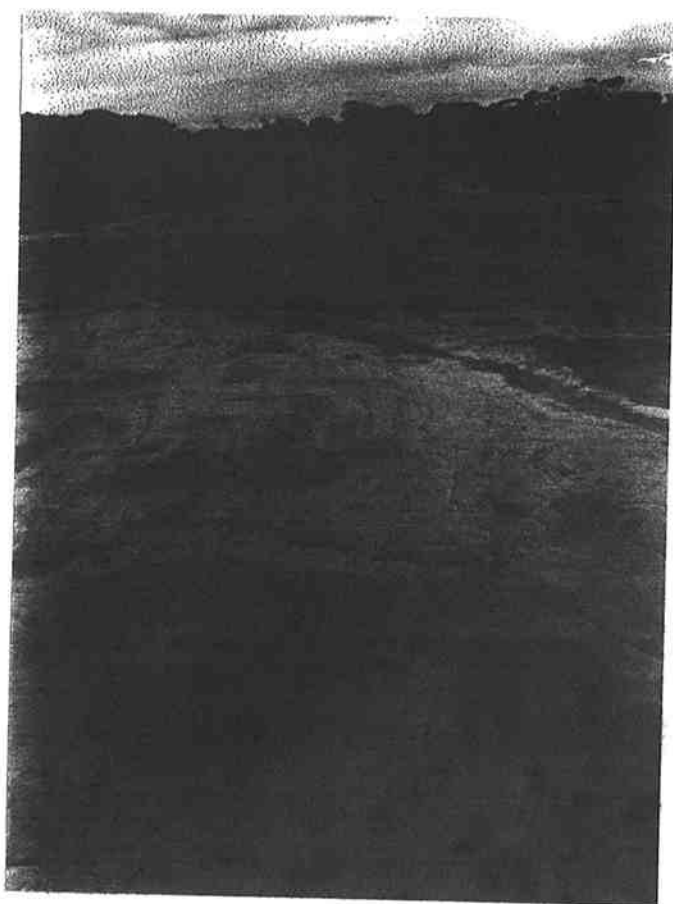


Plate 45 SILTSTONE BLOCKS IN UPPER OLISTOSTROME J.D. Carter

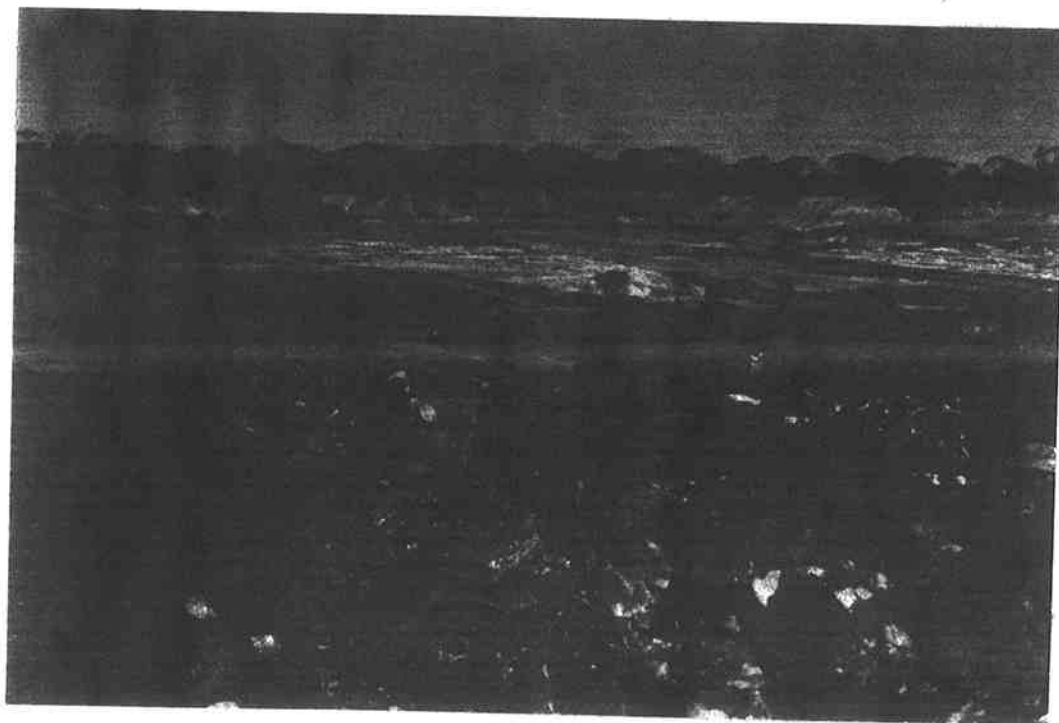


Plate 46 PILLOWED BASALT IN LOWER OLISTOSTROME J.D. Carter
 Siltstone blocks of the upper olistostrome
 (Plate 45) lie in the white middle background area

Proposal : an illustrated guide to this complex geology with a map (1:2000 or larger) based on plans of T. Taylor (1984) held in the Records of the Survey would be an invaluable aid for geologists.

Presentation : great visual appeal and thus suitable though access is not straightforward and effective surveillance is a pre-requisite.

The owner of the mining tenement and the Shire of Boulder should be consulted.

(62.)

ROBINSON MINE

GEOLOGICAL NOTE

An unusual quartz-fuchsite-carbonate rock in waste of the old Robinson Mine alongside the Alunite Amphitheatre track consists largely of ankerite and mesitite and displays spinifex texture indicating an ultramafic extrusive origin.

Elsewhere in the world carbonate rocks of similar composition in the same geological setting are considered to have formed from volcanic exhalations but the Robinson mine carbonate is clearly an altered ultramafic lava (W.K. Witt pers. comm.).

Reference: Blatchford, T. and Jutson, J.T., 1912, The mining geology of the Kanowna Main Reef Line: West. Australia Geol. Survey Bull. 47.

ACCESS and COMMENT

This mine lies 100 m north of the track to the Alunite Amphitheatre 0.65 km beyond the Gordon road turn-off.

The interest here was noted at a late stage in the survey. Tenures in this active mining area need to be considered and no specific recommendation is made though a Class IV Geological Site of about 100 m square would be appropriate for the mine waste and its carbonate rocks.

(63.)

FOUR MILE HILL

Location: 1:250,000 Geological Series Kurnalpi
lat 30 35 S long 121 39 E

SIGNIFICANCE and VALUE

Class III : Felsic Volcanism
Reference
Attractive Setting

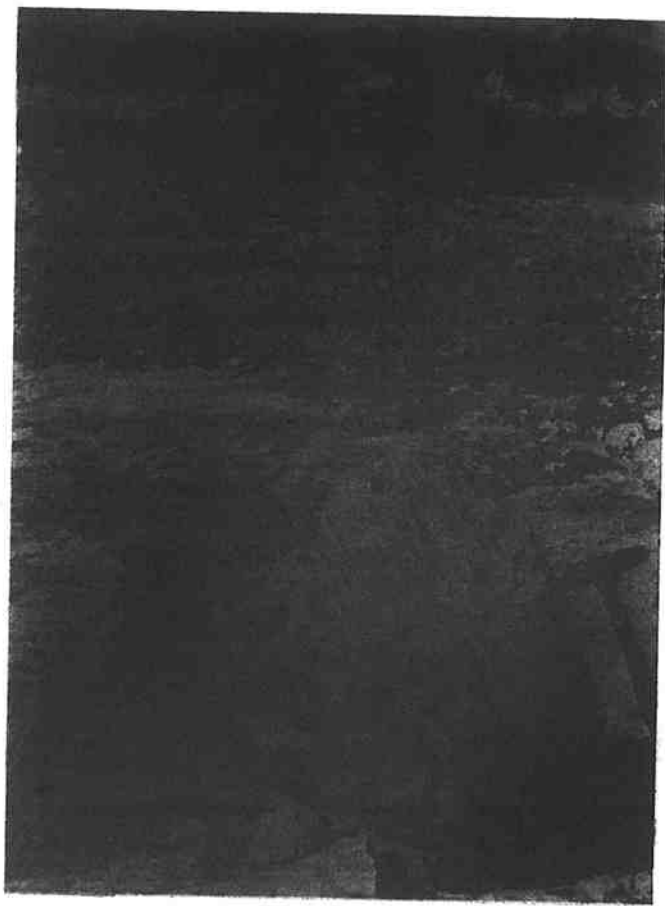


Plate 47

AMPHITHEATRE STROMATOLITES

J.D. Carter



Plate 48

AMPHITHEATRE DACITIC BOULDER BED

J.D. Carter

GEOLOGICAL NOTE

Four Mile Hill dacitic complex is composed dominantly of subvolcanic intrusions and dacitic epiclastic sediments, and rock types include intrusive quartz-phyric dacite accompanied by dacitic fragmental rocks, and dacitic wacke and siltstone, and Taylor (1984) identified tourmaline rich sediments.

Reference: Williams, I.R., 1970, Kurnalpi, W.A.: West. Australia Geol. Survey 1:250,000 Geol. Series Explan. Notes.

TENURE, ACCESS and POSSIBLE THREATS

Four Mile Hill is shown as Mount Gwynne on topographical sheets with a Four Mile Hill a little distance to the west. As positioned on the Geological Series sheet, Four Mile Hill lies within Pastoral Lease 3114/951 Black Flag, Matigny Pty. Ltd., Black Flag Station, P.O. Box 740, Kalgoorlie, WA 6430. Vacant Crown Land lies to the west and mining tenements cover the ground (Mines Department plan Kanowna NE).

Access is obtained by a track running along the eastern flank of the hill which leaves the Kalgoorlie-Kurnalpi road to the southeast 6.4 km northeast of the Townsite monument.

There are no obvious threats.

RECOMMENDATIONS

A Geological Monument of 1.3 km² is recommended as shown on aerial photograph WA 1849 Kurnalpi Run 9 No. 5716 (p.202).

Protection : normal care.

Presentation : not suitable; the geology is not readily understood.

The owners of the Pastoral Lease, mining tenements and the nearby Shire of Boulder should be consulted.

(64.)

KANOWNA TOWN DAM

Location: 1:250,000 Geological Series Kurnalpi
lat 30 38 S long 121 36 E

SIGNIFICANCE and VALUE

Class III : Sedimentary and Volcanic Structures
Education

GEOLOGICAL NOTE

Immediately south of Town Dam, low outcrops of deeply weathered, white dacitic conglomerate, wacke and siltstone with exceptionally well-preserved sedimentary structures are exposed at the foot of a small breakaway. Deposition, erosion and post-deposition structures are seen and include graded bedding, cross-bedding, scours and fills, convolute bedding and flame structures.

Some 300 m east of the dam, Taylor (1984) describes deeply weathered but clear exposures of zoned komatiite flows overlain by massive basalt showing spinifex textures, varioles and pillows.

At both localities reconstructions of the palaeoenvironment are made and both offer excellent teaching opportunities in the art of interpreting structures in deeply weathered Archaean rocks.

Reference: Williams, I.R., 1970, Depositional structures in the Archaean Gindalbie Formation at Kanowna Western Australia: West. Australia Geol. Survey Ann. Rept. 1969, p.22-23.

Plate: 49

TENURE, ACCESS and POSSIBLE THREATS

Town Dam is situated in Class C Reserve No. 4354 'Water' vested in the Minister for Works though the easternmost exposures described by Taylor (1984) may just extend into Class C Reserve No. 4459 'Common', vested in the Shire of Boulder.

A track of 2.7 km to Town Dam leaves the Kalgoorlie road southward some 500 m southwest of the Townsite monument.

These soft rocks are readily abused and some bear carved graffiti.

RECOMMENDATIONS

A Geological Monument of about 95 ha is proposed for the northern half of Class C Reserve No. 4354 and its surrounds of Class C Reserve No. 4459. The dam is shown on aerial photograph WA 1849 Kurnalpi Run 9 No. 5716 (p.202).

Protection : high priority; liaise with the Minister for Works to fence the area south of the dam.

Presentation : not suitable; this geology is small in scale.

The Minister for Works and the Shire of Boulder should be consulted.

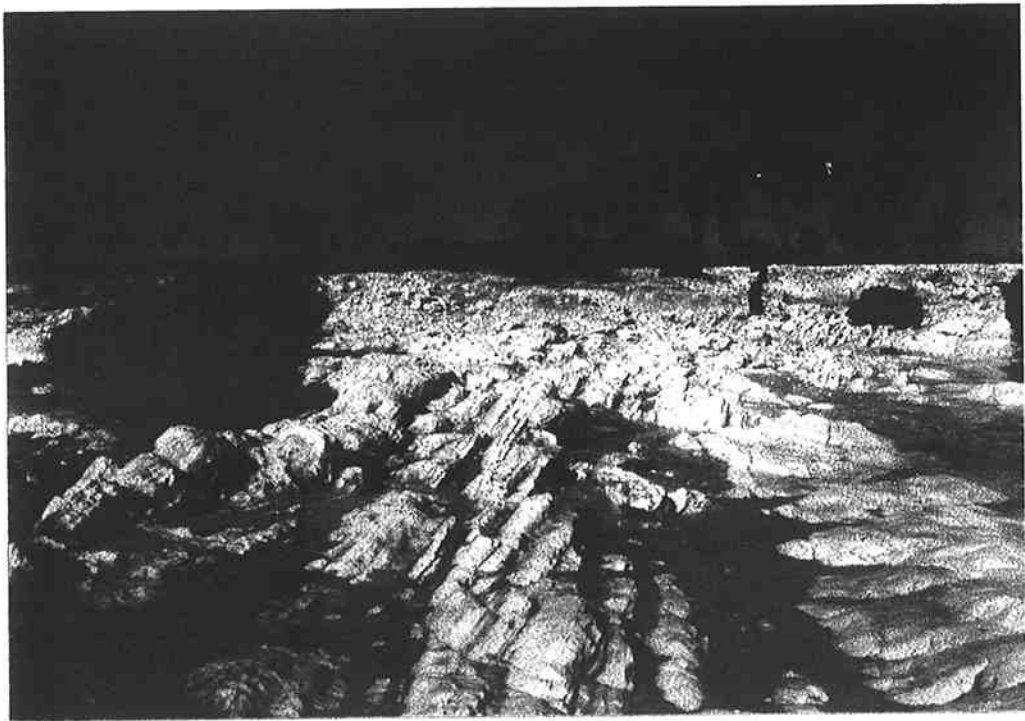


Plate 49

KANOWNA TOWN DAM

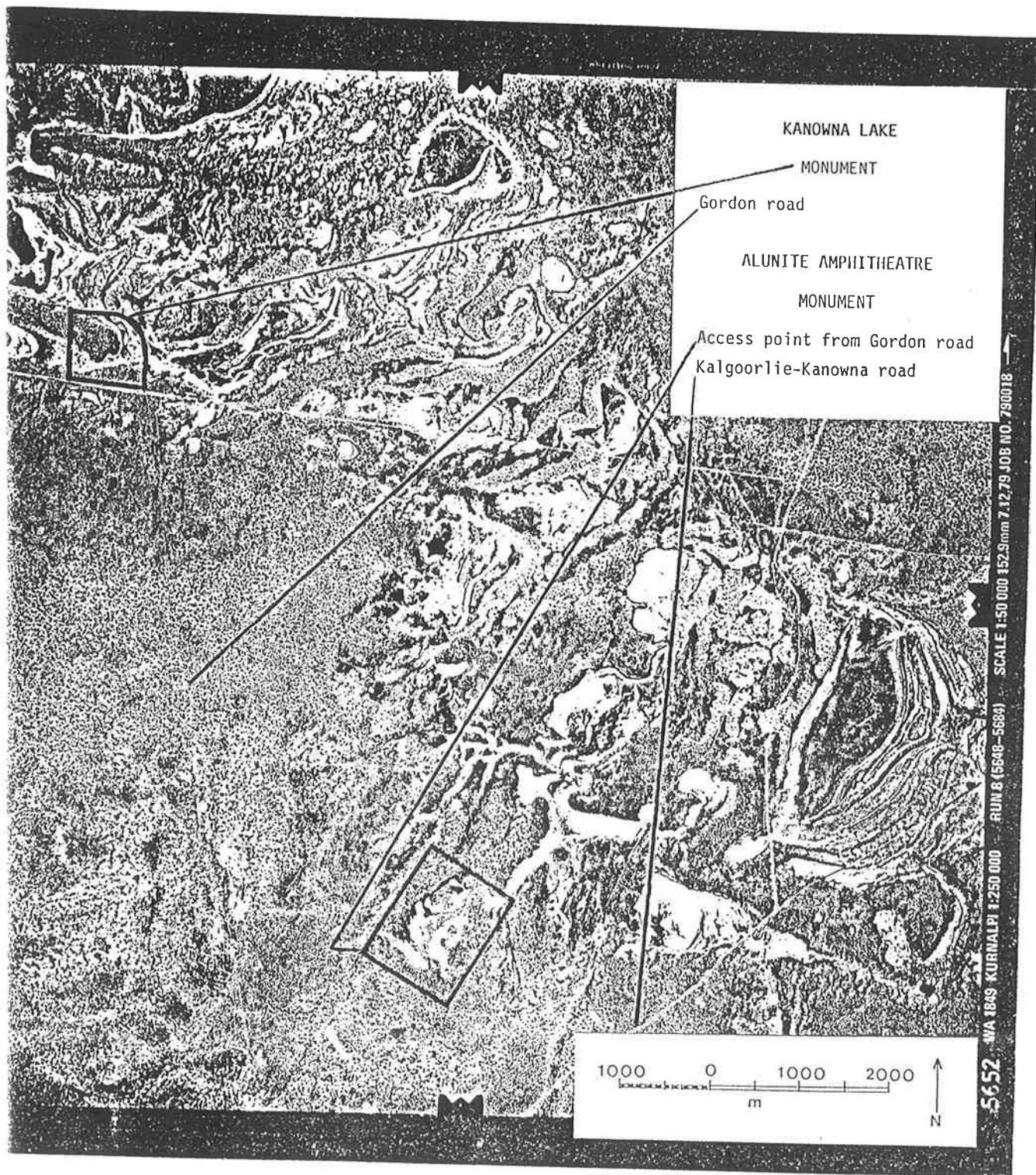
J.D. Carter

These deeply weathered dacitic rocks display
exquisite Archaean sedimentary structures

(65.)

PERKOLILI CONGLOMERATE

A Kanowna field laboratory would be incomplete without an example of the youngest rocks, the Perkolili Conglomerate, a rhyolitic conglomerate with tuffs. Exposures examined around a track 5 km southeast of Kanowna (this track leaves the Kalgoorlie road just north of the Townsite monument) are too poor to recommend though a Class IV Geological Site could be established following identification and marking outcrops in the surrounding scrub using large-scale maps of Taylor (1984) held in the Records of the Survey. The locality is shown on aerial photograph WA 1849 Kurnalpi Run 9 No. 5716 (p.202).



5716

WA 1849 KURNALP 1:250 000

RUN 9 (5683-5720)

SCALE 1:50 000 152.9mm 7.12.79 J08 NO. 790018

FOUR MILE HILL
MONUMENT

Vacant Crown Land
Black Flag P.L. 3114/951
Kanowna Townsite Monument
To Kalgoorlie

Perkolili Conglomerate

KANOWNA TOWN DAM
MONUMENT

Archaean structures in
breakaways

1000 0 1000 2000
m

N

STATEMENT OF INTEREST

On the western shore of Lake Lefroy a little south of Kambalda, a well-exposed syncline contains the Archaean Merougil Beds, a sequence of pebbly sandstone with minor siltstone and schist which displays clear sedimentary and other structural features. This locality was visited by an excursion of the 1983 Eastern Goldfields field conference.

Location: 1:250,000 Geological Series Widgiemooltha
lat 31 15 S long 121 38 E

SIGNIFICANCE and VALUE

Class IV : Archaean Pebbly Sandstone
Reference
Attractive Setting

GEOLOGICAL NOTE

While part of the Merougil Beds resemble the polymictic conglomerate at Lake Douglas Dam (p.190), most geologists place the beds lower in the succession.

Reference: see Griffin et al, p.182.

TENURE, ACCESS and POSSIBLE THREATS

Ground falls within Vacant Crown Land and is covered by mining tenements ML 15/138 and 139 (Mines Department plan Kambalda).

Look for the Kambalda Information Bay on the Norseman road; drive over the creek; turn left for 1.7 km to cross the railway and turn right for 300 m; turn left to the lake.

The outcrops along the lake shore are unlikely to be threatened.

RECOMMENDATIONS

A Geological Site of 1.4 km² is recommended as shown on aerial photograph WA 1839 Widgiemooltha Run 4 No. 5834 (p.204).

Protection : normal care.

Presentation : not suitable; lacks visual appeal.

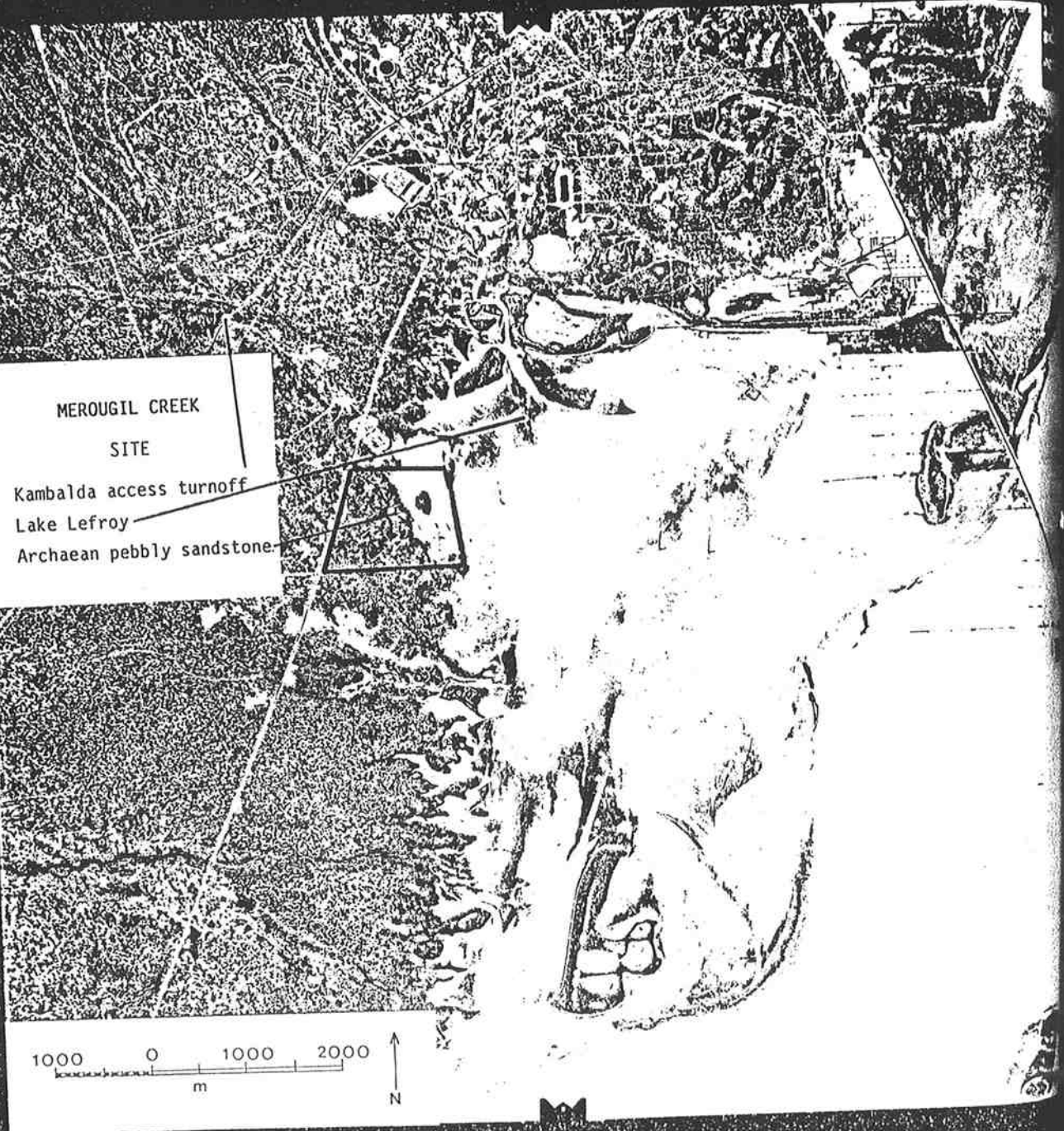
The owners of mining tenements and the Shire of Coolgardie should be consulted.

5834

WA 1839 WIDGIEMOOLTHA 1:250 000

RUN 4 (5804-5839)

SCALE 1:50 000 152.5mm 19.10.73 JOB NO. 790016



67.

BINARONCA ROCK

STATEMENT OF INTEREST

Attractive low hills just east of the Coolgardie-Norseman road mark the Binneringie Dyke, one of the largest true dyke occurrences in the world. This gabbroic intrusion of the Proterozoic runs for more than 320 km with widths up to 4 km and at Binaronca Rock where there is continuous exposure across the dyke, it forms large smooth pavements.

This locality was visited by an international excursion in 1970.

Location: 1:250,000 Geological Series Widgiemooltha
lat 31 35 S long 122 6 E

SIGNIFICANCE and VALUE

Classes III and V : Proterozoic Gabbroic Dyke
Reference
Attractive Setting

GEOLOGICAL NOTE

At Binaronca Rock the predominant rock type is coarse augite gabbro showing crude layering and porphyritic marginal facies.

Reference: McCall, G.J.H. and Peers, R., 1971, Geology of the Binneringie Dyke: Geol. Rundschau, v.60 pt. 3, p.1174-1263.

TENURE, ACCESS and POSSIBLE THREATS

Binaronca Rock is incorporated within Class C Reserve No. 32552 for the 'Conservation of Flora and Fauna', vested in the National Parks and Nature Conservation Authority. Mining tenement E 15/25 covers the southern part of the Reserve.

It is reached by a short track leaving the Coolgardie-Norseman road eastward some 3.6 km south of the Redross turnoff. Defacement of rock pavements appears to be a possible threat.

RECOMMENDATIONS

Class C Reserve No. 32552 of some 186 ha is recommended as a Geological Monument. Binaronca Rock is shown on aerial photograph WA 1837 Widgiemooltha Run 10 No. 5311 (p.206).

Protection : normal care.

Presentation : a notice board explaining this intrusion could be considered.

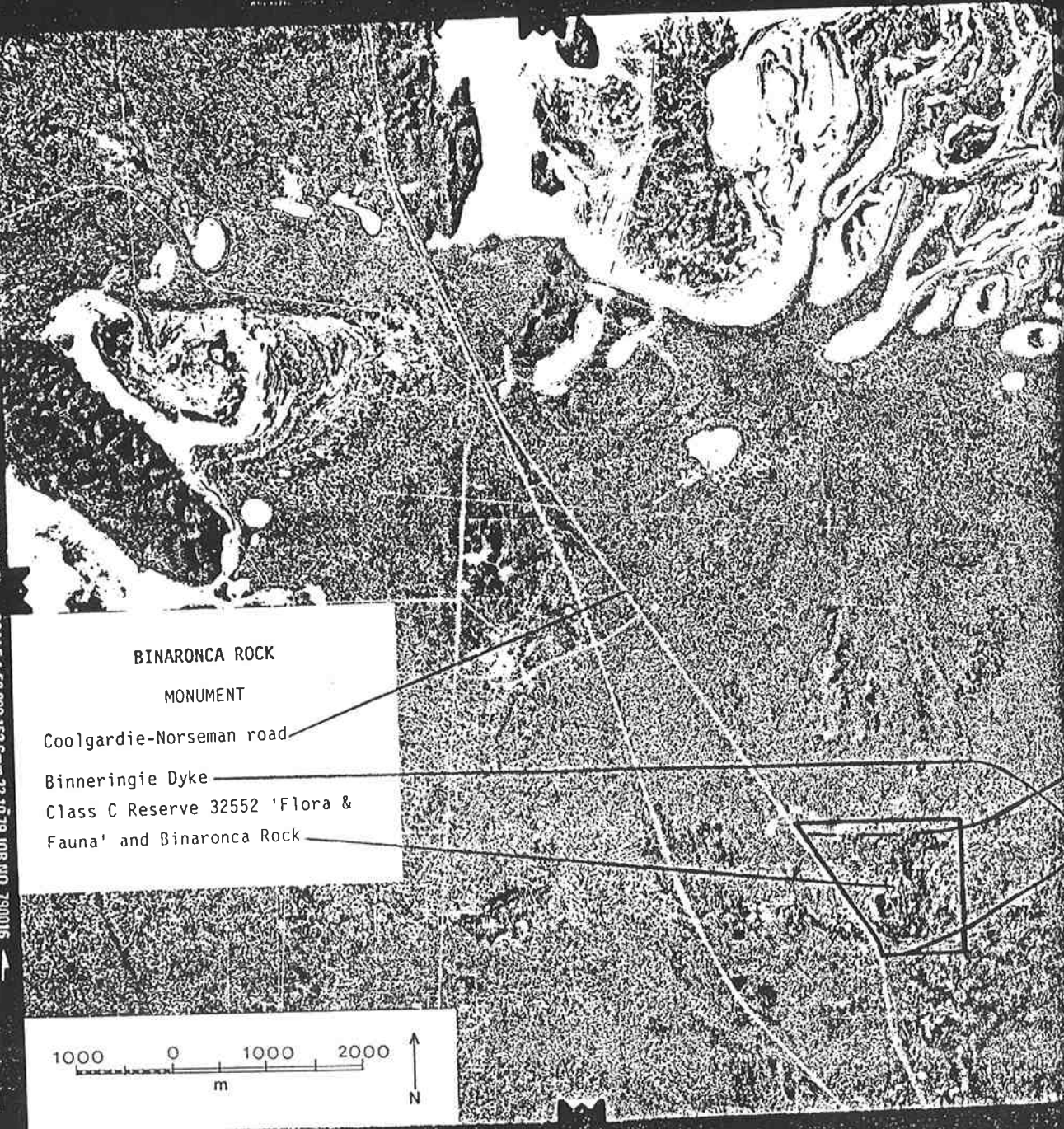
The National Parks and Nature Conservation Authority of Western Australia, the owners of the mining tenement and the Shire of Coolgardie should be consulted.

5311

VIA 1837 WIDGIEMOOLTHA 1:250 000

RUN 10 (5282-5315)

SCALE 1:50 000 152.5mm 22.10/79 JOB NO. 790016



68.

LAKE COWAN CAUSEWAYS

STATEMENT OF INTEREST

Excellent exposures of the large dyke-like, layered Jimberlana Intrusion of the Proterozoic and pillow lavas of the enclosing greenstone sequence are seen along the shores of Lake Cowan near the road and rail causeways a few kilometres northwest of Norseman. Here the Cowan Complex of the Jimberlana Intrusion is composed of feldspathic bronzitite overlain by norite-gabbro; just north of the railway causeway there are good outcrops of pillowed tholeiitic metabasalt. These exposures were examined by international geological excursions in 1970 and 1976.

Location: 1:250,000 Geological Series Widgiemooltha
lat 32 8 45 S long 121 44 E

SIGNIFICANCE and VALUE

Class III : Archaean Mafic Intrusion
Research
Attractive Setting

GEOLOGICAL NOTE

The Jimberlana Intrusion extends for 180 km east-west and is up to 2.5 km wide, and is a sub-horizontal pipe-like body.

Reference: Doepel, J.J.G., 1973, Norseman, W.A.: West. Australia Geol. Survey 1:250,000 Geol. Series Explan. Notes.

TENURE, ACCESS and POSSIBLE THREATS

The northern part of this western shore of Lake Cowan lies within Class C Reserve No. 23101 'Camping Boy Scouts' vested in the Scouts Association of Australia, W.A. Branch, and the remainder is Vacant Crown Land covered partly by mining tenement E 63/133. Access is obtained from the Coolgardie-Norseman road at the western end of the causeways. No threats are foreseen.

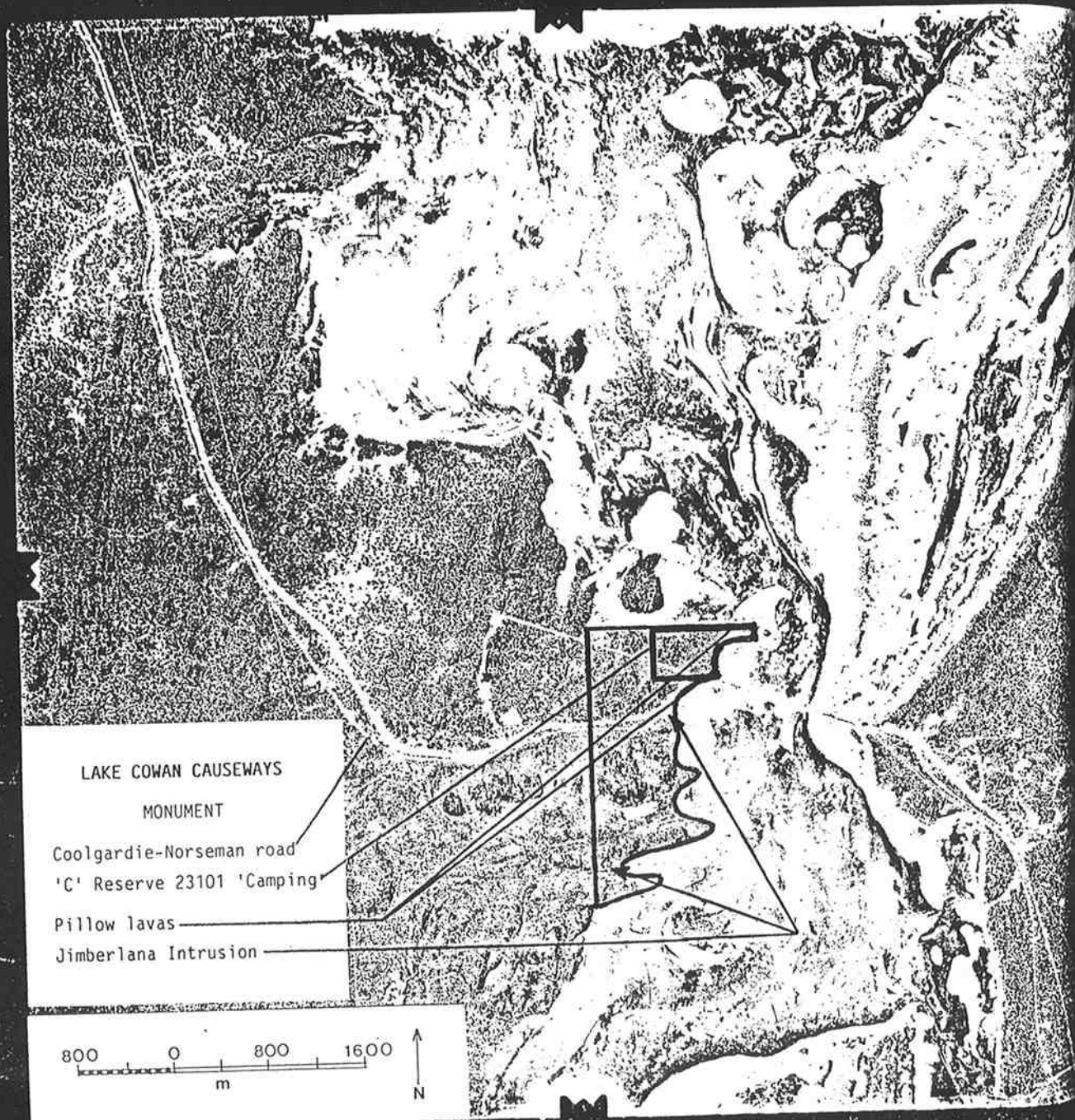
RECOMMENDATIONS

A Geological Monument is recommended for a 3 km strip along the western shore of Lake Cowan extending over 2 km² as shown on aerial photograph WA 1325 Norseman Run 3 No. 5060 (p.208).

Protection : normal care.

Presentation : not suitable; lacks visual appeal.

The Scouts Association, owners of the mining tenement and the Shire of Dundas should be consulted.



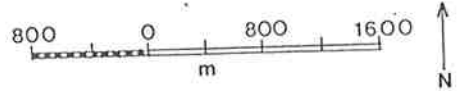
LAKE COWAN CAUSEWAYS
MONUMENT

Coolgardie-Norseman road

'C' Reserve 23101 'Camping'

Pillow lavas

Jimberlana Intrusion



OTHER LOCALITIES

Field examinations were made of the first seven stops of the **Spargoville-Kambalda Traverse** of the Eastern Goldfields Geological Field Conference of 1983 described by Griffin et al (p.182). Of these only Merougil Creek is recommended, exposures elsewhere being rather poor.

The proposals below were not followed up.

Snake Hill (Menzies 1:250,000 Geological Series); exposures of contacts between ultramafic flows.

Jubilee, Lake Yindarlgooda and Fox's Find (Kurnalpi 1:250,000 Geological Series); respectively basalt flows and turbidites showing contacts and structures, and pillow basalts (the latter are recommended at Mount Hunt, etc.).

Binneringie (Widgiemooltha 1:250,000 Geological Series); lake shore exposures of the Binneringie Dyke (recommended now at Binaronca Rock).

Mission Sill and Mount Norcott (Norseman 1:250,000 Geological Series); flooded access prevented examination of the mafic and ultramafic Mission Sill which outcrops within an Aboriginal Reserve where an entry permit is required, and flooding cut off Mount Norcott, an outcrop of the Jimberlana Intrusion (seen also at the recommended feature Lake Cowan Causeways).

SOUTHWEST AND SOUTH COAST

Fine geological localities in the Perth area are discussed by Lemmon et al, 1979 (p.2). Four further Southwest localities (shown on Figure 1) are now considered together with eight features on or near the south coast shown on Figure 17 (p.217), and recommendations are made as follows:

SOUTHWEST

69. Wave Rock	Monument
70. Pinnacles	Monument
71. Kiaka Cliff	Site
72. Del Park	outline monument

SOUTH COAST

73. Bunker Bay	Monument
74. Meekadarrabee Tufa Barrier	Monument
75. Skippy Rock	Monument
76. Hamelin Bay	Site
77. Augusta Shell Bed	Monument
78. Black Point	Monument
79. Point D'Entrecasteaux	Monument
80. Mount Chudalup	Monument

Wave Rock and Pinnacles are well-known scenic attractions and are visited by many thousands of tourists annually; Bunker Bay, the tufa barrier at Meekadarrabee, Black Point, Point D'Entrecasteaux and Mount Chudalup are likely to generate increasing public interest.

69.

WAVE ROCK

STATEMENT OF INTEREST

Here a perfect wave shaped from granite by one of the most gentle tools of nature, rain seepage, rears a 12 m high crest above wheatland plains imparting to the sculpted rock a dynamic vitality rarely seen in nature.

Wave Rock is perhaps the most graceful small-scale landform in Western Australia and it attracts thousands of visitors annually to Hyden 340 km east of Perth.

Location: 1:250,000 Geological Series Hyden
lat 32 27 S long 118 53 30 E

SIGNIFICANCE and VALUE

Classes II and V : Geomorphology
Recreation
Outstanding Natural Beauty

GEOLOGICAL NOTE

Concave overhangs are commonly developed by weathering at the base of granite monoliths such as that at Hyden but none are as magnificent as Wave Rock where strong scarp foot weathering and subsequent erosion of the weathered debris have fashioned a remarkable landform.

Reference: Twidale, C.R., 1968, Origin of Wave Rock: Royal Soc. South Australia, Trans., v.92, p.115-123.

Plate: 50

TENURE, ACCESS and POSSIBLE THREATS

Hyden Rock of which Wave Rock is part is covered by a group of Reserves for 'Water', 'Caravan Park' and 'Public Recreation', etc., with Class C Reserve No. 28833 'Public Recreation Wave Rock' being vested in the Shire of Kondinin.

Access is shown by signpost from Hyden a few kilometres to the west. Despite large numbers of visitors Wave Rock remains in pristine condition.

RECOMMENDATIONS

Wave Rock should be listed as a Geological Monument.

Protection : high priority; there is some supervision.

Presentation : Wave Rock is well-known.

The Shire of Kondinin should be consulted.

STATEMENT OF INTEREST

One of Australia's strangest landscapes is the extraordinary spectacle of thousands of limestone pillars rising out of multicoloured desert sands in the Nambung National Park 270 km north of Perth. The pillars stand up to 5 m and assume varied and sometimes outlandish shapes with many forming regular parallel-sided columns and others rising to a pointed apex or appearing as fanciful castellations. They are not the remnants of a petrified forest but are residual columns left by the subterranean dissolution of limestone and exposed by wind removing covers of sand.

Location: 1:250,000 Geological Series Dongara - Hill River
lat 30 35 S long 115 7 E

SIGNIFICANCE and VALUE

Classes II and V : Geomorphology
Recreation
Great Landscape Value

GEOLOGICAL NOTE

The pillars were formed by underground dissolution of Pleistocene Tamala Limestone and an account of a sequence of events is provided in the reference.

Reference: McNamara, K., 1983, Pinnacles : Western Australian Museum p.20.

Plate: 51

TENURE, ACCESS and POSSIBLE THREATS

Nambung National Park incorporates the Pinnacles Desert and access is by roads from Cervantes 244 km north of Perth.

Use of the National Park is supervised.

RECOMMENDATIONS

Pinnacles Desert should be listed as a Geological Monument.

Protection : high priority; use of the Park is supervised.

Presentation : Pinnacles Desert is well-publicised.

The National Parks and Nature Conservation Authority should be consulted.



WAVE ROCK
Dynamic vitality
in granite

Plate 50

J.D. Carter

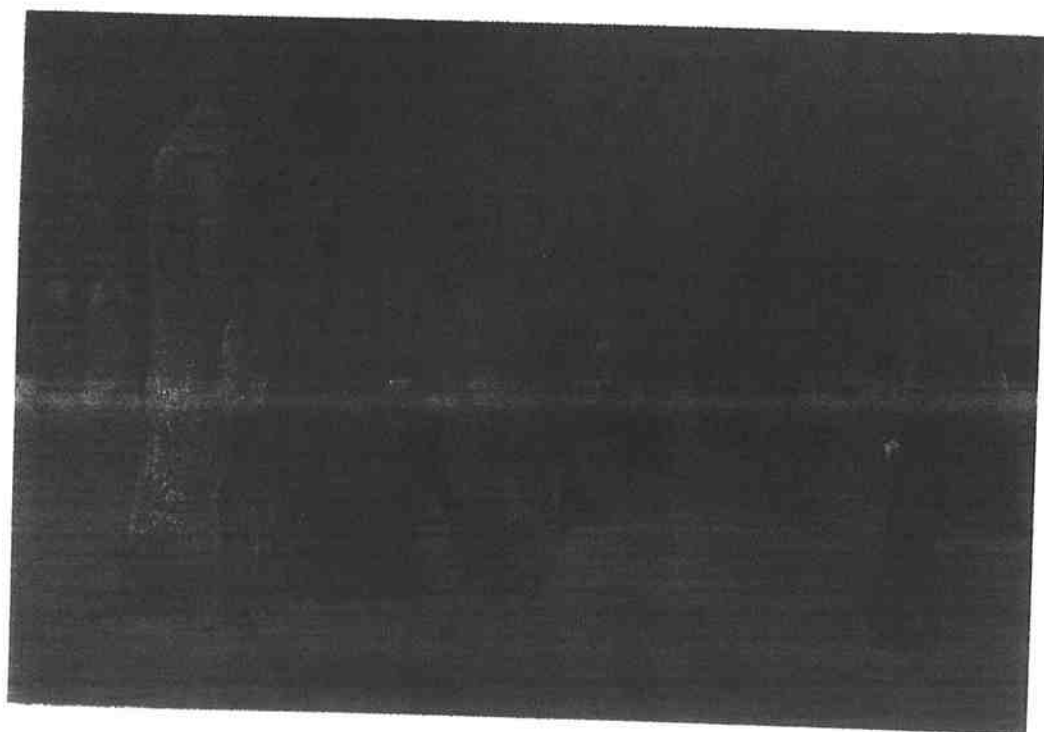


Plate 51

PINNACLES

Thousands of limestone pillars stand in a desert

J.D. Carter

71.

KIAKA CLIFF

STATEMENT OF INTEREST

Clear exposures of Proterozoic chert in a low cliff 16 km north of Moora show good examples of minor structures including slump folding and brecciation.

The cliff is visited by parties from tertiary institutions.

Location: 1:250,000 Geological Series Moora
lat 30 31 S long 116 2 15 E

SIGNIFICANCE and VALUE

Class IV : Proterozoic Minor Structures
Education

GEOLOGICAL NOTE

Until recently cherts of the Moora Group were assigned to a Coomberdale Chert but work in the Perenjori area to the north suggests the cherts should be placed in a Noondine Chert of the Moora Group.

References: Logan, B.W. and Chase, R.L. 1961, The stratigraphy of the Moora Group, Western Australia: Royal Soc. West. Australia Jour., v.44, p.14-31.
Baxter, J.L. and Lipple, S.L., 1985, Perenjori, W.A.: West. Australia Geol. Survey 1:250,000 Geol. Series Explan. Notes.

TENURE, ACCESS and POSSIBLE THREATS

Kiaka Cliff stands on Melbourne Location 909 Lot M 573 of Mr. L. Doust, Box 1, Moora, WA 6510 and is covered by mining tenement M 70/191 of Agnew Clough Ltd., 22 Mount Street, Perth, WA 6000.

From Moora the Watheroo road is taken for 15.6 km to turn east to Kiaka for 1 km where the cliff is seen on the south of the road. The cliff is not classed as ore by Agnew Clough Ltd.

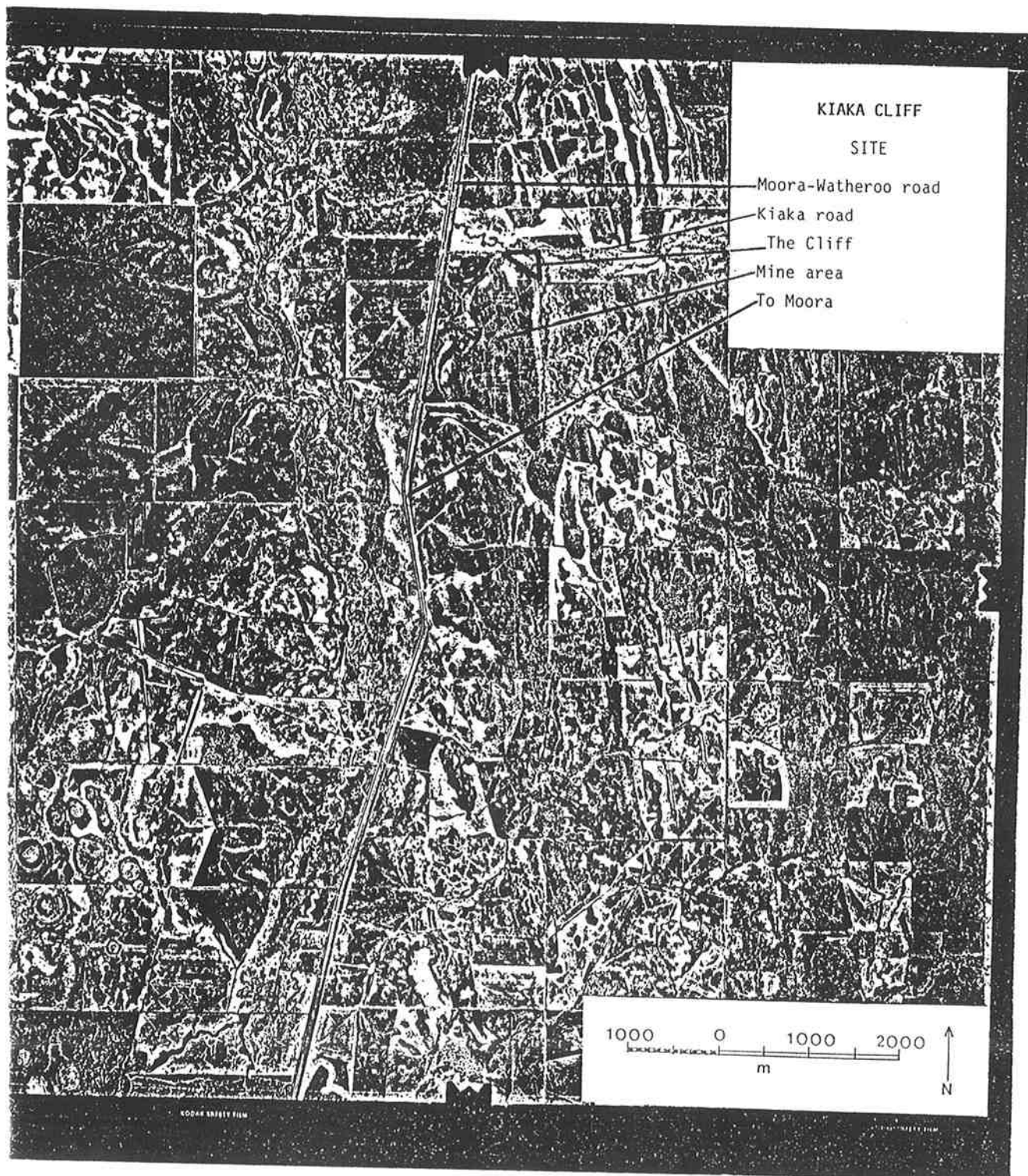
RECOMMENDATIONS

A Geological Site of 10 ha is recommended as shown on aerial photograph WA 1958 Moora Run 8 No. 5241 (p.215).

Protection : normal care; this is a useful teaching site with easy access and should be reserved for geological education.

Presentation : not suitable; the geology is intricate.

The landowner and owners of the mining tenement, and the Shire of Moora should be consulted.



The Del Park mine site of Alcoa of Australia Ltd near Pinjarra 90 km south of Perth contains the Del Park Basic Pegmatite of the Perth area report of Lemmon et al (p.2), but as well as the basic pegmatite or dyke and its rare pseudomorphs of gibbsite after labradorite, a nearby bauxite mining face of some 8 m is preserved by the company. Ground surrounding this face is undergoing rehabilitation and when complete it is proposed to encourage public examination of the mining face and outcrops of the unusually interesting basic dyke. Thus an attractive geological education locale will become available within the next year or two and a Class III Geological Monument should be designated here.

In the Perth area report, the Jarrahdale Railway Cutting (Perth report reference 6.5) was recommended as a Geological Monument for its profile illustrating the development of bauxitic laterite but as is explained, exposures in the cutting will deteriorate and there is mention of a need to clean the face every decade or so. This difficulty would be encountered at Del Park also but preserving the mine face should be a more practical proposition than cleaning up a railway cutting exposure.

OTHER SOUTHWEST LOCALITIES

Other Southwest localities mentioned in various papers include **Mount Bakewell** near York and the **Canning Dam Quarry** near Perth, both for metamorphic rocks and migmatites. The writer believes examples of these rock suites are adequately represented in the Perth area report. However the suggestions could be taken up if there is need to expand systematically the listing of localities close to the Metropolitan area when the results of recent research over this ground by tertiary institutions should be taken into account.

SOUTH COAST

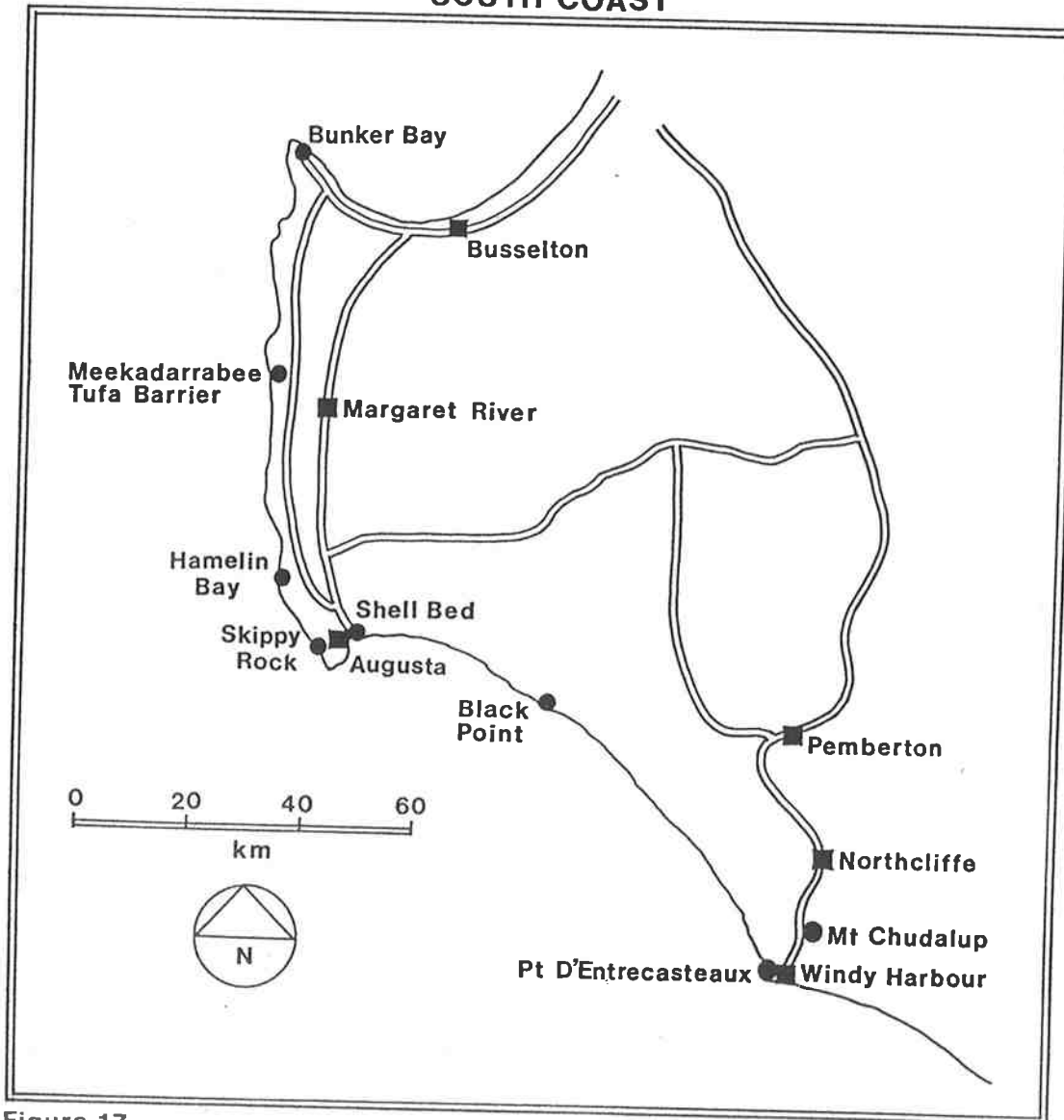


Figure 17

STATEMENT OF INTEREST

A striking angular unconformity separating late Proterozoic charnockitic and garnetiferous gneisses of the Leeuwin Block from Tamala Limestone of the Pleistocene is excellently exposed in a cliff face on the west of Bunker Bay some 13 km north of Dunsborough. The unconformity is again superbly exposed about a kilometre to the west and set off by a magnificent sea cave cut into gneiss with roof level at the plane of unconformity. From Tamala Limestone great stalactites hang to form a portcullis ruin lending the cave a medieval quality.

This locality is used for teaching at the tertiary level.

Location: 1:250,000 Geological Series Busselton and Augusta
lat 33 32 S long 115 2 E

SIGNIFICANCE and VALUE

Classes III and V : Unconformity and Sea Cave
Education
Attractive Setting

GEOLOGICAL NOTE

Leeuwin Block consists largely of paragneiss and orthogneiss and at Bunker Bay where granite intrudes the gneisses, exposures are useful for illustrating structural features of high-grade metamorphic rocks.

Tamala Limestone of the Middle and Late Pleistocene is a wide-spread lithified fossil dune deposit consisting largely of calcareous sands.

Reference: Harris, L., 1985, The Leeuwin Block Excursion in IGCP Project 236 The Albany-Fraser Province of Western Australia, Conference and Excursion Guide, compiled by S.A. Wilde: West. Australia Institute of Technology.

Plate: 52

TENURE, ACCESS and POSSIBLE THREATS

Coastline immediately west of Bunker Bay falls within Leeuwin-Naturaliste National Park.

Access from Dunsborough is by the Cape Naturaliste road turning north to Bunker Bay after 11.8 km. From the parking area walk northwest to the headland cliff displaying the unconformity and a further kilometre westward along the shore to the sea cave.

There are no obvious threats apart from possible vandalism of speleothems in the sea cave.

RECOMMENDATIONS

A Geological Monument is recommended for a 100 m wide strip of coastal cliff extending westward for 1.5 km from the west headland of Bunker Bay as shown on aerial photograph WA 1977 Busselton Run 1W No. 5241 (p.220).

Protection : a high priority for speleothems in the sea cave.

Presentation : a notice board explaining the unconformity could be considered.

The National Parks and Nature Conservation Authority should be consulted.

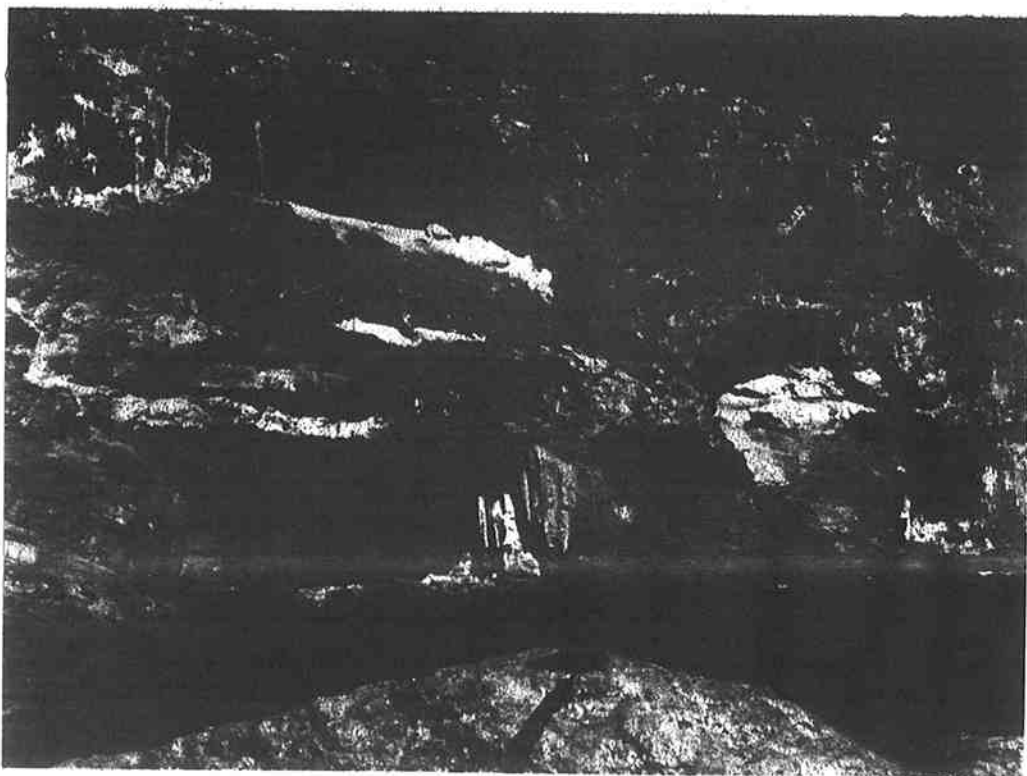


Plate 52 BUNKER BAY SEA CAVE J.D. Carter
The roof of the cave extends along the plane of unconformity
with inclined gneiss below and horizontal limestone above

5241

WA 1977 BUSSELTION 1:250000

RUN IV (5239-5242)

SCALE 1:50000 1526mm 13481 JOB NO. 800030

BUNKER BAY
MONUMENT

- Sea Cave
- Unconformity cliff
- Bunker Bay
- To Dunsborough

1000 0 1000 2000
m

N

STATEMENT OF INTEREST

Along Ellen Brook Valley, near Margaret River, a rich greenery including an exotic flora with fig trees and gooseberry conceals a lime-saturated spring which has built a tufa terrace to carry its waters completely over Ellen Brook and this brook now flows through a cave-like grotto beneath the barrier formed by the tufa terrace. From the terrace a waterfall leads the spring waters to Ellen Brook a little upstream of the barrier causing them to pass through the grotto and the spring is thus enticed to flow below its own waters.

Location: 1:250,000 Geological Series Busselton and Augusta
lat 33 54 30 S long 114 59 30 E

SIGNIFICANCE and VALUE

Classes III and V : Geomorphology and Speleothems
Recreation
Attractive Setting

GEOLOGICAL NOTE

It is likely the lime-saturated spring is thrown out of Pleistocene Tamala Limestone near its contact with Proterozoic crystalline basement.

The barrier, perhaps a unique phenomenon, is set on the north side of the valley where the tufa terrace some 2 m thick extends for more than 50 m to bridge Ellen Brook and where the entrance to the grotto is crowded with active and colourful speleothems, notably flowstones, terraces and rimstone pools (L.V. Bastian pers. comm.).

Plate: 53

TENURE, ACCESS and POSSIBLE THREATS

Ellen Brook Valley lies within Leeuwin-Naturaliste National Park. The tufa barrier is shown on tourist maps as Meekadarrabee Falls.

From Margaret River the Busselton road is taken for half-a-kilometre to turn west onto Carter Road for 6 km meeting Caves Road and turning north to find the Ellen Road signpost after some 2 km. A difficult sandy track is followed west for 3 to 4 km to Bussell Homestead on Ellen Brook where a path leads 400 m

upstream to the tufa barrier (4WD).

This valuable environment has been threatened by proposals to dam the valley for water supply and perhaps also to intercept by borehole the lime-saturated waters of the tufa barrier spring. It is difficult to believe that a modest water source outweighs the value of this singular geomorphology and attractive waterfall.

RECOMMENDATIONS

A Geological Monument of 175 ha is recommended for Ellen Brook valley as shown on aerial photograph WA 2133 Busselton Run 5 No. 5424 (p.223).

- Protection : high priority; use of this fragile locality should be controlled.
- Proposal : a ready appreciation of the drainage reversal is needed and a large-scale map of the barrier should be prepared.
- Presentation : very high potential using notice boards, etc., though over-use would lead to degradation.

The National Parks and Nature Conservation Authority should be consulted.

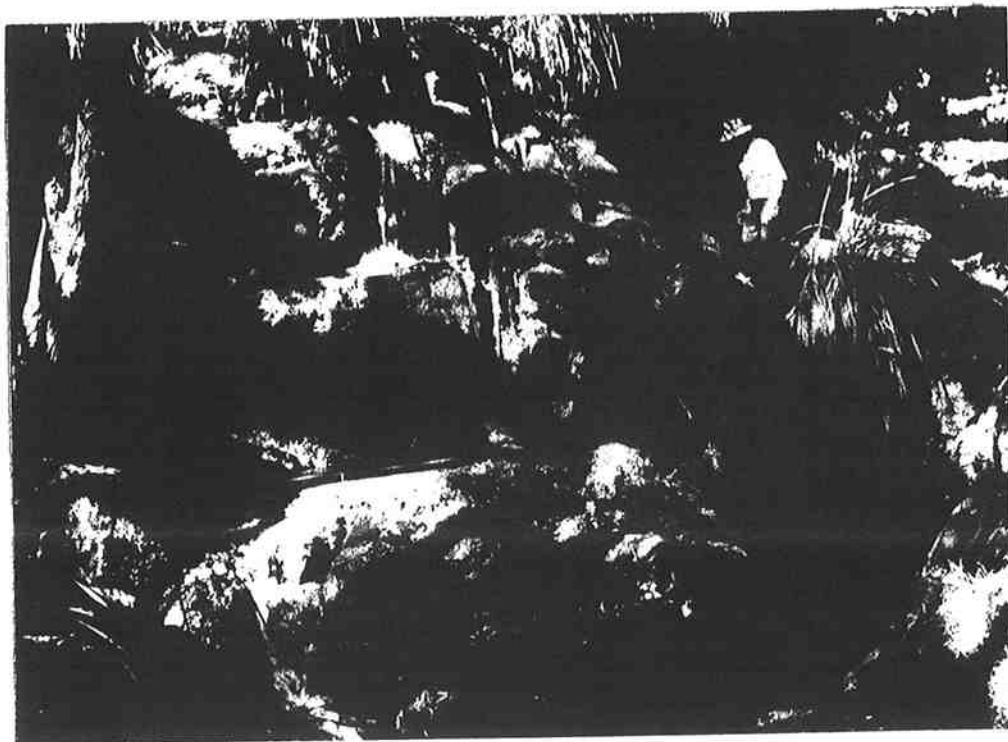
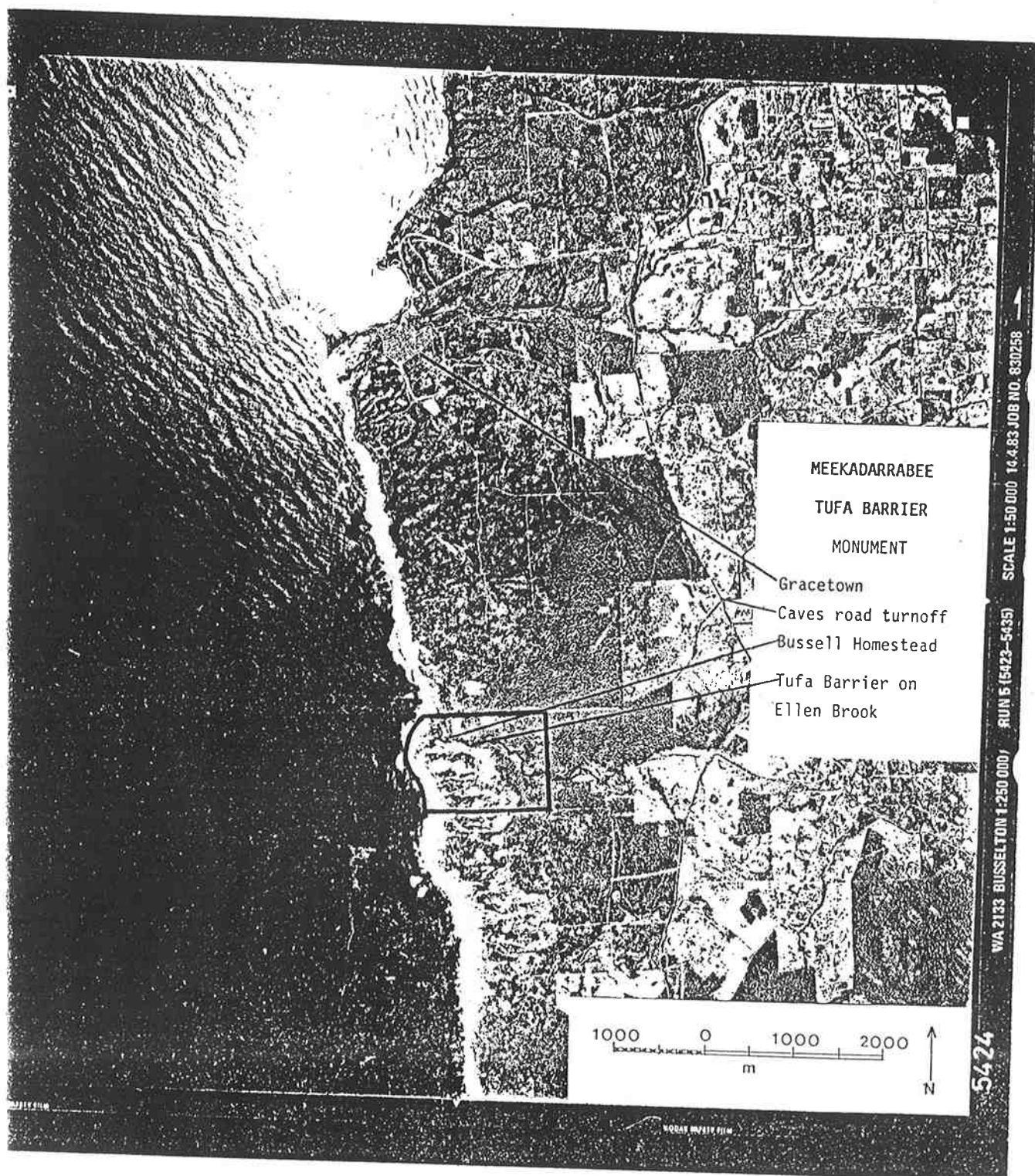


Plate 53 MEEKADARRABEE TUFA BARRIER Cliff Winfield
The spring falls over the tufa barrier to join Ellen Brook
to flow through the grotto where the ranger stands, and
thus to flow below its own waters



75. - 76. SKIPPY ROCK and HAMELIN BAY

STATEMENT OF INTEREST

Of the youngest sedimentary rocks in Western Australia perhaps the best known is the Tamala Limestone, a thick sequence of fossil calcareous dune deposits with thin marine limestones of the Middle and Late Pleistocene now seen in many bold coastal cliffs. Rottnest Island is a drowned remnant of an ancient dune ridge of this formation.

Although Tamala Limestone is a complex unit with many of its dune phases separated by fossil soils, no systematic naming of its belts of dunes has been attempted. At Skippy Rock near Cape Leeuwin, mature fossil soils (palaeosols) suggest important breaks within the Limestone and these contrast conspicuously with less mature palaeosols reflecting minor breaks during dune formation exposed at nearby Hamelin Bay.

(75.)

SKIPPY ROCK

Location: 1:250,000 Geological Series Busselton and Augusta
lat 34 21 S long 115 7 30 E

SIGNIFICANCE and VALUE

Class III : Pleistocene Relationships
Research
Attractive Setting

GEOLOGICAL NOTE

In the coastal cliffs 600 to 800 m north of Skippy Rock mature palaeosols, completely leached and orange-brown and one nearly a metre thick in places, separate distinctive limestones. A brown limestone with an irregular karst-like surface underlies the principal palaeosol and this is capped by a thin bed of waterworn gneiss and limestone cobbles on which rests a pale-grey shelly limestone similar to limestone exposed at Hamelin Bay. The karst-like surface and the mature palaeosol and its cobble bed capping represent a considerable disconformity within Tamala Limestone possibly corresponding to a major lowering of sea level during a glacial maximum.

Reference: Bastian, L.V., 1982, Minerals and their relationships

in the Leeuwin Block, Leeuwin-Naturaliste National Park : West.
Australia Government Chemical Laboratories (unpublished).

Plate: 54

TENURE, ACCESS and POSSIBLE THREATS

Skippy Rock lies within the Leeuwin-Naturaliste National Park with access from Augusta by the Cape Leeuwin road and a track with signpost to Skippy Rock parking area (9.5 km).

There is no obvious threat.

RECOMMENDATIONS

A Geological Monument is recommended for a 100 m wide strip of coastal cliff extending for 1.5 km north of Skippy Rock as shown on aerial photograph WA 1976 Augusta Run 5 No. 5673 (p.228).

Protection : normal care providing coastal development does not take place.

Presentation : not suitable; a little remote and the geology is not easily appreciated.

The National Parks and Nature Conservation Authority should be consulted.

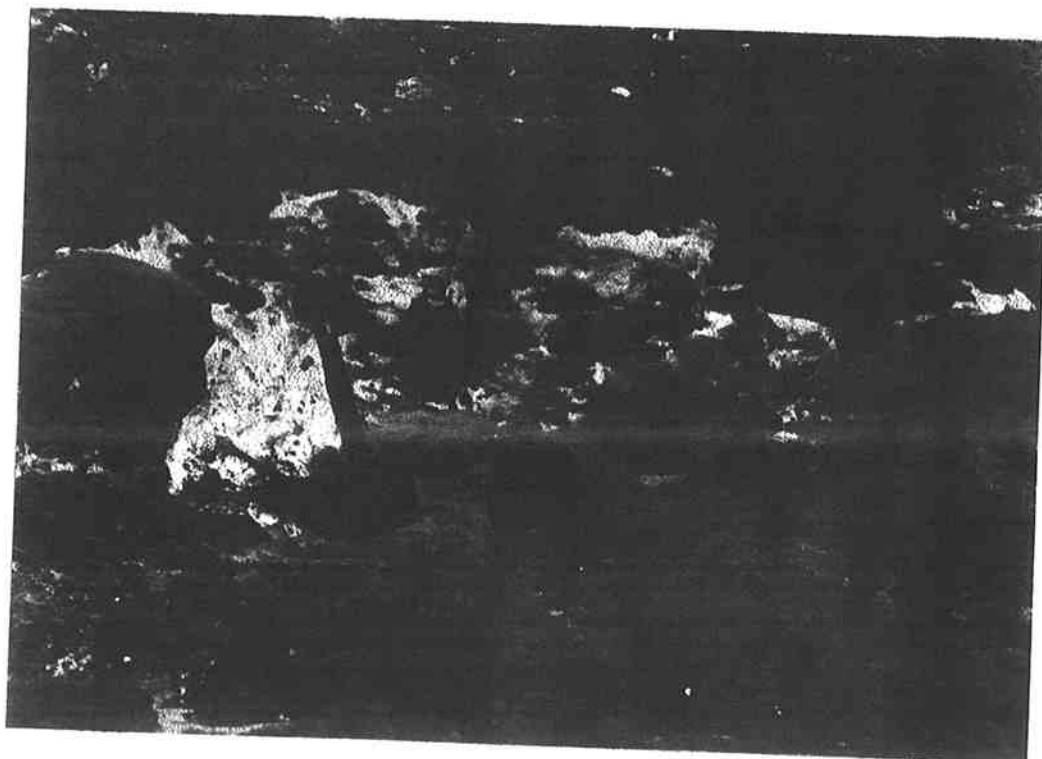


Plate 54 TAMALA LIMESTONE PALAEOSOL NEAR SKIPPY ROCK J.D. Carter
The hammer stands on a karst-like limestone surface and lies
on a discoloured chocolate-brown palaeosol with a cobble bed cap

(76.)

HAMELIN BAY

Location: 1:250,000 Geological Series Busselton and Augusta
lat 34 13 S long 115 1 30 E

SIGNIFICANCE and VALUE

Class IV : Pleistocene Environment
Education
Attractive Setting

GEOLOGICAL NOTE

Bluffs of conspicuously cross-bedded Tamala Limestone incorporating prominent palaeosols form the southern point of Hamelin Bay. These fossil soils are less mature than the palaeosols near Skippy Rock and contain for example, a high proportion of calcareous material unlike the leached Skippy Rock soils and are much lighter in colour, and apparently represent slight breaks in Pleistocene dune building processes. The limestone here almost certainly corresponds to the upper pale-grey limestone at Skippy.

Reference: Fairbridge, R.W. and Teichert, C., 1953, Soil horizons and marine bands in the coastal limestones of Western Australia : Royal Soc. New South Wales Jour. and Proc., v.86, p.68-87.

Plate: 55

TENURE, ACCESS and POSSIBLE THREATS

Hamelin Bay lies within the Leeuwin-Naturaliste National Park some 20 km northwest of Augusta and is reached by a turn-off (signpost) from Caves Road. Cliff faces displaying palaeosols stand 250 m south of the old jetty.

Development would threaten this locality.

RECOMMENDATIONS

A Geological Site of about a hectare covering the southern headland at Hamelin Bay is recommended as shown aerial photograph WA 2301 Augusta Run 4 No. 5226 (p.229).

Protection : normal care.

Presentation : a notice board may interest holiday makers.

The National Parks and Nature Conservation Authority should be consulted.

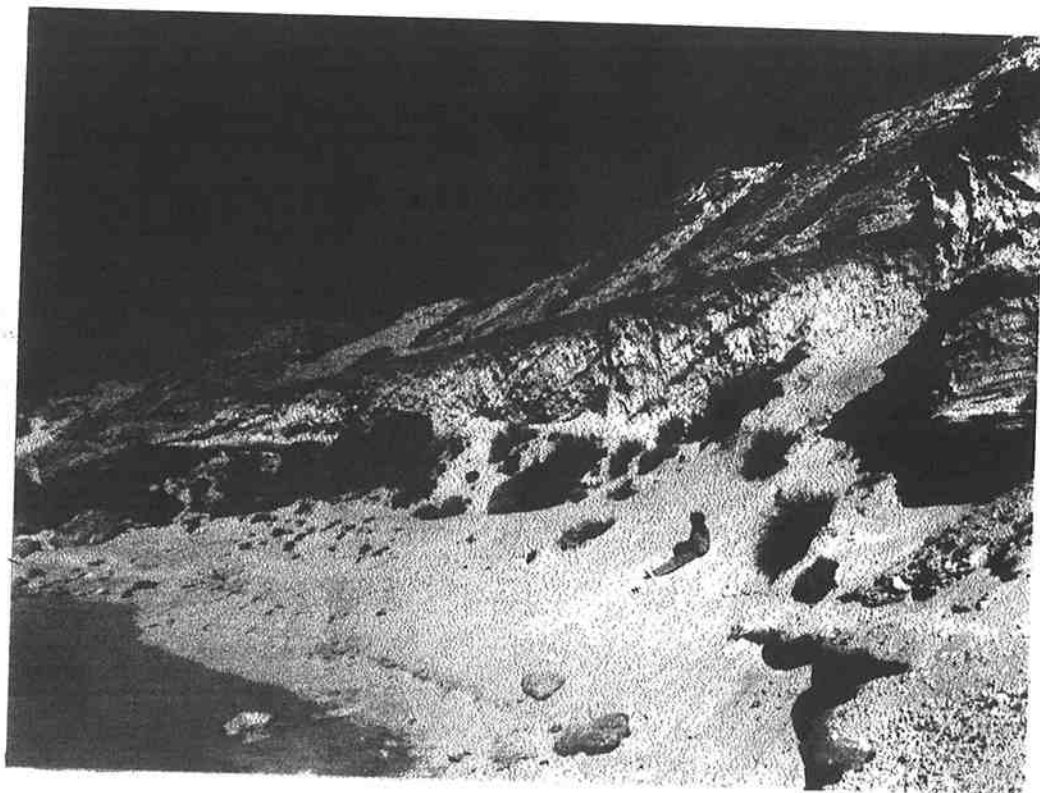
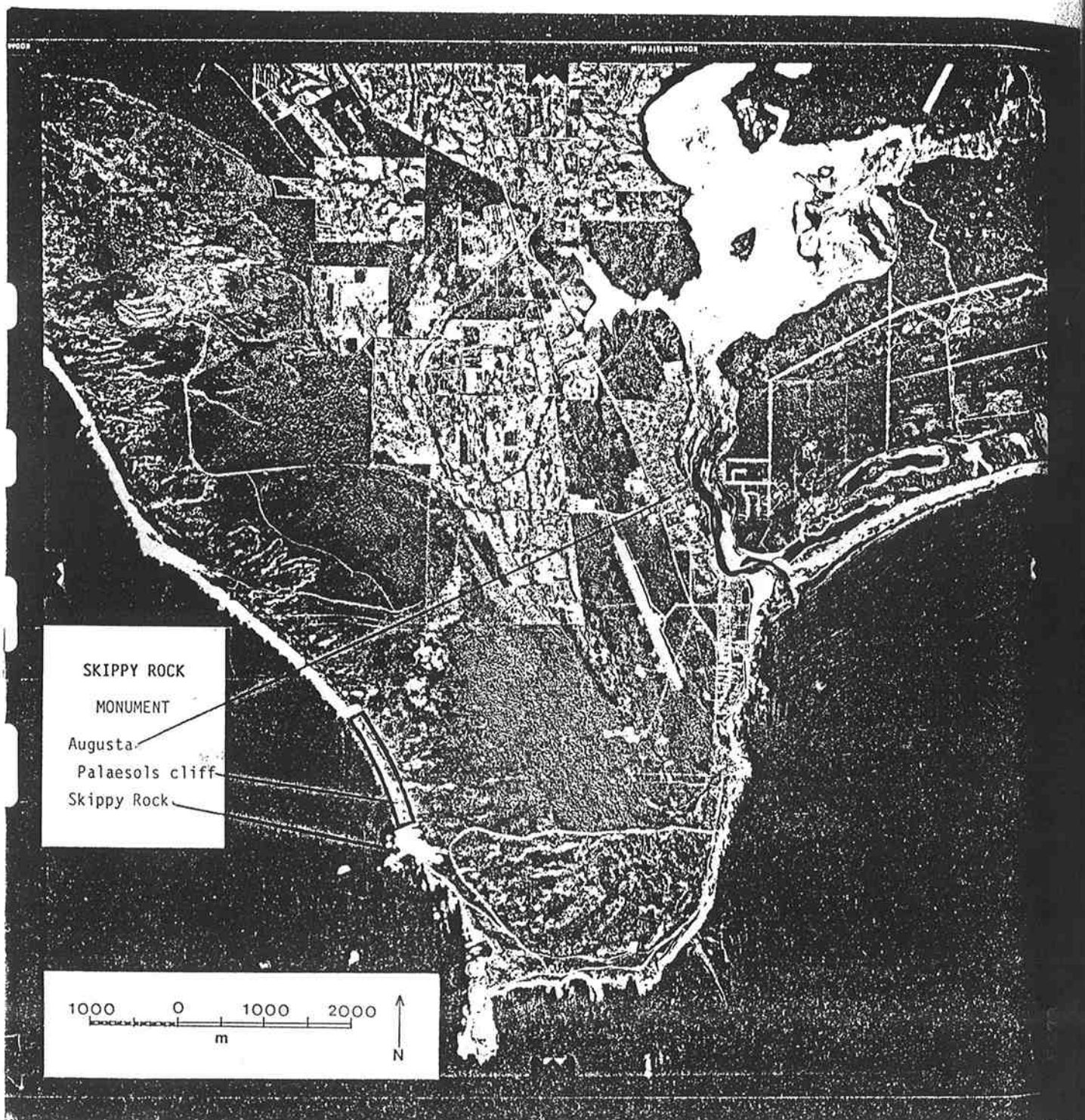


Plate 55

PALAEOSOL AT HAMELIN BAY

J.D. Carter

Tamala Limestone displays a prominent fossil soil horizon
(palaeosol) and steep foreset bedding



STATEMENT OF INTEREST

Along the eastern shore of Hardy Inlet opposite Augusta, a thin marine limestone crowded with fossils of the Pleistocene including corals forms a low rock ledge. This shell bed probably accumulated during a final interglacial episode approximately 100,000 years ago when the minimum sea temperature here was a little higher than at present and is the most southern example of its type in Western Australia.

Location: 1:250,000 Geological Series Augusta and Busselton
lat 34 19 S long 115 10 E

SIGNIFICANCE and VALUE

Class III : Pleistocene Palaeontology
Research
Attractive Setting

GEOLOGICAL NOTE

Information is based on an unpublished account of the shell bed by G.W. Kendrick of the Western Australia Museum.

The shell bed, 1.7 m high and extending for some 220 m, is a marine sequence of the predominantly eolian Tamala Limestone. A grey richly fossiliferous limestone of some 0.3 m is overlain by a locally shell-rich calcarenite incorporating a thin band of black mineral sand and the uppermost 0.5 m is a calcarenite with well-sorted mollusc shells and occasional corals. More than a hundred species of molluscs, three of corals and an echinoid have been identified.

Several species of mollusc and coral lie well outside their known modern geographic ranges, the corals being the best examples with a species of *Alveopora* unknown south of Rottnest. One mollusc is believed to be a species of *Perna*, a genus not known to be living in any part of Australia.

TENURE, ACCESS and POSSIBLE THREATS

The shell bed lies within Class C Reserve No. 25211 'Recreation' vested in the Shire of Augusta-Margaret River; its northern extremity may fall within a Tattersall Street of a residential subdivision largely undeveloped at present.

The shell bed is reached by crossing the inlet by boat and making for the limestones which are a little south of the town centre, or by long circuitous roads, leaving Augusta on the Bussell Highway, taking the Nannup road at Karridale and turning south on the gravel road 8 km east of Alexandra Bridge and proceeding south and then westwards to Hardy Inlet.

Housing and other development are a threat to this interesting but small outcrop.

RECOMMENDATIONS

A Geological Monument is recommended for a 100 m wide strip of foreshore and Class C Reserve 25211 along Hardy Inlet as shown on aerial photograph WA 2301 Augusta M/S Run 6 No. 5134 (p.232).

Protection : a high priority; this small and vulnerable outcrop could be lost to development.

Presentation : not suitable; the friable shell bed could be spoiled by casual visitors.

The Shire of Augusta-Margaret River should be consulted.

AUGUSTA SHELL BED
MONUMENT

Augusta

Hardy Inlet

'C' Reserve 25211

'Recreation' with shell
bed exposure in
foreshore cliff

800 0 800 1600
m

N

78.

BLACK POINT

STATEMENT OF INTEREST

Basalt flows showing good examples of columnar structure stand in spectacular cliffs at Black Point on the south coast some 40 km east of Augusta where Bunbury Basalt of the early Cretaceous includes the remnants of a fine colonnade rising 12 m above basaltic tuffs. This colonnade is the most perfect columnar basalt known in Western Australia.

Location: 1:250,000 Geological Series Pemberton - Irwin Inlet
lat 34 25 S long 115 32 30 E

SIGNIFICANCE and VALUE

Classes III and V : Cretaceous Columnar Basalt
Education
Attractive Setting

GEOLOGICAL NOTE

Bunbury Basalt reflects the sole Phanerozoic volcanic event known within the Perth Basin. Basalt flows spread along valleys of a Cretaceous landscape and the lavas now appear as relatively small and isolated outcrops south of Bunbury.

At Black Point the principal basalt extends for about 3 km along the coast. Columnar structure however is best developed in a smaller outcrop a kilometre to the northwest across a sandy bay where the fine colonnade shows symmetrical hexagonal pillars 12 m high and a metre thick seated on basaltic tuff and overlain by Tamala Limestone. Tuffs and late injection basaltic dykes at Black Point suggest this was an eruptive centre.

The northwest outcrop has been described as overlying Yarragadee Formation but it appears well-stratified basaltic tuffs were mistakenly thought to represent this formation.

Reference: Burgess, I., 1978, Geology and geochemistry of the Cretaceous Bunbury tholeiite suite, Perth Basin, Western Australia: Univ. West. Australia Science Hons. thesis (unpublished).

TENURE, ACCESS and POSSIBLE THREATS

Black Point falls within the D'Entrecasteaux National Park and threats are not foreseen.

In 1986 only summer access was possible (4WD). From Pemberton the Nannup road is taken for 41 km to turn west onto Stewart road for 7 km and then taking the very rough Black Point road for some 23 km. Black Point is also reached from Augusta by the Brockman Highway.

RECOMMENDATIONS

A Geological Monument is recommended for a 500 m wide strip of coast and adjoins extending for some 5 km as shown on aerial photograph WA 1976 Pemberton Run 6 No. 5748 (p.235).

Protection : normal care providing coastal development does not take place.

Presentation : if access is improved a notice board could be considered.

The National Parks and Nature Conservation Authority should be consulted.

(Note: an excellent photograph of the colonnade in the northwest basalt outcrop appears on p.145 of Bulletin 124 of the Geological Survey of Western Australia.)



79. - 80. POINT D'ENTRECASTEAUX and MOUNT CHUDALUP

STATEMENT OF INTEREST

At Point D'Entrecasteaux there is a unique meeting of ancient granulites of more than 3000 m.y. of the Yilgarn Block exposed along the shoreline with the best known of Western Australia's young coastal formations, the Tamala Limestone of the Pleistocene. The latter towers above the granulites to build the precipitous cliffs of the Point where cross-bedding on a grand scale and unusual columnar-like weathering attract for this southern bastion of the State the popular name of Cathedral Rock.

Here also the junction between two major tectonic units, Yilgarn Block and Albany Fraser Province, is marked by the confrontation across Gardner River swamplands of Point D'Entrecasteaux with its shoreline exposures of Archaean granulites and the bold granitoid dome of Mount Chudalup, a westernmost landscape of the Proterozoic Albany-Fraser Province.

(79.) POINT D'ENTRECASTEAUX

Location: 1:250,000 Geological Series Pemberton - Irwin Inlet
lat 34 51 S long 116 E

SIGNIFICANCE and VALUE

Classes III and V : Geomorphology and Ancient Rocks
Research
Great Landscape Value

GEOLOGICAL NOTE

Granulite exposures on the shore below Point D'Entrecasteaux at Windy Harbour are part of the Western Gneiss Terrain of the Yilgarn Block, a tract famous for ancient minerals and rocks found at Mount Narryer and Jack Hills in the Terrain's northern reaches (p.128). Windy Harbour granulites are composed of inter-banded felsic and mafic units with pods of ultramafic material rich in pyroxenes and shot through by distinctive veins of blue quartz.

Piled more than 100 m high on the granulites are fossil dunes of the Middle and Late Pleistocene Tamala Limestone, exposed magnificently in cliff faces of Point D'Entrecasteaux.

Reference: Wilde, S.A., 1985, Albany to Pemberton Excursion in IGCP Project 236 The Albany-Fraser Province of Western Australia, Conference and Excursion Guide, compiled by S.A. Wilde: West. Australia Institute of Technology.

Plate: 56

TENURE, ACCESS and POSSIBLE THREATS

This coastline falls within the D'Entrecasteaux National Park and while threats are not foreseen, measures may be needed to protect the rather limited Windy Harbour granulite exposures from development.

Windy Harbour lies 28 km south of Northcliffe; granulites are exposed on the shore at the centre of the settlement and a gravel road leads to Point D'Entrecasteaux.

RECOMMENDATIONS

A Geological Monument of 3.7 km² is recommended as shown on aerial photograph WA 1975 Pemberton Run 12 No. 5302 (p.240).

Protection : normal care providing shore exposures at Windy Harbour are preserved.

Presentation : a notice board explaining the nature of the Tamala Limestone could be considered.

The National Parks and Nature Conservation Authority should be consulted.

(80.)

MOUNT CHUDALUP

Location: 1:250,000 Geological Series Pemberton-Irwin Inlet
lat 34 46 S long 116 5 E

SIGNIFICANCE and VALUE

Classes III and V : Geomorphology
Education
Great Landscape Value

GEOLOGICAL NOTE

The granitoid dome of Mount Chudalup records the westward termination of the Proterozoic Albany Fraser Province and rises above the Gardner River plains offering spectacular views of coastal scenery to the south. It forms part of the Burnside Batholith and incorporates equigranular and porphyritic granites.

A short distance south at Lookout Rock alongside the Windy Harbour road, Proterozoic gneisses with sillimanite and rich in garnet are well-exposed.

Reference: Wilde, S.A. and Walker, I.W., 1984, Pemberton-Irwin Inlet, Western Australia: West. Aust. Geol. Survey, 1:250,000 Geol. Series Explan. Notes.

TENURE, ACCESS and POSSIBLE THREATS

Mount Chudalup lies within the D'Entrecasteaux National Park and a pleasant picnic spot is provided.

There is access from the Northcliffe-Windy Harbour road about 16 km south of Northcliffe where a left turn to the picnic area is taken. A track to the left 1.7 km further south leads to Lookout Hill.

No threats are foreseen.

RECOMMENDATIONS

A Geological Monument of 1.9 km² is recommended as shown on aerial photograph WA 1971 Pemberton Run 11 No. 5225 (p.241).

Protection : normal care.

Presentation : a notice board explaining the geology could be considered.

The National Parks and Nature Conservation Authority should be consulted.

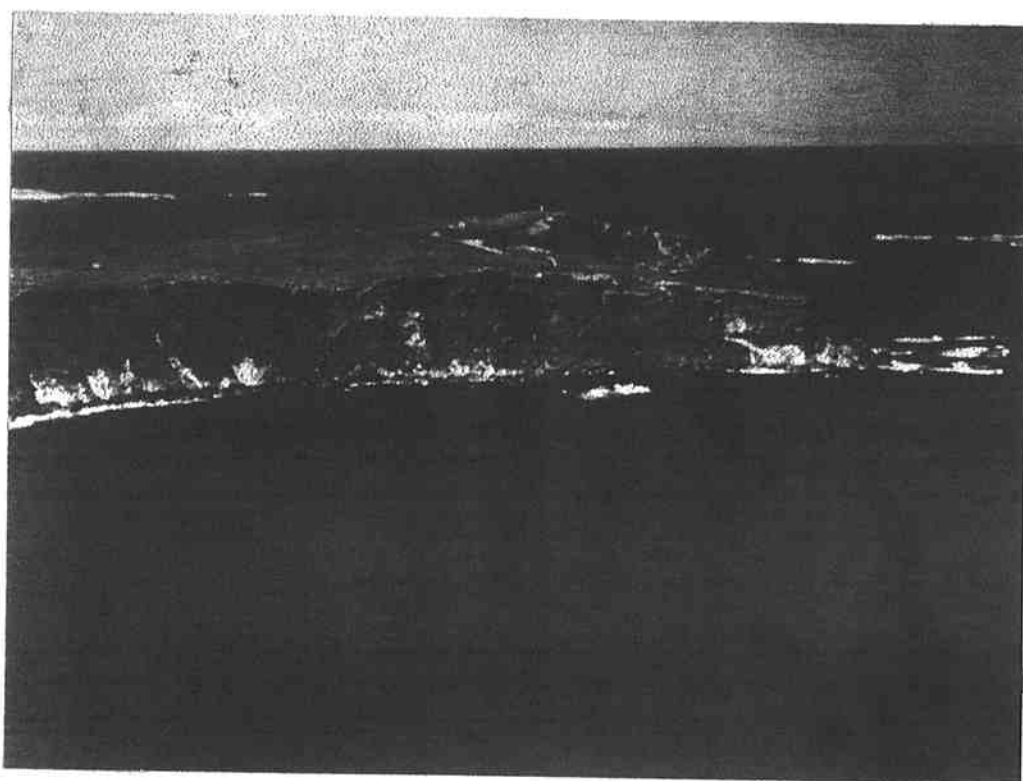


Plate 56

POINT D'ENTRECASTEAUX

Cliff Winfield

Tamala Limestone of the Pleistocene builds this southern bastion of the State. Beyond the lighthouse at the foot of the Point, gneiss 3000 m.y. in age outcrops along the shore

POINT D'ENTRECASTEAUX
MONUMENT

To Northcliffe and Mount
Chudalup (Monument)

Point D'Entrecasteaux built by
Pleistocene Tamala Limestone
Windy Harbour with granulites
3000 m.y. in age along foreshore

1000 0 1000 2000
m

N



PART II : COUNTRY NOT EXAMINED

KIMBERLEY

METEORITE IMPACT STRUCTURES

Part II country was not examined and consequently structures of locality dossiers are varied.

Three proven meteorite craters are recommended as Geological Monuments; other features should be examined on the ground and for the time being are recommended as outline monuments.

KIMBERLEY

In the northeast, Western Australia is distinguished by two of its more important geological elements, reef complexes of the Devonian and lamproites of Miocene age in West Kimberley. These features are shown on Figure 18 and form the bulk of the recommendations:

Devonian Reef Complexes

- | | |
|-------------------------|------------------|
| 81. Windjana Gorge | outline monument |
| 82. Tunnel Creek | outline monument |
| 83. Dingo Cap | outline monument |
| 84. Elimberrie Bioherms | outline monument |
| 85. Geikie Gorge | outline monument |
| 86. Bugle Gap | outline monument |
| 87. Westwood Creek | outline monument |

Lamproites of West Kimberley

- | | |
|--------------------|------------------|
| 88. Mount North | outline monument |
| 89. 81 Mile Vent | outline monument |
| 90. Walgidee Hills | outline monument |
| 91. Mount Cedric | outline monument |

- | | |
|----------------------|------------------|
| 92. Gantheaume Point | outline monument |
|----------------------|------------------|

The unique, enormously rich diamondiferous lamproite diatrema at Argyle in East Kimberley clearly is a paramount geological feature of the region but as it lies within a high security mining area where access is necessarily very strictly restricted, it is not considered.

Many visitors are attracted to the 'Devonian reef complex' National Parks of Windjana Gorge, Tunnel Creek and Geikie Gorge. Quite close to the Windjana Gorge road two fine lamproite features are found, Mount North and 81 Mile Vent, and these appear to offer promising opportunities to expand the geological reward for those making the long journey to the Kimberley.

WEST KIMBERLEY

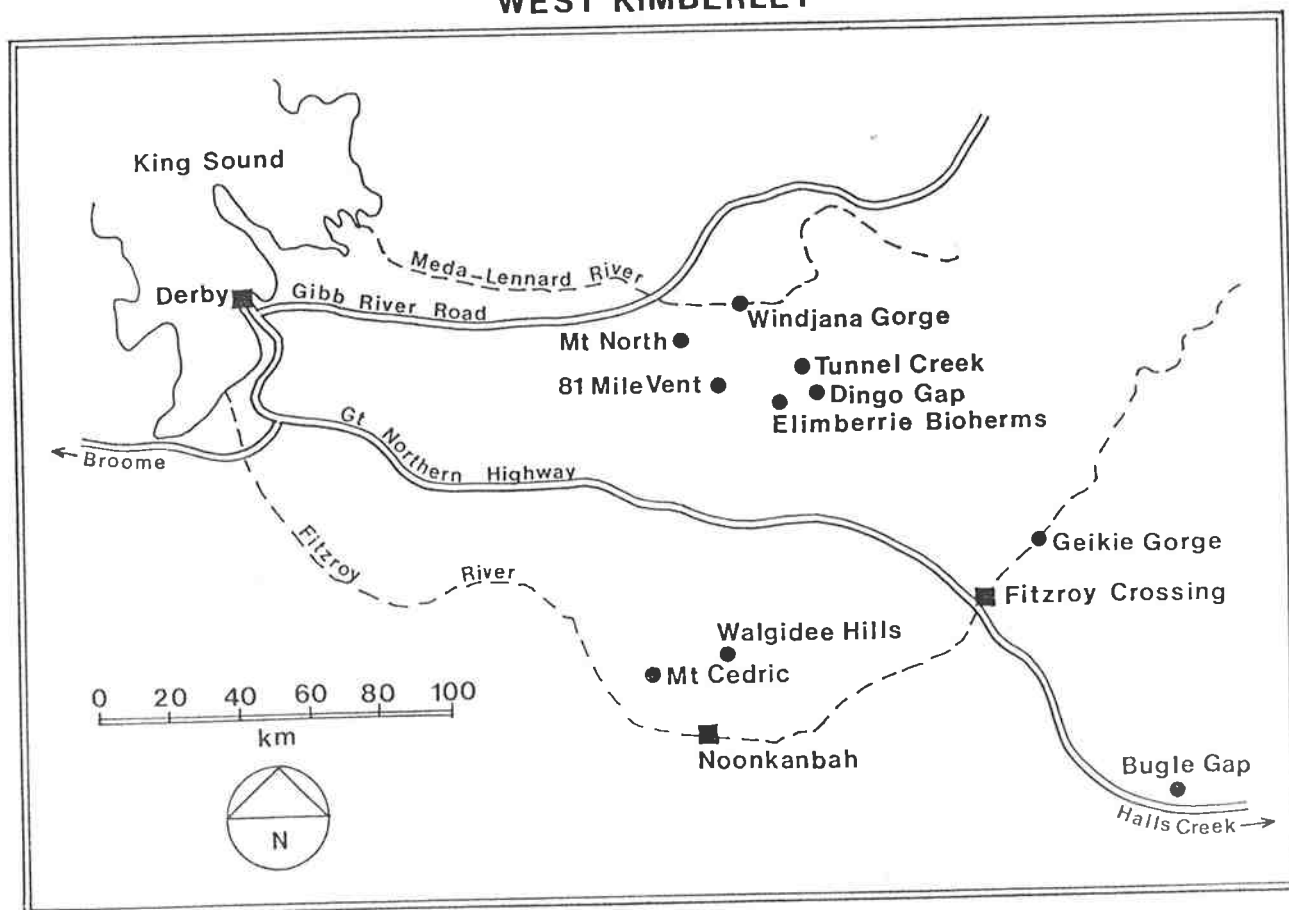


Figure 18

STATEMENT OF INTEREST

'In this long belt of limestone ranges we have the uplifted remnants of an ancient barrier reef which flanked the shores of the mountainous country to the north' so wrote Arthur Wade in 1936 when he introduced the now world famous Devonian great barrier reef of the Canning Basin where splendid sedimentary phenomena produced largely by simple plants and animals 350 m.y. ago are shown with compelling clarity among landscapes of exceptional beauty.

The exhumed limestone reefs form narrow hill ranges extending for 350 km such as Napier, Oscar, Pillara and Emanuel and these are cut by fine gorges, the best examples being Windjana and Geikie along the Lennard and Fitzroy Rivers where Middle and Upper Devonian limestones are magnificently presented along precipitous chasm walls. But perhaps the most arresting expressions of the exhumed reefs are seen near Bugle Gap where pinnacle reefs and platform atolls appear as they lived in warm Devonian seas.

Almost certainly this barrier reef continued for 1000 km around the present Kimberley region to the Kununurra area of the Bonaparte Basin where similar limestone reefs are exposed.

From the magnificent community of reef complex features in the Canning Basin six are selected:

Windjana Gorge,
Tunnel Creek,
Dingo Gap,

Elimberrie Bioherms,
Geikie Gorge and
Bugle Gap.

Westwood Creek is proposed in the Bonaparte Basin.

GEOLOGICAL BACKGROUND

This brief explanation of reef geology is derived from the reference followed for Canning Basin reef complexes, the comprehensive guidebook of Playford (1981).

Growth of the barrier reefs commenced in the Givetian of the Middle Devonian and extended through Frasnian and Famennian times in shallows over Precambrian rocks on which the reefs largely rest. There were two cycles of reef development, the first in the Givetian-Frasnian period when the chief builders were stromatoporoids, algae and corals and the second following a major faunal extinction when algae constructed limestone platforms in the Famennian shortly before the reef systems themselves became extinct for causes uncertain, and were covered by shale and sandstone of the Fairfield Group, a sequence extending into Lower Carboniferous times.

Essentially the complexes were reef-fringed limestone platforms flanked by slopes where layers of limestone descended several hundred metres into surrounding basins with shale, sandstone and thin limestone. Of the three principal facies, platform facies includes some five subfacies, marginal-slope facies incorporates three subfacies and together with basin facies, these rocks are assigned to the formations:

platform facies	marginal-slope and basin facies	
Nullara Limestone	Napier Formation	Piker Hills Formation
Windjana Limestone	Bugle Gap Formation	Virgin Hills Formation
Pillara Limestone	Gogo Formation	Sadler Limestone

References: Wade, A., 1936, The geology of the West Kimberley district of Western Australia: Freney Kimberley Oil Co. Rept., open file.

Playford, P.E., 1981, Devonian reef complexes of the Canning Basin, Western Australia: Fifth Australian Geological Convention Field Excursion Guidebook.

(81.) WINDJANA GORGE

Location: 1:250,000 Geological Series Lennard River

lat 17 24 S long 124 57 E

SIGNIFICANCE and VALUE

Classes I and V : Devonian Reef Environment
Research
Great Landscape Value

GEOLOGICAL NOTE

This picturesque gorge of some 4 km is cut by the Lennard River through Napier Range and contains a 'Classic Face' showing a Frasnian platform of Pillara Limestone with marginal-slope of Napier Formation, and sections of Famennian platforms formed by Windjana Limestone, and many other features.

Plate: 57

TENURE and ACCESS

Windjana Gorge lies within a National Park with access from Derby 140 km to the west and is best visited during cooler months. A mining tenement E 04/236 covers the National Park.



Plate 57 WINDJANA GORGE CUTS THROUGH NAPIER RANGE P.E. Playford

View to northwest: the gorge of the Lennard River cuts the exhumed Frasnian-Famennian reef complex of Napier Range.

It is 4 km long and up to 80 m deep and reveals the 'Classic Face'. Some 30 km southeast of Windjana Gorge the waters of Tunnel Creek flow below Napier Range.

RECOMMENDATIONS

Almost all the geological features of the Windjana Gorge area listed by Playford (1981) fall within the National Park and the Park of some 21 km² is recommended as an outline monument; the National Parks and Nature Conservation Authority should be consulted.

(82.)

TUNNEL CREEK

Location: 1:250,000 Geological Series Lennard River

lat 17 36 S long 125 8 E

Figure 19

SIGNIFICANCE and VALUE

Classes III and V : Geomorphology
Education
Attractive Setting

GEOLOGICAL NOTE

A remarkable tunnel cave carries Tunnel Creek through Napier Range for some 600 m and it is possible to walk from one entrance to the other. Tunnel Creek appears to have flowed along the top of the Range before it took an underground course following solution enlargements of joints in the limestone.

TENURE and ACCESS

The Tunnel lies within a National Park of about a square kilometre and there is access from Windjana Gorge 30 km to the northwest. A mining tenement E 04/350 affects this ground.

RECOMMENDATIONS

An outline monument is recommended for this National Park; the National Parks and Nature Conservation Authority should be consulted.

(83.)

DINGO GAP

Location: 1:250,000 Geological Series Lennard River

lat 17 39 S long 125 11 E

Figure 19

DEVONIAN REEF COMPLEXES

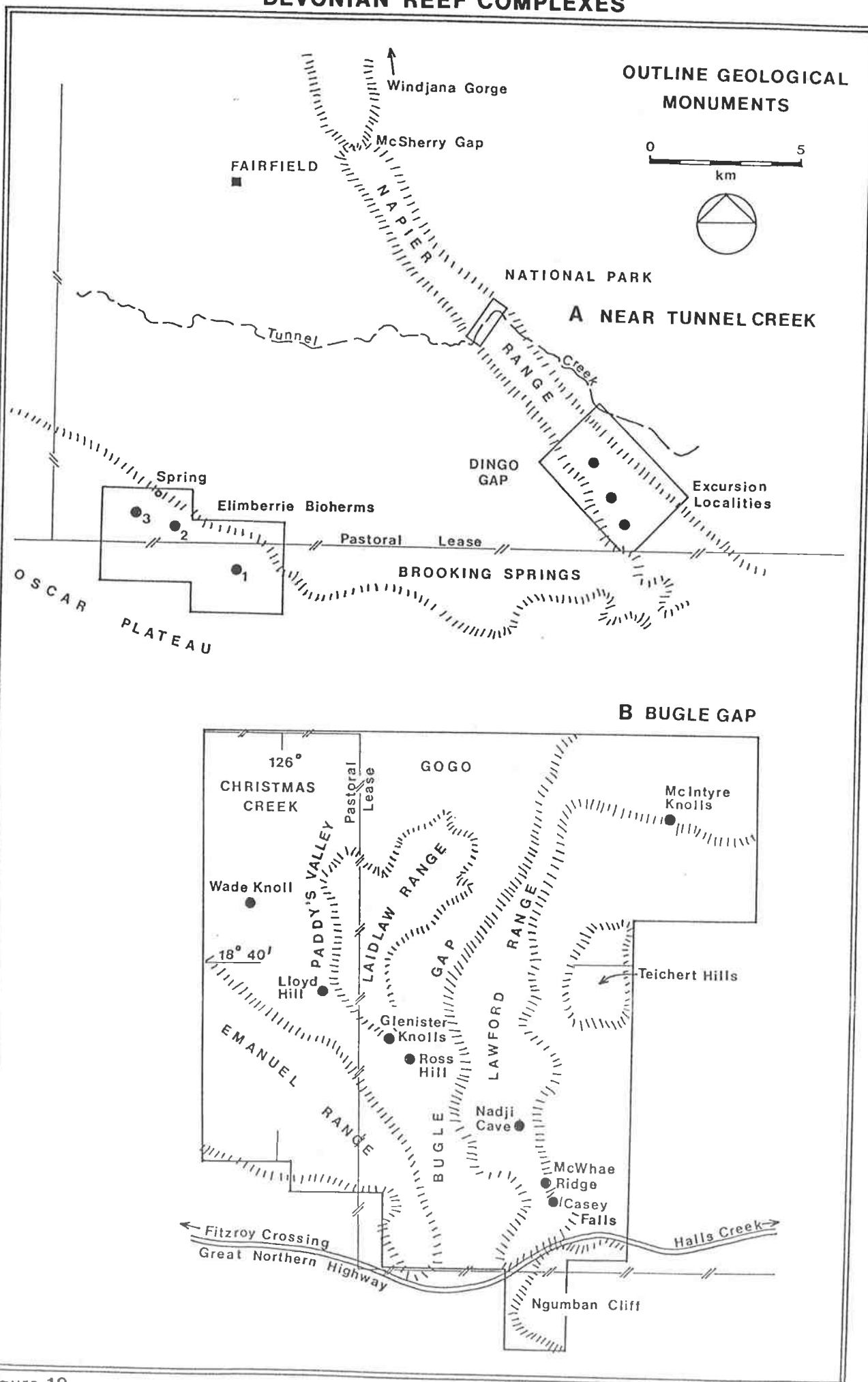


Figure 19

SIGNIFICANCE and VALUE

Class II : Devonian Reef Environment
Research
Attractive Setting

GEOLOGICAL NOTE

This wind and water gap through the Napier Range lying 4 km southeast of Tunnel Creek follows a relatively soft part of the marginal-slope facies of the Napier Formation and is flanked by resistant limestone ridges where huge debris flow deposits (olistostromes) derived from the ancient limestone platforms are particularly well-displayed.

TENURE and ACCESS

Fairfield Pastoral Lease 3114/748 includes Dingo Gap and owners, Banyena Pty. Ltd., are contacted through Leopold Downs Station, P.O. Box 207, Broome, WA 6725. Mining tenement E 04/350 encroaches on the ground now recommended.

There is access by track from Tunnel Creek.

RECOMMENDATIONS

For Dingo Gap an outline monument of some 12 km² is recommended as shown on Figure 19.

The owners of Fairfield Station and the mining tenement and the Shire of Derby-West Kimberley should be consulted.

(84.)

ELIMBERRIE BIOHERMS

Location: 1:250,000 Geological Series Lennard River
lat 17 41 S long 25 3 E
Figure 19

SIGNIFICANCE and VALUE

Class I : Devonian Stromatolites
Research

GEOLOGICAL NOTE

On the Oscar Plateau some 12 km southwest of Tunnel Creek National Park are found the most outstanding examples known in the world of Devonian stromatolite and stromatolite-sponge bioherms, one almost a kilometre in length. The group of three is of early Famennian age and represent sequences of life-forms grown in deep water on the top of drowned pinnacle reefs.

TENURE and ACCESS

Pastoral Leases of Fairfield, 3114/748, and Brooking Springs, 3114/573, cover the northern and southern parts of the bioherm group with owners respectively at Banyena Pty. Ltd., Leopold Downs Station, P.O. Box 207, Broome, WA 6725, and Bells Pastoral Co. Pty. Ltd., c/- Geikey Partnership, P.O. Box 50 Claremont, WA 6010. Access is by means of temporary tracks from Elimberrie Spring.

RECOMMENDATIONS

For the bioherms an outline monument of some 18 km² is recommended as shown on Figure 19.

The owners of Fairfield and Brooking Springs Stations and the Shire of Derby-West Kimberley should be consulted.

(85.)

GEIKIE GORGE

Location: 1:250,000 Geological Series Noonkanbah
lat 18 5 S long 125 43 E

SIGNIFICANCE and VALUE

Classes I and V : Devonian Reef Environment
Research
Outstanding Natural Beauty

GEOLOGICAL NOTE

The arresting beauty of this gorge and its permanent fresh water, the home of sawfish, stingrays and the Johnston crocodile, is heightened by flood-cleaned white limestone walls where internal features of limestones and fossils are shown with great clarity. The gorge cuts Geikie Range reef complex and contains excellent exposures of Pillara Formation platform facies and marginal-slope facies of Napier Formation.

Plate: 58

TENURE and ACCESS

Geikie Gorge lies partly within a National Park with access from Fitzroy Crossing and is visited usually from April to November. The Park is affected by mining tenement E 04/295. A sanctuary excludes visitors for 200 m from both banks of the gorge but many of the geological features described by Playford (1981) are approached by boat.

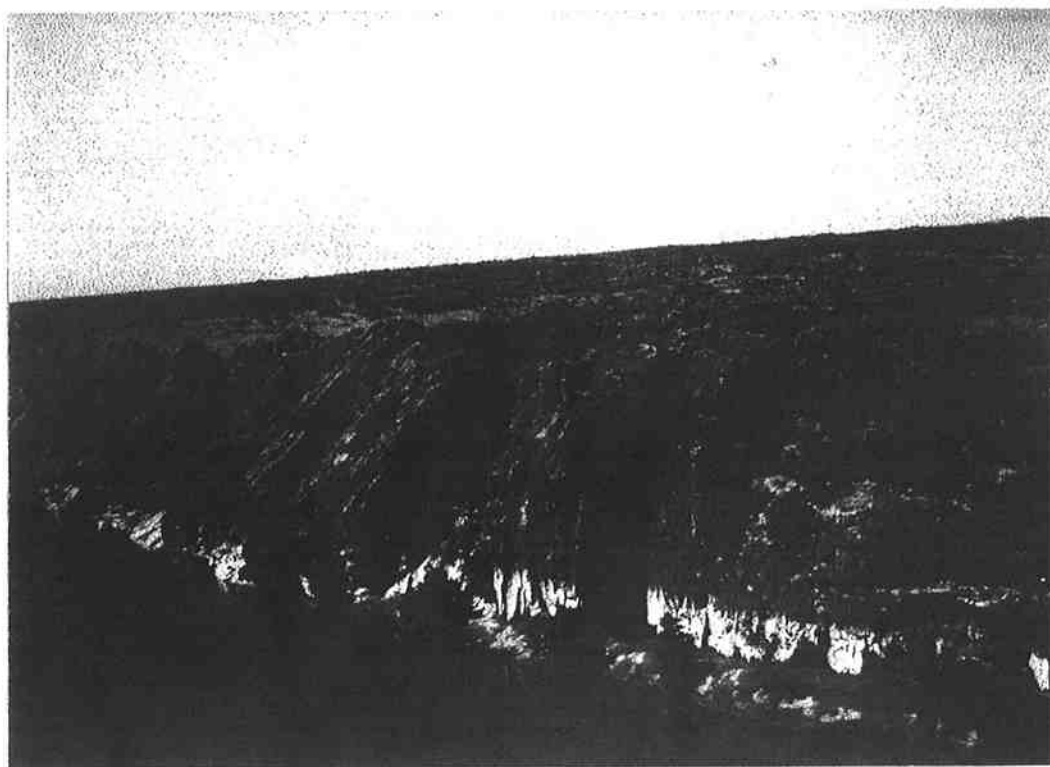


Plate 58 GEIKIE GORGE ON THE FITZROY RIVER P.E. Playford

View to northeast: near-horizontal platform facies of Pillara Limestone interfinger with or abut steeply dipping Napier Formation, a marginal-slope facies. Flood-cleaned white limestone walls display internal features of limestone and fossils with exceptional clarity

RECOMMENDATIONS

The National Park of some 31 km² is recommended as an outline monument but to include all important geological features, the monument may need to be extended northward along the Gorge, beyond the National Park. The National Parks and Nature Conservation Authority should be consulted.

(86.)

BUGLE GAP

Location: 1:250,000 Geological Series Mount Ramsay and Noonkanbah

lat 18 40 S long 126 E

Figure 19

SIGNIFICANCE and VALUE

Classes I and V : Devonian Reef Environment
Research
Outstanding Natural Beauty

GEOLOGICAL NOTE

Quite remarkable landscapes revealing the configuration of a Devonian sea floor and embracing a unique ensemble of large-scale reef complex phenomena place Bugle Gap among the foremost of the world's finest displays of classic geology. Here pinnacle reefs and platform atolls crowded with fossils, stand as they rose through tropical seas more than 350 million years ago and massive collapses of the great reef platforms are still marked by huge knolls of limestone debris.

This country lies about 100 km southeast of Fitzroy Crossing and covers some 260 km² and includes Bugle Gap and Paddy's Valley, and ranges such as Emanuel, Laidlaw and Lawford. Playford (1981) devotes 10 excursion stops to Emanuel Range, Wade Knoll, Lloyd Hill, Glenister Knolls, McIntyre Knolls, McWhae Ridge, Casey Falls, Teichert Hills, Nadji Cave and Ngumban Cliff, and this exceptional community of reef complex features should be treated together as a geological monument on a grand scale.

Plate: 59

TENURE and ACCESS

Pastoral Leases of Gogo, 3114/1115, and Christmas Creek, 3114/586, incorporate Bugle Gap, owners respectively being Margaret Downs Pty. Ltd. and Christmas Creek Pty. Ltd. both c/- W.A. Livestock Holdings Ltd., P.O. Box 682, West Perth, WA 6005. Ground now recommended is presently covered by a complex pattern of mining tenements (Mines Department plans Bohemia and Bruten 1:100,000 sheets).

Access is from the Great Northern Highway which runs along the southern limit of the area.

RECOMMENDATIONS

An outline monument of some 260 km² is recommended as shown on Figure 19. In the southwest it incorporates a small area of Vacant Crown Land but excludes Aboriginal Reserve No. 39302.

The intrinsic geological interest of Bugle Gap geomorphology is unsurpassed in Western Australia and the potential for public presentation of these fossil landscapes of Devonian times is very high.

The owners of Gogo and Christmas Creek Stations and mining tenements, and the Shires of Halls Creek and Derby-West Kimberley should be consulted.

(87.)

WESTWOOD CREEK

Location: 1:250,000 Geological Series Medusa Banks

lat 14 51 40 S long 128 30 5 E

Figure 1

SIGNIFICANCE and VALUE

Class III : Devonian Reef Environment
Research

GEOLOGICAL NOTE

A fine exposure of an exhumed Frasnian reef in the Bonaparte Basin at Westwood Creek about 120 km north of Kununurra is one of many Devonian reef outcrops in this Basin and these were almost certainly part of the ancient great barrier reef seen in the Canning Basin. Westwood Creek is distinguished by large pinnacle outcrops of stromatoporoid and stromatolite limestones, and good exposures of oncolite banks. The limestones are assigned to the Westwood Member of the Hargreaves Formation and because of their isolation are thought to represent a patch or pinnacle reef.

Reference: Beere, G. and Mory, A., The geology of the onshore Bonaparte and Ord Basins, Western Australia: West. Australia Geol. Survey Bull., in press.

TENURE and ACCESS

These Devonian reefs outcrop on Vacant Crown Land and access is obtained from Kununurra through Carlton Hill Station where permission is needed to negotiate a locked gate on Ningbing track.

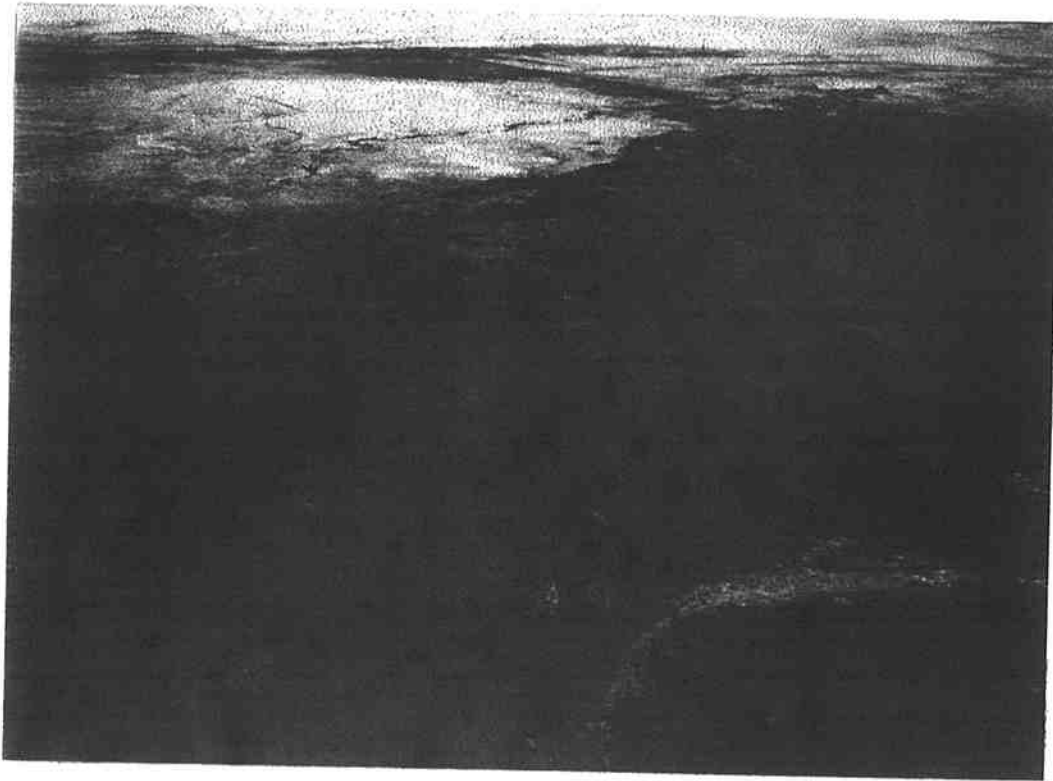


Plate 59

AN EXHUMED DEVONIAN SEAFLOOR
LAIDLAW RANGE AT BUGLE GAP

P.E. Playford

View to north over the Laidlaw Range Frasnian platform atoll. Lloyd Hill pinnacle reef-platform atoll is in left middle distance; Glenister Knolls patch reefs are seen below the tail of Laidlaw Range and Bugle Gap (right) and Paddy's Valley (left) follow interreef basins. In the right foreground Carboniferous-Permian rocks of Ross Hill rest upon the reef complex

RECOMMENDATIONS

For Westwood Creek an outline monument about one kilometre square is recommended for the locality now defined by latitude and longitude on the Medusa Banks 1:250,000 Geological Series.

The Shire of Wyndham-East Kimberley should be consulted.

DISCUSSION: OTHER LOCALITIES, THREATS and PROPOSAL

Other localities in the Canning Basin suggested in various papers include **McSherry Gap** (Figure 19; debris flow deposits in Napier Range), **Brooking Gorge** (best section of Oscar Range reef complex) and **Menyous Gap** in Pillara Range (outstanding sections through Pillara and Sadler Limestones). These are not taken up as the essentials of their geology are exemplified by the locales recommended but they should be considered whenever the reef complexes are inspected.

Threats to the reef complexes, over-collecting fossils apart, are not obvious as the rocks are secured by the imposing scales of the ranges and gorges and to some extent by their isolation, and three of the recommended features are incorporated within National Parks. There is mention of damage by tourists and cattle but no specific examples are described although wanton hammering has spoiled formations at Westwood Creek in spite of its remoteness (p.271). A high priority protection status should be given to all outline monuments apart from Dingo Gap where normal care should be taken.

What appears to be needed is an assessment of the impact of tourism, geological excursions and pastoral activity on the reef complexes to determine whether further protection measures are necessary, and to use the assessment to decide what additional portions of this outstanding geology should be covered by Class A Reserves with access facilities. For example the public should be introduced to the magnificent spectacles of Bugle Gap where geomorphology on a grand scale portrays one of the most imposing fossil landscapes known on Earth.

88. - 91. LAMPROITES OF WEST KIMBERLEY

STATEMENT OF INTEREST

Nearly half-a-century ago R.T. Prider brought attention to lamproite plugs in west Kimberley by remarking 'that they were derived by differentiation from a peridotite magma, like the well-known kimberlites of South Africa' and thus prepared the way for Kimberley diamond exploration and its successful culmination in the late 1970s with the discovery of diamonds in these volcanic intrusions of the Miocene. Ultrapotassic lamproitic rocks while broadly kimberlitic have significant petrological and chemical differences but diamond grades show they are an important source of the gemstone.

Numerous features of high geological interest were revealed during diamond searches including a host of well-preserved volcanic forms and structures, rocks of unusual chemical composition and rare minerals. More than 100 separate pipes, plugs, sills and dykes are identified and from these four are selected to represent many outstanding examples of volcanic geology and their petrologically interesting rocks and unusual minerals:

Mount North
81 Mile Vent

Walgidee Hills
Mount Cedric

References: Wade, A. and Prider, R.T., 1940, The leucite-bearing rocks of the West Kimberley area, Western Australia: Quart. J. Geol. Soc. Lond., 98, 39-98.

Jaques, A.L., Lewis, J.D. and Smith, C.B., 1986, The kimberlites and lamproites of Western Australia: West. Australia Geol. Survey Bull. 132.

Gunn, M.J., 1986, (Compiler), Excursion guide to the Lamproites of the Kimberley region Western Australia: Fourth International Kimberlite Conference, Perth 1986.

J.D. Lewis of the Geological Survey of Western Australia advised on the selection of features now recommended for listing.

DISCUSSION: OUTLINE MONUMENTS, ACCESS AND THREATS

Outline geological monuments for lamproite intrusions are defined without recourse to figures or aerial photographs by proposing square-shaped areas centred on the generally prominent landmarks formed by these ovoid bodies. Scaled drawings in the Excursion Guide (Gunn, 1986) allow this approach though ground checks of recommendations are needed.

Access to Mounts North and Cedric for a 1986 international excursion was by specially constructed tracks which may not have

survived subsequent wet weather and there is no reliable information on routes over the final kilometres to these features.

Lamproites alongside main roads, 81 Mile Vent and Walgidee Hills, may be threatened if exploited for road metal. On the other hand controlled quarrying could improve poor exposures in the same way as along the Darling Range near Perth where features recommended for listing in 1979 include a quarry suite; quarrying proposals therefore should not be rejected as a matter of course.

(88.)

MOUNT NORTH

Location: 1:250,000 Geological Series Lennard River
lat 17 29 S long 124 48 E

SIGNIFICANCE and VALUE

Classes I and V : Lamproite Volcanism
Research
Attractive Setting

GEOLOGICAL NOTE

This prominent landmark with steep cliffs of columnar lamproite rises some 90 m above the Lennard River plains. An excellent exposition of lamproite geology includes tuffs, sills and a massive central intrusion.

Plate: 60

TENURE, ACCESS and THREATS

Mount North is situated within Pastoral Lease 3114/692 Kimberley Downs with owners Kimberley Downs Pty. Ltd., c/- Australia Land and Cattle Co., G.P.O. Box T 1664, Perth, WA 6001. It is incorporated within mining tenement E 04/75 with mineral claims to the west.

An approximate instruction - Mount North is reached from Derby about 130 km to the west by taking the road to Windjana Gorge National Park and bearing southeast some 30 km west of the Park; immediate access 4WD.

There are no obvious threats other than possible development for construction material which should be resisted here.

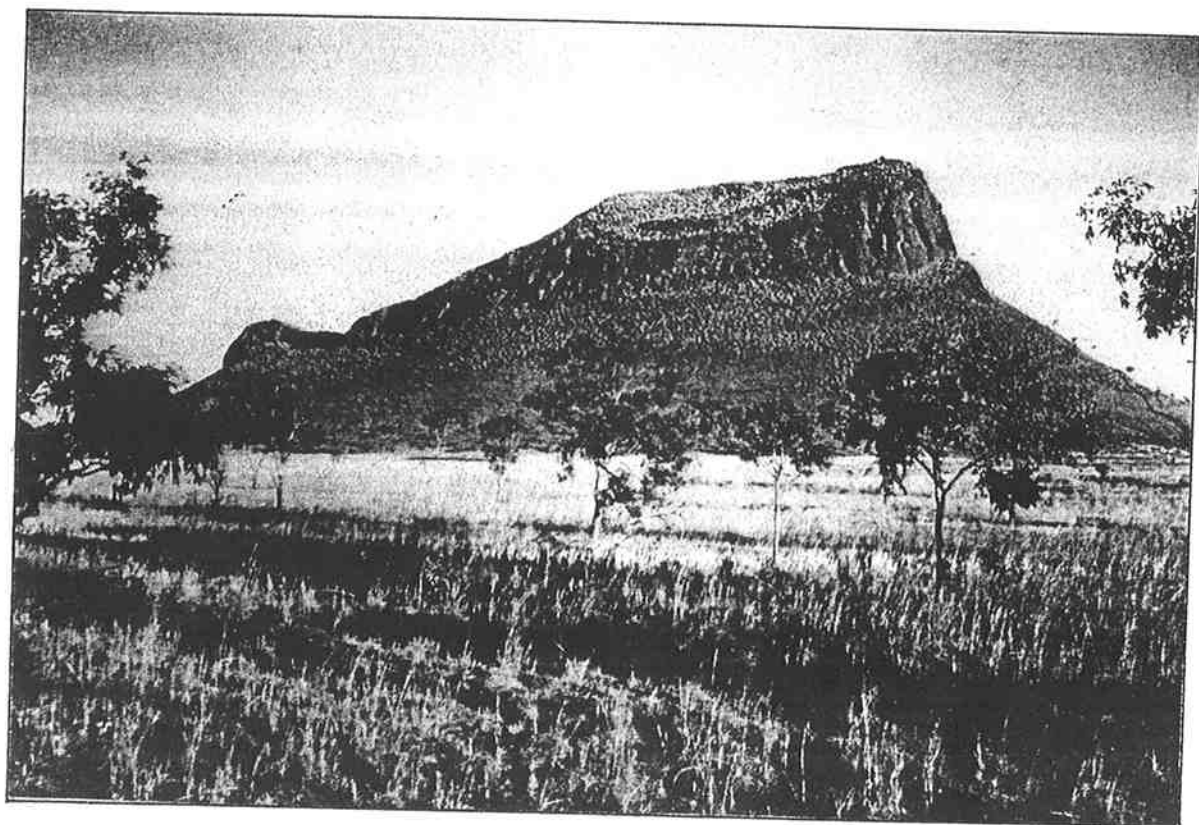


Plate 60

MOUNT NORTH

G.M. Derrick

This landmark rises some 90 m above the plains:
steep cliffs of columnar jointed lamproite overlie
lamproite tuffs with thin interlayered lamproite sills

RECOMMENDATIONS

An outline monument one kilometre square centred on Mount North is recommended.

Protection : a high priority for this conspicuous and pristine example of volcanic geology.

Presentation : there is good potential; this well-exposed volcanic plug stands not far from the road to much visited Windjana Gorge.

The owners of Kimberley Downs Station and the mining tenement, and the Shire of Derby-West Kimberley should be consulted.

(89.)

81 MILE VENT

Location: 1:250,000 Geological Series Lennard River

lat 17 38 S long 124 53 E

SIGNIFICANCE and VALUE

Classes II and V : Lamproite Volcanism
Research

GEOLOGICAL NOTE

A roughly circular ridge 200 m in diameter and 15 m high marks one of the best-exposed and most instructive of the lamproite vents with a host of volcanic structures.

TENURE, ACCESS and THREATS

The Vent lies within Pastoral Lease 3114/692 Kimberley Downs of Kimberley Downs Pty. Ltd., c/- Australia Land and Cattle Co., G.P.O. Box T 1664, Perth, WA 6001. An involved mining tenement situation is shown on Mines Department 1:100,000 plan Ellendale.

81 Mile Vent lies alongside a track some 20 km southeast of Mount North and is reached from Derby perhaps 150 km distant by taking the Windjana Gorge National Park and Mount North roads.

Proximity to a track suggests it could be used for road construction material.

RECOMMENDATIONS

An outline monument 500 m square centred on the Vent is recommended.

Protection : normal care but could controlled quarrying improve exposure?

Presentation : there is potential; the Vent stands alongside a track and is not too far from the road to Windjana Gorge.

The owners of the Pastoral Lease and mining tenements, and the Shire of Derby-West Kimberley should be consulted.

(90.)

WALGIDEE HILLS

Location: 1:250,000 Geological Series Noonkanbah
lat 18 19 S long 124 52 E

SIGNIFICANCE and VALUE

Class I : Rare Minerals
Research

GEOLOGICAL NOTE

Rare minerals are found in the lamproite intrusion of Walgidee Hills and this at nearly 3 km in diameter is the largest of West Kimberley lamproites but apart from a small central portion it is poorly exposed. However this central portion of coarse-grained lamproite contains pegmatoid veins up to a metre across carrying rare minerals of potassium, zirconium, titanium and barium for which the intrusion is famous and species include potassic richterite, priderite (Ba,Ti), wadeite (Zr), jeppeite (Ba,Ti) and shcherbakovite (Ba).

TENURE, ACCESS and POSSIBLE THREATS

The Hills lie within Pastoral Lease 3114/576 Noonkanbah of the Noonkanbah Pastoral Co. Pty. Ltd., c/- Yungngora Association Inc., P.O. Box 35 Fitzroy Crossing, WA 6765.

The graded road leaving the Great Northern Highway south to Calwynyardah and Noonkanbah crosses Walgidee Hills.

Rare minerals must attract collectors.

RECOMMENDATIONS

An outline monument 4 kilometres square centred on the intrusion should be considered.

Protection : probably a high priority for rare minerals but information on resources of these is not precise. (Controlled quarrying may improve exposure.)

Proposal : a survey of this rare mineral source should be undertaken to determine whether measures are needed to protect it.

Presentation : there is potential because of easy roadside access but consideration should await the findings of the mineral survey now suggested.

The owners of the Pastoral Lease and the Shire of Derby-West Kimberley should be consulted.

(91.)

MOUNT CEDRIC

Location: 1.250,000 Geological Series Noonkanbah
lat 18 21 S long 124 43 E

SIGNIFICANCE and VALUE

Class II : Lamproite Volcanism
Research

GEOLOGICAL NOTE

One of the larger lamproite intrusions, Mount Cedric, a well-exposed multivalent complex with two intrusive centres of differing ages, incorporates a range of lamproite rocks and lithologies including pyroclastics, dykes and coarse lamproites of varied mineralogy.

TENURE, ACCESS and POSSIBLE THREATS

Pastoral Lease 3114/975 Liveringa of Northern Developments Pty. Ltd. and A.E. Four Inc., c/- Peat, Marwick, Mitchell and Co., G.P.O. Box A29, Perth WA 6001, includes Mount Cedric which is covered partially by mining tenement E 04/183.

Access is from the Fitzroy River road near Noonkanbah (4WD).

No threats are foreseen.

RECOMMENDATIONS

An outline monument one kilometre square centred on Mount Cedric is recommended.

Protection : normal care.

Presentation : not suitable; remote.

The owners of the Pastoral Lease and the mining tenement, and the Shire of Derby-West Kimberley should be consulted.

92.

GANTHEAUME POINT

STATEMENT OF INTEREST

Several sets of generally well-preserved footprints of a large dinosaur are seen in Lower Cretaceous sandstone along the shore in the tidal zone below Gantheaume Point near Broome. Comparisons made with similar dinosaur prints in other parts of the world and the Broome locality add to evidence of the distribution of these large reptiles.

Location: 1:250,000 Geological Series Broome
lat 17 58 30 S long 122 10 30 E
Figure 1

SIGNIFICANCE and VALUE

Class II : Dinosaur Footprints
Reference
Attractive Setting

GEOLOGICAL NOTE

The Broome Sandstone in which the footprints occur is a continental deposit and its several sets of dinosaur footprints were probably made by a single species with a stride length of about 2 m.

Reference: Colbert, E.H. and Merrilees, D., 1967, Cretaceous dinosaur footprints from Western Australia: Journal of the Royal Society of Western Australia, v.50, p.21-25.

TENURE, ACCESS and POSSIBLE THREATS

The footprints are exposed below high water mark and this shore is incorporated in the Port of Broome under the control of the Minister of Transport. The shore is adjoined by Class C Reserve No. 19289 'Recreation' vested in the Shire of Broome.

There is access to Gantheaume Point by roads from Broome.

There are no obvious threats other than reckless collectors.

RECOMMENDATIONS

An outline monument is recommended for a 100 m wide strip of coastline and the intertidal zone along Gantheaume Point extending for a kilometre east of the Point and 5 km southeast of the Point.

Protection : high priority.

Presentation : not suitable; tidal vagaries.

The Minister of Transport and the nearby Shire of Broome should be consulted.

OTHER LOCALITIES

Bungle Bungle National Park (Dixon Range 1:250,000 Geological Series); as well as incorporating the Piccaninny Astrobleme (p.270), the Park is famous for its landforms including sandstone 'bee-hive' topography on a grand scale.

Hidden Valley, Kununurra (Cambridge Gulf 1:250,000 Geological Series); this small National Park of 18 km² incorporates sandstone 'bee-hive' landscape similar to the much larger examples in Bungle Bungle National Park.

Osmond Creek, Ord River (Dixon Range 1:250,000 Geological Series, 17 10 10 S 128 50 50 E); outstanding exposures of Cambrian trilobite tracks on sandstone bedding surfaces.

Roadside fossiliferous gravel heaps of the Carboniferous Fairfield Group 16 km northwest of Fitzroy Crossing were suggested but it is understood these heaps have been removed. Type sections and fossiliferous localities of Permian strata in West Kimberley such as **Mount Hardman, Brutens Yard and Grant Range** appear in some lists.

METEORITE IMPACT STRUCTURES

Western Australia lays claim to one of the two best-known meteorite impact structures of the world and perhaps the more beautiful of these structures, the crater in the Kimberley plains at Wolf Creek which is a little smaller than the great scar of Meteor Crater in Arizona in the United States.

Indeed, the old land surfaces of the State are distinguished by their number and variety of meteoritic indentations for of the 15 proven meteorite craters known on Earth, these being craters containing meteorite fragments, three are found in Western Australia, Wolf Creek and the much smaller craters at Veevers in the Gibson Desert and Dalgara near Cue. As well as these, there are seven probable and possible impact structures including the very large and extraordinarily shaped Spider in the Kimberley and the large Piccaninny Astrobleme close by in Bungle Bungle National Park:

Proven meteorite craters		Diameter
		m
93. Wolf Creek		950
94. Veevers		80
95. Dalgara		25
Probable meteorite impact structures		km
96. Connolly Basin		9
97. Goat Paddock		5
Deeply eroded probable meteorite impact structures		
98. Lake Teague		30
99. The Spider		20
100. Piccaninny Astrobleme		7
Possible meteorite impact structures		
101. Dampier		100 ?
102. Pippingarra		50-100 ?

General reference: Shoemaker, E.M. and Shoemaker, C.S., 1985, Impact Structures of Western Australia: Meteoritics v.20, No. 4.

Figure 20 shows the locations of the impact structures.

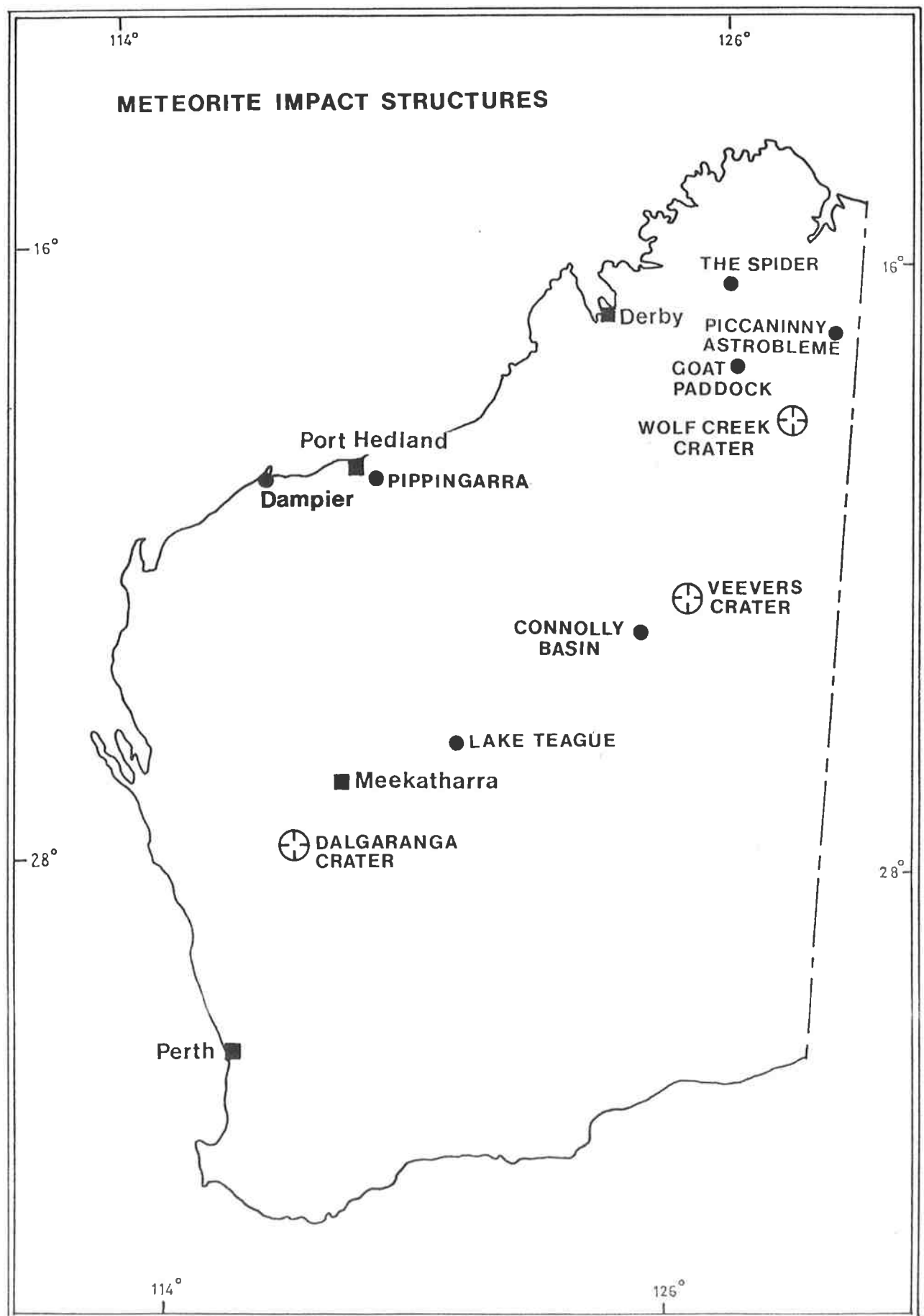


Figure 20

DISCUSSION

No meteorite impact structure was examined but proven meteorite craters can be recommended as Class 1 Geological Monuments with a satisfactory degree of assurance and a 'high priority' protection status should be assigned to each. The Dalgara Crater, a stop for tourist coaches (it is understood) requires inspection to assess whether the feature needs special protection. Wolf Creek lies within a National Park and Veevers in the central deserts. Other impact structures are huge and situated in remote country, and all are unaffected by threat.

PROVEN METEORITE CRATERS

93.

WOLF CREEK CRATER

Location: 1:250,000 Geological Series Billiluna
lat 19 11 S long 127 48 E

SIGNIFICANCE and VALUE

Classes I and V : Meteorite Crater
Reference
Outstanding Natural Beauty

COMMENT

Wolf Creek crater is incorporated within a National Park and this beautiful structure in the Kimberley sandplain is up to 950 m across and some 50 m deep, and is approached from Halls Creek a little more than 100 km to the north.

Reference: McNamara, K., 1982, Wolf Creek Crater, Western Australian Museum, p.20.

RECOMMENDATIONS

Wolf Creek Crater National Park (14.6 km²) is recommended as a Geological Monument; the National Parks and Nature Conservation Authority should be consulted.

94.

VEEVERS CRATER

Location: 1:250,000 Geological Series Ural
lat 22 58 S long 125 22 E

SIGNIFICANCE and VALUE

Class I : Meteorite Crater
Reference

COMMENT

This crater of some 80 m diameter lies in the central desert on Vacant Crown Land; meteorite fragments were found in 1984 (Shoemaker et al, 1985).

Reference: Yeats, A.N., Crowe, R.W.A. and Towner, R.R., 1976, The Veevers Crater: a possible meteoritic feature. BMR Journal of Australian Geology and Geophysics, 1(1), 77-78.

RECOMMENDATIONS

A Geological Monument one kilometre square centred on the crater is recommended; the Shire of East Pilbara should be consulted.

95. DALGARANGA CRATER

Location: 1:250,000 Geological Series Cue

lat 27 38 S long 117 17 E

SIGNIFICANCE and VALUE

Classes I and V : Meteorite Crater
Reference

COMMENT

This 25 m diameter crater is approached from Mount Magnet by an hour's drive along the Mount Farmer road and is a minor tourist attraction. It is situated within Class C Reserve No. 28497 'Museum Meteorite Crater' of 259 ha controlled by the Lands Administration Department.

Reference: McCall, G.J.H., 1965, New material from, and a reconsideration of the Dalgara meteorite and crater, Western Australia: Mineralog. Mag. v.35, p.476-487.

RECOMMENDATIONS

A Geological Monument corresponding to the Class C Reserve is recommended and the Lands Administration Department should be consulted. An inspection to consider protective measures should be undertaken.

PROBABLE METEORITE IMPACT STRUCTURES

These potential Class 1 Geological Monuments were not investigated beyond determining locations and principal information sources. E.M. Shoemaker (General Reference, p.265) is conducting research into Western Australia's meteorite impact structures and further recommendations for listing should be taken up following an assessment of his findings though a list should include the convincing and spectacular Spider and the equally convincing Piccaninny Astrobleme.

96.

CONNOLLY BASIN

Location: 1:250,000 Geological Series Morris

lat 23 33 S long 124 45 E

Surface evidence consists of a form line (unnamed on Morris map sheet) enclosing a shallow 9 km basin with a central peak of highly deformed sandstone (Shoemaker et al, 1985).

97.

GOAT PADDOCK

Location: 1:250,000 Geological Series Mount Ramsay

lat 18 20 S long 126 40 E

The crater consists of a circular plain about 5 km in diameter bounded by steep cliffs up to 150 m high. Shocked rocks suggest an origin by meteorite impact.

Reference: Harms, J.E., Milton, D.J., Ferguson, J., Gilbert, D.J., Harris, W.K. and Goleby, B., 1980, Goat Paddock cryptoexplosion crater, Western Australia: Nature v.286, p.704-706.

98.

LAKE TEAGUE

Location: 1:250,000 Geological Series Nabberu

lat 25 52 S long 120 53 E

This is an enormous structure nearly 30 km across and may represent a meteorite impact during the Proterozoic.

Reference: Bunting, J.A., de Laeter, J.R. and Libby, W.G., 1980, Evidence for the age and cryptoexplosive origin of the Teague Ring Structure, Western Australia: West. Australia Geol. Survey Ann. Rept., 1979, p.125-129.

99.

THE SPIDER

Location: 1:250,000 Geological Series Mount Elizabeth

lat 16 45 S long 126 5 E

An extraordinarily shaped structure and surrounds of up to 20 km in diameter are believed to be the result of an oblique impact and attract the name from a core of sub-radial quartzite ridges (where shatter cones are found) resembling a spider over-endowed with legs with striking appearance when viewed on aerial photographs and Landsat image 116-72 Lennard River (C.D Arndt, pers. comm.). From the air the Spider rivals Wolf Creek Crater in geomorphological interest; it is shown on the cover of 'The Australian Geologist' Newsletter No. 60, September 20th, 1986.

100.

PICCANINNY ASTROBLEME

Location: 1:250,000 Geological Series Dixon Range

lat 17 25 S long 128 26 E

This elliptical structure up to 7 km in diameter lies within the Bungle Bungle National Park and has a central zone of intense disharmonic folding surrounded by inwardly dipping beds.

Reference: Beere, G.M., 1983, The Piccaninny Structure - a cryptoexplosive feature in the Ord Basin, East Kimberley: West. Australia Geol. Survey Record, 1983/6 (unpublished).

See Records of the Survey, aerial photograph Dixon Range Run 4 No. 7328.

POSSIBLE METEORITE IMPACT STRUCTURES

101. - 102.

DAMPIER AND PIPPINGARRA

Dampier and Pippingarra, located respectively on the Dampier and Barrow Island (20 30 S, 116 45 E), and Port Hedland-Bedout Island (20 30 S, 118 45 E) Geological Series sheets, with diameters thought to range up to 100 km are believed to be possible impact structures but are merely noted. Should they prove to be of impact origin then critical portions could be selected for listing as Geological Monuments.

DISCUSSION

IMPORTANT GEOLOGICAL LOCALITIES : PROTECTION AND PRESENTATION

Introduction

Geologists are concerned by the misuse of fine geological localities. There are many examples such as those described 25 years ago on p. 220 of the report* on National Parks and Nature Reserves in Western Australia: 'Today it is almost impossible to find certain fossils which were formerly abundant in the Irwin River and Geraldton districts'. Similar assertions are made for rare rock and mineral occurrences elsewhere in Australia and other parts of the world and these aptly describe the despoiled stromatolite horizons of North Pole (7) in the Pilbara discovered a few years ago. And in the Kimberley during 1987, the type section of the fossiliferous Ordovician Emanuel Formation near Bugle Gap (86) was found scarred by diamond sawing and senseless hammer damage was seen at Westwood Creek (87)+.

It is not surprising therefore when seeking information on important localities the writer was confronted with opposition to the survey including the remark 'when the Heritage Commission demonstrates a capacity to protect their listed areas then the Commission can expect co-operation', for many geologists feel it is irresponsible to list and thus publicise geology and further expose it to uncontrolled use and possible destruction. However every fine geological locality will be discovered and 're-discovered' over the years and will be used over and over again, and if these are to be protected then formal measures will need to be introduced eventually for all important geology no matter where it is situated.

Formal measures call for protective land reservation but no legislation exists specifically to protect important geological localities and land reservation alone will not be successful unless geologists and the public are educated in the careful use of sites. It is thought education should be promoted by issuing a code for geological fieldwork and by systematically presenting selected examples of field geology to the public both to foster appreciation of the geological heritage and to involve non-specialists in its protection. The writer does not believe that communicating geological arcana to non-specialists breaks some celestial seal so that evil ensues and does believe geologists have a responsibility to encourage an informed public to use selected geological localities.

* See Antecedents, p.1

+ S.K. Skwarko, pers. comm.

Scattered throughout the dossiers there is information on land reservations closely related to geological features as well as various recommendations for their protection and presentation and this is gathered together with the purpose of identifying guidelines to suggest policies for the subjects. Much consideration was given to the protection of geology in the reports on National Parks and Nature Reserves (p.1) and the 1979 Perth district survey. Contributions now made are intended to supplement these ideas and advance the debate which so far appears to have been ineffective for the writer is not aware that any geological locality is actually secured for controlled general geological use apart from the Armadale Shale Quarry referred to in the next section.

Land Reservation

In Part A of the 1979 Perth district report factors of land tenure and legislation relating to geological localities are examined and these discussions should be consulted with suggestions now put forward.

During the Perth survey it was disclosed that two localities both subsequently recommended as Geological Monuments were recognised as being important by local authorities:

Armadale Shale Quarry - a teaching site used since the 1930s; at the request of the landowner the quarry of some 1.39 ha was zoned by the Armadale-Kelmscott Shire Council in 1976 as 'Public Amusement (Geological Exhibit)';

Peppermint Grove Limestone - a Pleistocene shell bed exposed in a Class A Reserve for 'Recreation' along the Swan River foreshore also used for teaching; the Peppermint Grove Shire following consultation with the Western Australian Museum set up a notice board prohibiting the removal of material to stop despoilation of the shell bed but unfortunately in 1986 the notice board was not to be seen.

In the tabulation derived from the recent study, other locales recognised as having geological importance by State and local authorities are shown. Only those reserves aimed chiefly at protecting geological features are listed and large National Parks where the conservation of geological features does not appear to be the principal intention are not included. Among these are the Hamersley, Cape Range, Kalbarri and Nambung National Parks, and the Parks along the south coast.

Tabulation : Land 'Reserved' for Geological Features

	Reserve Class	Purpose	Area ha	Controlling Shire/Authority
1. Marble Bar & Chinaman Pools	II	A Recreation	97	East Pilbara
52. Bindoo Spring	III	- (Glacier Bed Road to Greenough River Reserve)	-	Mullewa
53. Coal Seam Park	II	A Protection of Natural Features	642	Mingenew
67. Binaronca Rock	III	C Flora & Fauna	186	National Parks
69. Wave Rock	II	C Recreation	98	Kondinin
81. Windjana Gorge	I	A National Park	2134	National Parks
82. Tunnel Creek	III	A National Park	91	National Parks
85. Geikie Gorge	I	A National Park	3136	National Parks
93. Wolf Creek	I	A Meteorite Crater	1460	National Parks
95. Dalgara	I	C Museum-Meteorite Crater	259	Lands Administration

Binaronca Rock is included as this Class C Reserve seems to owe its existence to a single geological element, the Binneringie Dyke.

These features are recommended as Geological Monuments and their levels of geological significance are shown (II, etc.). More than half are covered by Class A Reserves and ideally it appears that Geological Monuments and more important Geological Sites should attract land reservations corresponding in consequence to a Class A reserve but with regulations designed to facilitate careful geological use. This useful summary of the range of regulations needed is set out on p.220 of the National Parks and Nature Reserves report (p.1) but the scope should be widened to encourage participation by an educated public since their involvement is essential for the long-term protection of sites, many of which are remote and could not be supervised:

- (a) Building, or construction work of any kind, should be undertaken only with the approval of the controlling authority.
- (b) Mining, quarrying, dam-construction, or any other activity involving the destruction of rock outcrops, should be controlled. The designation of an area as a geological reserve need not necessarily preclude its use for the purposes mentioned. The important thing is that authorization of destructive activities should rest with a responsible scientific body.
- (c) Although it would usually be necessary to restrict cultivation on geological reserves, there seems to be no reason why they should not be used for pastoral purposes.

- (d) Unrestricted collecting, particularly of fossils, must be prohibited. This is especially important in the south-western portion of Western Australia, where few richly fossiliferous localities are known. Today it is almost impossible to find specimens of certain fossils which were formerly abundant in the Irwin River and Geraldton districts. As roads improve, and the population becomes more mobile, one may expect the depredations of the casual collector to become even more apparent. It is therefore suggested that the collection of at least certain species within geological reserves should be subject to restrictions similar to those which apply to many elements of our present flora and fauna.
- (e) Access to a geological reserve must be guaranteed, at least to professional geologists, students, and other people with a genuine scientific interest in the area. At present access to geologically important areas is not a problem in Western Australia, and the overwhelming majority of property owners are most co-operative. However, with closer settlement it may become as subject to the whims of individual landowners as it has in some other Australian States. At the same time the regulations governing the purposes of geological reserves should be framed to give neighbouring property owners adequate protection from additional fire risks and intrusions on their rights.

No insurmountable conflict is foreseen by the writer between existing land uses and land reservation for geological purposes even in the wheat belt ('C' above, as outcrop is not cropped), providing a code for geological fieldwork is drawn up - suggestions for a code are made in a later section.

It should be mentioned that areas of ground shown in the tabulation reflect the practice of incorporating large buffer zones around geological features where circumstances permit. Wolf Creek Crater, for example, is covered by a reserve almost ten times larger than the crater and Dalgara Crater (25 m in diameter) is covered by a reserve of nearly 260 ha. Buffer zones are incorporated in ground now recommended for Geological Monuments and Sites.

Veevers meteorite crater (94) is not secured by a reserve and perhaps it is accepted as being adequately protected by its isolation in the central deserts.

Priorities for Protection

Protective legislation could be far away in Western Australia for although it appears that Geological Monuments and some Sites should attract land reservations corresponding to a Class A reserve, a total protection scheme is unlikely to be introduced within the foreseeable future. As an interim measure therefore a 'high priority' protection status is recorded in the dossiers, particularly for fragile and critical sites and more important fossiliferous localities. These are listed:

- | | |
|----------------------------------|------------------------------|
| 1. Marble Bar and Chinaman Pools | 55. Moonyoonooka |
| 2. Camel Creek | 56. Mount Hunt |
| *7. North Pole | *61. Alunite Amphitheatre |
| *8. Strelley Pool | 64. Kanowna Town Dam |
| *9. Strelley Pool West | 69. Wave Rock |
| *10. Meentheena | 70. Pinnacles |
| *11. Knossos | 73. Bunker Bay |
| 19. Duck Creek Gorge | 74. Meekadarrabee Tufa Basin |
| 24. Gneudna Paddock-Williambury | 77. Augusta Shell Bed |
| 28. Coolkilya Pool | 81. Windjana Gorge |
| 29. Wandagee Hill | 82. Tunnel Creek |
| 31. Remarkable Hill | 84. Elimberrie Bioherms |
| 33. Callytharra Spring | 85. Geikie Gorge |
| 34. Mount Leake | 86. Bugle Gap |
| 36. Boogardie Orbicular Granite | 87. Westwood Creek |
| *39. Mount Narryer | 88. Mount North |
| *40. Jack Hills | *90. Walgidee Hills |
| *42. Geraldine Lead Mine | 92. Gantheaume Point |
| *43. Warribanno Chimney | 93. Wolf Creek Crater |
| 48. Blue Hills | 94. Veevers Crater |
| 53. Coal Seam Park | 95. Dalgaranga Crater |

Every important geological locality should be examined with care but a 'high priority' status calls for extraordinary care especially with hammers - these should not be used on living rock unless sampling is essential for research purposes. Obviously features such as Warribanno Chimney and Wave Rock are as a matter of course exempt from hammer attack but these are included for the sake of completeness. Those localities indicated with an asterisk should be given early attention for protection by legislation and include the stromatolite sites of the Pilbara (7 to 11), the subject of a discussion on p.39, ancient minerals and rocks of Mount Narryer and Jack Hills, Geraldine Lead Mine and Warribanno Chimney, the magnificent exposures of Alunite Amphitheatre and possibly Walgidee Hills.

Pilbara stromatolite sites and Mount Narryer are locales of universal importance, and rank with the Devonian reef complexes of the Canning Basin as the most valuable features of Western Australia's geological heritage recognised so far. Three National Parks cover parts of the Devonian reef complexes and the writer is of the opinion that on geological grounds the Pilbara locales 7, 8 and 9, and Mount Narryer merit similar protection.

Coal Seam Park (53) a Class A Reserve incorporating perhaps the best known fossil locality in the Perth region is used for collecting during school outings, so the writer is given to understand. Interested palaeontologists could assess the result -

this experience should help to draw up regulations for the use of geological features.

Code for Geological Fieldwork

As legislation to protect geological localities is a distant prospect, the equally important and complementary means of protection by enlisting the support of geologists and the public should be taken up and this could be begun by framing a code for geological fieldwork. A code needs to look after the interests of landowners - their co-operation is essential and a number complained about trespassers at geological localities. It needs to restrain idle hammering and indiscriminate collecting. A code should be sponsored by a professional body and naturalists and lapidarists as well as land and lease holders should be consulted. Among other matters a code should bring out the need to:

- obtain permission before entering land;
- observe country practice about gates, bores and fires;
- avoid tracks when very wet;
- break living rock only as a last resort;
- never make exposures unsightly by hammering;
- collect minimum samples and avoid taking *in situ* fossils, rare minerals and rare rocks except where research requires such sampling;
- avoid littering;
- leave venues more tidy than found.

Presentation of Localities

Geologists have a responsibility to foster public appreciation of geological features for should the fraternity speak only to itself then it could expire like some inbred fossil species. But nowadays there is a more cogent reason for shouldering responsibility for general geological edification, the advent of creation science. In Perth during 1986 its adherents taught that Earth could not be older than 10,000 years and Western Australia's varied and unique evidence for Earth's immense antiquity of more than 4300 million years was not mentioned.

In this context at least it is unfortunate that no popular guide to the geology of Western Australia exists and that not a single geological feature in the State is explained by notice board to the public (as far as the writer can determine) not even in National Parks with strong geology such as Cape Range (32) where this component of natural history is lost to most visitors and in the Hamersley Range Park (12), where geologists suffer also.

Some pamphlets explaining geology are prepared but these are often difficult to relate to what is seen; notice boards with a geological diorama and explanation would enhance the interest of many public viewpoints and those in Cape Range and in the Hamersley Park are obvious examples. As well as information on geology, notice boards and geological guides should carry advice about taking care of features. Attractively designed boards could attract and hold attention and thus serve the purpose of protection.

Potential for public presentation by notice board or illustrated material is signalled by 'Class V' in the dossiers and criteria for the selection of these features are that they should be accessible, show strong visual appeal or have geology readily appreciated by the non-specialist, and are unlikely to be easily damaged by increased use, or are already supervised or apparently could be easily supervised. Class V features are as follows:

- | | |
|---|--------------------------------|
| 1. Marble Bar & Chinaman Pools | 61. Alunite Amphitheatre |
| 5. Black Range | 67. Binaronca Rock |
| 12. Wittenoom Gorges of the Hamersley Range | 69. Wave Rock |
| 13. Woongara Gorge | 70. Pinnacles |
| 23. Ten Mile Creek | 72. Del Park |
| 25. Minilya River South Branch Boulder Bed | 73. Bunker Bay |
| 26. K 52 Hill | 74. Meekadarrabee Tufa Barrier |
| 32. Cape Range | 78. Black Point |
| 38. Mount Singleton | 79. Point D'Entrecasteaux |
| 41. Pencell Pool | 80. Mount Chudalup |
| 42. Geraldine Lead Mine | 81. Windjana Gorge |
| 43. Warribanno Chimney | 82. Tunnel Creek |
| 44. Murchison River Gorge | 85. Geikie Gorge |
| 46. Shell House Coastal Cliffs | 86. Bugle Gap |
| 52. Bindoo Spring | 88. Mount North |
| 53. Coal Seam Park | 89. 81 Mile Vent |
| | 93. Wolf Creek Crater |
| | 95. Dalgara Crater |

Dossiers should be consulted for specific suggestions with examples at Marble Bar and Chinaman Pools (1) where the magnificent pillow lavas should be brought to the attention of the public, and nearer Perth, Pencell Pool (41) and Geraldine Lead Mine and Warribanno Chimney (42 & 43) have promising potential.

Localities with High Potential for Presentation

Excellent possibilities for public presentation and education are offered by **Mount Narryer** (39) and the **Minilya River** and **North West Cape** groups of localities (24 to 32). These are not excessively distant from Perth and difficulties of immediate access (some are not designated Class V for this reason) could be overcome without recourse to major works.

Mount Narryer of universal importance for its rocks from the beginnings of the Planet should be made a Class A reserve for geological research and the range opened up with discretion for geological education at all levels.

A few hours drive north takes one to the Minilya River and North West Cape locales where fossiliferous sections of the Palaeozoic, Mesozoic and Cainozoic reveal huge thicknesses of superposed strata testifying to the great lengths of time during which life evolved and where evidence for the antiquity of Earth can be convincingly demonstrated. Minilya River and North West Cape localities are put forward for consideration as a **Geological Heritage Trail** to be developed for teaching geology to students at every level and for all non-specialists and creation scientists wishing to see evidence for the progressive accumulation of fossiliferous sequences. A few short access tracks would be needed with camp areas and explanatory maps and guides, and sections defined on the ground. **Parties should be supervised by experienced leaders.** The Western Australian Heritage Committee has supported nature trails of the type envisaged.

In the Kimberley, exhumed Devonian landscapes and geology of **Bugle Gap** (86) are of universal importance, and possess exceptional visual appeal. These lie just north of the Great Northern Highway and offer splendid possibilities for prudent public presentation. Also in this region, near Windjana Gorge (81), **Mount North** (88) and perhaps **81 Mile Vent** (89) should be considered.

Four Gorges Near Ashburton River

Four gorges near Ashburton River deserve to be singled out for fine displays of Archaean and Proterozoic stratigraphy within beautiful surrounds. Difficulties of access to some and intricate geology of most make the quartet unsuitable for general presentation and so they are recommended for supervised, well-organised parties wishing to take advantage of relatively close-spaced locales incorporating sequences of the Fortescue, Hamersley, Turee Creek, Wyloo and Bangemall Groups. These are **Woongarra Gorge** (13), **Top Camp Unconformity** (16), **Duck Creek Gorge** (19) and **Irregully Gorge** (p.80; inclusion based on personal communications). To them could be added the small gorge at **Three Corner Bore East** (17) with its spectacular conglomerate of iron formation clasts.

Summary

No matter how inconspicuous or remote, important geological localities will be used repeatedly over the years and need protection:

their protection calls for special land reservations corresponding in consequence to Class A reserves, and land reservations should be sustained by educating all to use geological localities with discretion.

To foster appreciation of the geological heritage selected localities should be presented to the public with instruction on how to care for their rocks, minerals and fossils.

GENERAL RECOMMENDATIONS

Previous Studies

1. Recommendations should be considered with those made in Chapter 6 of the 1960s report on National Parks and Nature Reserves in Western Australia (Antecedents, p.1) and in the 1979 Perth area report (Antecedents, p.2).

Register of the National Estate

2. Sixty nine localities nominated as Geological Monuments and outline monuments and identified by asterisks in the Summary of Recommendations (p.i) should be listed on the **Register of the National Estate**. Outline monuments not proposed for listing at this time are those for which information is poor, specifically Black Range (5), Carawine Pool (6), North Pole (7), Strelley Pool West (9) and Mount Stuart (22), with also Boogardie Orbicular Granite (36) where there may be mining complications and Del Park (72) where rehabilitation of mining faces is under way.

Protection of Important Geological Localities

3. Important geological localities should be protected by land reservations corresponding in consequence to **Class A land reserves** with regulations designed to facilitate careful geological use (p.273).
4. The Geological Society should promote a '**Code for Geological Fieldwork in Western Australia**' (p.276). A code should be widely distributed, to colleges and schools and to lapidarist and natural history clubs, and made known through publications such as those of the Department of Conservation and Land Management.
5. Thought should be given to the protection of localities with '**high priority**' protection status (p.275), particularly to those unsupervised at present. The Pilbara stromatolite localities (7 to 11; see also p.39), Mount Narryer (39), Geraldine Lead Mine and Warribanno Chimney (42 and 43), Alunite Amphitheatre (61) and possibly Walgidee Hills (90) warrant special attention.
6. Palaeontologists should consider compiling a register of fossil localities under pressure from collectors - Coal Seam Park (53) may be an example. The register could be used to expand those with 'high priority' protection status and perhaps endangered sections should be mentioned in a code for geological fieldwork.

Presentation of Important Geological Localities

7. Controversy over the prudence of encouraging the use of important geological localities is unlikely to fade, nevertheless it is difficult to overstate the need to secure public participation in the protection of geology. This role could be developed by presenting selected features with notice boards carrying advice on how to take care of exposures.
8. For many of the **Class V (Public Interest) localities** (p.277) large-scale maps and illustrated guides could be produced. Perhaps prior attention should be given to National Parks such as Cape Range (32) and Kalbarri with Murchison River Gorge (44), and importantly, Wittenoom Gorges of the Hamersley Range (12) where the Park loves to death its geological component for there is no useful map and detail is difficult to see on rock faces, and who dares to pick up a rock there?
9. **Localities with high potential for public presentation** (p.277) include Mount Narryer (39) and Bugle Gap (86). Minilya River and North West Cape locales (24 to 32) where **geological heritage trails** could be established, offer admirable opportunities for geological edification.
10. **A popular account of the geology of Western Australia** should be published. The dramatic gorges of Ashburton River (p.278) alone merit journalistic treatment (perhaps in Landscape) and this should underscore the need for their protection.
11. The Shire of Mullewa has endeavoured to promote public interest in Bindoo Spring (52) but geological assistance is needed to explain and realise the potential of this feature; the Geological Society or an official body could help here.

Special Topics : Modern Sedimentary Environments and Caves

12. Modern sedimentary environments should be the subject of a special study when Shark Bay (p.179) would be taken up.
13. The many caves in Western Australia with bone and other deposits should become the subject of a separate study also.

Further Studies of the Geological Heritage

14. What is believed to be the most important element of Western Australian geology, **the stromatolite record** ranging from Archaean times in the Pilbara to present day in Shark Bay and lakes elsewhere in the southwest, requires early investigations to ensure these unique tableaux of the origins of life on Earth receive priority for conservation.

15. Other systematic surveys of important geological localities should not take place until policy towards land reservations for geological purposes is determined - there need to be guidelines if surveys are to be effective.
16. In the interim, geologists should be encouraged to record localities of importance especially when these are selected for formal excursions and perhaps set down information in a dossier similar to the one used here. Examples of features not considered during the study and which invite attention include exhumed karst topography on the Proterozoic Carawine Dolomite in the Mount Divide district of the Balfour Downs 1:250,000 Geological Series (I.R. Williams pers. comm.) and Permian glacial geomorphology exhumed on a grand scale in the Rudall River National Park.
17. **Excursion guides** are critical sources for geologists seeking an introduction to a district and guides should be preserved in libraries.

General

18. The proposal for Del Park (72) of Alcoa of Australia Ltd. should be followed up.
19. Advances in geological research have been made in and around Perth since the 1979 survey of geological localities (p.2). It is not known whether results of this work were taken into account during a recent re-appraisal of the metropolitan planning scheme. The Western Australian Museum and universities would need to be consulted.

LIBRARY

ENVIRONMENTAL

PROTECTION AUTHORITY

1 MOUNT STREET PERTH