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THE GEOLOGY OF THE SPRINGSURE 1:250,000 SHEET AREA, QUEENSLAND

by

R.G. Mollan and N.F. Exon (Bureau of Mineral Resources), and A.G. Kirkegaard (Geological Survey of Queensland).

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SUMMARY

The Springsure Sheet area covers parts of three major basins: the Drummond Basin, the Bowen Basin, and the Great Artesian Basin.

About 15,500 feet of Middle Devonian to Lower Carboniferous sediments and volcanics are exposed in the Drummond Basin. The Dunstable Formation, which contains lenses of lower Middle Devonian limestone, rests on gneiss and schist in the Telemon Anticline; these pre-Devonian metamorphics form part of the basement to the Drummond Basin. The Dunstable Formation consists dominantly of primary volcanics; the sequence contains interbedded sediments which are exposed only in the northern part of the Nogoa Anticline; the sediments probably wedge-out southwards. The Dunstable Formation is overlain by the Telemon Formation, probably with slight regional overlap, and local unconformity. The Dunstable and Telemon Formations are intruded by a granite stock in the Telemon Anticline. The Telemon and Ducabrook Formations consist of about 11,000 feet of interbedded conglomerate, sandstone, and shale with much tuff and reworked volcanic material. The two formations are separated by about 1000 feet of quartz sandstone, the Raymond Sandstone, and a lenticular basal quartz conglomerate, the Mount Hall Conglomerate. The Raymond Sandstone and the Mount Hall Conglomerate are disconformable on the Telemon Formation, and the Raymond Sandstone is conformably overlain by the Ducabrook Formation.

The rocks of the Drummond Basin have been folded into broad north-trending anticlines which are increasingly more complex and intensely faulted eastwards; the most easterly structures are possibly overthrust to the west. The Nogoa Anticline persists farther southwards than was previously thought; it is a major axis along which folding has occurred intermittently from Carboniferous to, at least, Triassic times. The main period of folding followed the deposition of the Lower Carboniferous Ducabrook Formation and preceded the deposition of about 2000 feet of glacigene sediments of the Joe Joe Formation, which contains Carboniferous plants and Lower Permian spores. The Joe Joe Formation this eastwards and transgression of the Lower Permian Colinlea Sandstone from the east has limited outcrop of the Joe Joe Formation to a few isolated inliers in the eastern half of the Sheet area.

The part of the Bowen Basin in the Sheet area consists of two major structural and depositional provinces: the Denison Trough in the east and the Springsure Shelf in the west. The Denison Trough is a Lower Permian downwarp along the western margin of the Bowen Basin in which about 12,000 feet (5000 feet exposed) of interbedded marine and non-marine, mainly clastic sediments accumulated during almost uninterrupted sedimentation. The rate of sedimentation varied; periods of fluviatile - deltaic sandy sedimentation alternated with periods of shallow marine, often restricted, basinal silty sedimentation. While part of the sedimentary pile was accumulating in the trough a sheet of fluviatile sand was being slowly deposited on the Springsure Shelf, which is part of a Lower Permian relatively stable zone bordering the western margin of the trough. Periods of non-deposition and probably emergence on the shelf also accompanied the rapid Lower Permian sedimentation in the trough.

The end of the Lower Permian was marked by slight epeirogenic movements and the ending of the Denison Trough and Springsure Shelf as distinct depositional provinces. A widespread shallow marine transgression from the east marked the beginning of the Upper Permian. About 5000 feet of mainly fluviatile and shallow freshwater basinal sediments accumulated from the Upper Permian to the Middle Triassic; breaks in deposition during this period are evident in some areas.

The Permian-Triassic rocks in the Denison Trough area have been folded into a major north-trending anticline, on which the Springsure Anticline in the north, and Reid's Dome in the south are the main culminations. The Consuelo Anticline is the only other exposed anticline in this area. These folds are probably a mild orogenic consequence in Upper Permian to late Triassic times of the thick Permian sedimentary pile in the Denison Trough.

The Permian-Triassic rocks in the Springsure Shelf area dip mainly gently southwards; several north-trending folds appear to have formed along older folds in the rocks of the Drummond Basin. The Lower Permian Colinlea Sandstone thins, and the Lower Triassic Rewan Formation is absent, along the southward extension of the Nogoa Anticline. The Colinlea Sandstone overlaps older units in this area.

Previously published Permian stratigraphy has been revised thus:

(i) The 'Dilly beds' (Reid, 1930) are subdivided into the Orion and Stanleigh Formations.

(ii) The Catherine Sandstone is used as originally defined by Reid (1930). The 'Catherine Sandstone' of Hill (1957) is subdivided into the Catherine Sandstone and the Peawaddy Formation, a new formation, which contains coquinitic lenses of the Mantuan Productus Bed at the top.

(iii) The Colinlea Formation of Hill (1957) is subdivided into
(a) a thin unnamed lower unit, (b) the Colinlea Sandstone, and (c) the Peawaddy Formation.

(iv) The 'Cheshire Formation' of Hill (1957) is subdivided into the Bandanna and Rewan Formations.

The following Permian stratigraphic relationships are proposed:

(i) The Orion Formation is probably equivalent to the 'undivided freshwater beds' in A.O.E. Nos. 1 and 2 (Reid's Dome) wells (Webb, 1956).

(ii) The Cattle Creek Formation, formerly correlated by Patterson (1956) with the interval from the base of the Stanleigh Formation to the top of the Sirius Formation is probably equivalent to the Stanleigh Formation only.

(iii) The Staircase Sandstone, originally believed to be absent or poorly represented in Reid's Dome, is now thought to be the basal 1200 feet of the sequence mapped as 'Aldebaran Sandstone' in Reid's Dome. /The 'Aldebaran Sandstone' (1800 feet thick) as mapped in Reid's Dome in Enclosures 1 and 9 therefore probably represents the interval (2000 feet thick) from the base of the Staircase Sandstone to the top of the Aldebaran Sandstone, as mapped in the Springsure Anticline7.

(iv) The Sirius Formation probably has only a thin representative in Reid's Dome.

(v) A thin unnamed sandstone and siltstone unit between the Joe Joe Formation and Colinlea Sandstone on the Springsure Shelf is probably equivalent to part of the Orion Formation.

(vi) The Colinlea Sandstone is probably equivalent to the interval from the base of the Aldebaran Sandstone to the top of the Catherine Sandstone.

(vii) A thin equivalent of the Ingelara Formation is probably present in the Colinlea Sandstone only in the eastern part of the Springsure Shelf.

The Precipice Sandstone of the Great Artesian Basin, in the southern part of the Sheet area, is unconformable on Triassic formations in the west flank of Reid's Dome; westwards it is disconformable on the Moolayember Formation.

A sheet of Tertiary basalt with interbedded sediments covers much of the eastern half of the Sheet area. The sheet has collapsed where soft underlying formations have been undermined. The Tertiary basalt is petrogenetically related to acidic alkaline plugs and dykes of the Minerva Hills Volcanics. Laterite caps sediments of the Joe Joe Formation near the western boundary of the Sheet area and Tertiary sediments east of the Rewan Syncline. 'Billy' boulder scree is probably derived from siliceous cappings on sandstone formations overlain by Tertiary basalt.

Exploratory drilling for oil and gas in the Permian sequence of the Denison Trough has yielded some petroliferous gas. The Trough is the most promising province for oil and gas accumulations. The Drummond Basin and the Springsure Shelf contain some suitable structure traps and reservoir rocks for oil and gas and some shale in both provinces may be source rocks. Coal seams are present in the upper part of the Bandanna Formation.

INTRODUCTION

A joint Bureau of Mineral Resources and Geological Survey of Queensland field party mapped the Springsure 1:250,000 Sheet area in 1963 as part of a systematic plan, begun in 1960, to map the Bowen Basin and to aid the search for oil. This report and maps are based on field work done between 27th May and 16th October by R.G. Mollan and N.F. Exon of the Bureau of Mineral Resources, and A.G. Kirkegaard of the Geological Survey of Queensland. J.M. Dickins and E.J. Malone spent several weeks with the field party. In June, 1962 a preliminary investigation of the Permian section in the east of the Sheet area was made by E.J. Malone, J.M. Dickins, and P.R. Evans, accompanied by A. Fehr of the Institut Francais du Petrole. Several sections, measured in the Permian sequence during the 1962 investigation, are included in this report. The Baralaba and Taroom 1:250,000 Sheet areas were also mapped in 1963 (Olgers, Webb, Smit, and Coxhead, 1964, and Jensen, Gregory, and Forbes, 1964).

The Springsure Sheet area is bounded by longitudes 147°E and 148°30'E and latitudes 24°S and 25°S; the eastern boundary is 170 miles from the coast near Rockhampton. Springsure, the

TOPOGRAPHY, DRAINAGE, AND REFERENCE TO 1:50,000 SHEET AREAS

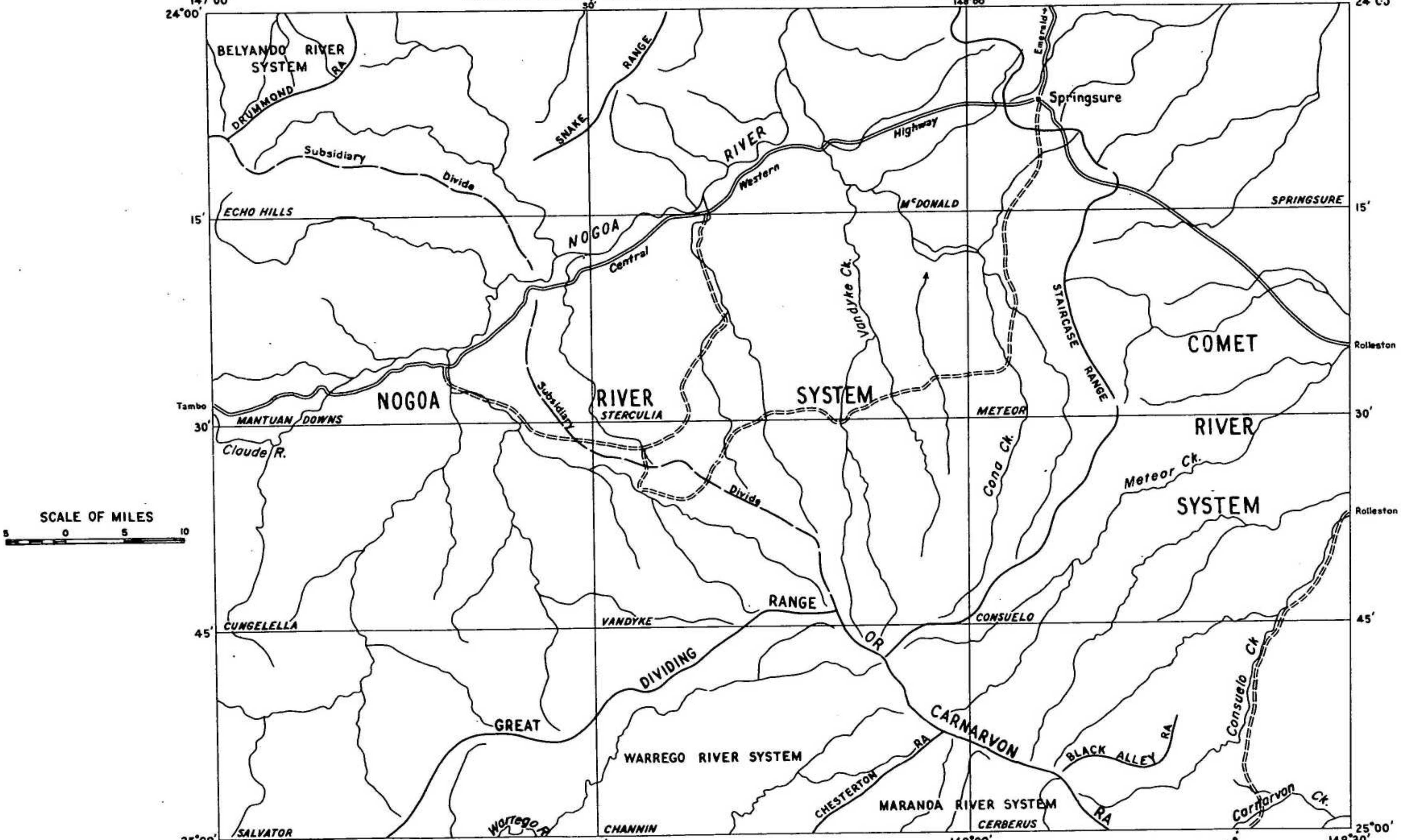

Fig. 1

Bureau of Mineral Resources, Geology and Geophysics. March 1964 To accompany Record No 1964/27

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only town in the area, is 200 miles from Rockhampton by road and rail. It is served by a branch railway line from Emerald and joined by all-weather roads to Emerald, to Rolleston (Springsure-Duaringa Highway) and to Tambo (Central Western Highway). Good vehicular access in the northern half of the Sheet area is provided by a network of station tracks and fair weather roads; in the south there are very few tracks.

The Sheet area has a range in elevation from about 700 feet above sea level in the north-east corner to 3340 feet in the Black Alley Range in the south-east; the eastern part of the Great Dividing Range is nearly 3000 feet above sea level. The Sheet area is divided into the following topographic regions:

(i) Rolling plains, less than 1000 feet above sea level, and mostly between 700 feet and 800 feet above sea level in the north-east corner of the Sheet. The region covers about 1/12 of the Sheet area.

(ii) Tablelands, from 2000 feet to 3000 feet above sea level, cover about 1/6 of the Sheet area in the southern central part; they cannot be traversed by vehicle.

(iii) The rest of the Sheet area lies between 1000 feet and 2000 feet above sea level. The area includes several prominent ranges, (e.g. the Snake Range) consisting of rocky escarpments, mesas, and cuestas as well as broadly undulating country and tableland with some distinct peaks, notably north of Springsure.

The drainage system and divides are shown in Figure 1. The Great Dividing Range is the main feature, separating drainage systems which flow north into the Fitzroy River system, from those which flow south into the Darling River system. The main water-courses to the north of the range are the Nogoa and Claude Rivers, and Vandyke, Cona, Meteor, Consuelo, and Carnarvon Creeks, which flow perennially, except during prolonged dry spells. The water in Carnarvon, Consuelo and Meteor Creeks is notably clear and soft. South of the range the upper reaches of the Warrego and Maranoa Rivers lie within the Sheet area.

The region enjoys a sub-tropical climate. It is situated outside the maritime influence, and consequently does not receive reliable rain. The annual rainfall is extremely variable; the average is between 20 and 30 inches. Most of the rain is cyclonic, falling in January, February and March; early summer storms occur from October to December. The rest of the year is usually dry. The summer months are very hot and the winter months are warm during the day and frequently cool to frosty at night.

The vegetation is dominantly of the savannah type with tall grass and an even cover of timber. The vegetation is controlled by the soil and underlying rock; for instance black soil derived from basalt supports grassy downs, and sandstone commonly supports a dense timber cover. Dense brigalow scrub covers parts of the western half of the Sheet area.

Cattle grazing is the main industry of the region though several stations run sheep. Wheat and other grain crops are grown in some areas, notably near Springsure, where the land is very much subdivided. Several large holdings in the western half of the Sheet area are being subdivided; clearing of scrub in this area is in progress.

The Springsure Sheet area is almost covered by two sets of air-photos taken by Adastra Airways Pty Ltd, at a scale of about 1:85,000: Springsure North (Runs 1-4, 1960) and Springsure (Runs 1-4, 1962); the Springsure set covers the southern half of the area. Emerald Run 9 and Eddystone Run 1 cover parts of the area. The geology was compiled at photo-scale and the 1:250,000 map (Enclosure 1) was drawn from photographic reductions. A photo-geological map of the Springsure Sheet at 1:250,000 scale by W.J. Perry, and J.Y. Scanvic, B. de Lassus Saint-Genies, and R. Richard of the Institut Francais du Petrole (Richard, 1963), was available before field work commenced.

Between 3rd and 8th October, 15 shallow holes were drilled for stratigraphic information (Malone, 1963). Detailed logs of the holes are included in this report (see Stratigraphic Drilling).

PREVIOUS INVESTIGATIONS

Geological work

Before 1930 several geologists made reconnaissance surveys covering parts of the Springsure Sheet area. Since 1930 numerous geologists have mapped the Permian rocks exposed in the Springsure Anticline and Reid's Dome, and a few have mapped the Devonian-Carboniferous rocks exposed in the Telemon and Nogoa Anticlines. Much of the work has been done in the search for oil. Several reports on parts of the Sheet area are either not available or could not be obtained. The most important reports on geological work in the Sheet area are referred to below.

Jack (1895), who was the first to report geological observations, recorded marine fossils at many localities. Richards (1918a) described volcanic rocks around Springsure.

Jensen (1926) made a geological reconnaissance of the area and areas to the east and south, and recognised the Serocold Anticline in which Permian sediments are exposed. Reid (1930) mapped the anticline in detail, subdividing the Permian rocks into formations. Reeves (1936) also mapped the Permian rocks. The major contribution to the geology of the area was made by Shell (Queensland) Development Pty.Ltd.in several detailed geological reports; notably Schneeberger (1942) and Woolley (1943). The work of Shell (Queensland) Development Pty.Ltd.from 1940 to 1951 was summarised in a general report (SQD, 1952). The first edition of the Springsure 4-mile Geological Sheet, published by the Bureau of Mineral Resources, and the accompanying explanatory notes (Hill, 1957), are based largely on the work of Shell. Whitehouse (1955) mapped the Mesozoic rocks of the Sheet area. Patterson (1955 and 1956) mapped the Springsure Anticline in detail. Webb (1956) reviewed the results of exploratory wells penetrating Permian sections, incorporating Patterson's stratigraphy. Phillips (1959, and in Hill and Denmead, 1960) mapped the Springsure Anticline and Reid's Dome. Laing (1961) mapped Reid's Dome. Madden (1960) mapped the Permian of the Springsure Shelf.

Geophysical surveys

Enclosures 4,5 and 6 are reproduced from results of seismic, gravity, and airborne magnetometer surveys in the Springsure Sheet area and may be used as overlays on the geological sketch map of the area (Enclosure 3).

Seismic

Two reflection seismic surveys have been carried out over small areas of the eastern part of the Springsure Sheet (Enclosure 4). In 1962 Austral Geo Prospectors Pty.Ltd.worked in the south-east corner of the Sheet area for Planet Exploration Co. Pty.Ltd. The main part of the surveyed area lies in the Baralaba and Taroom Sheet areas. In 1963 Geophysical Service International surveyed the north-east part of the Sheet for Associated Freney Oilfields N.L., as part of a large survey mainly in the Baralaba Sheet area.

Gravity

In 1959 Mines Administration Pty.Ltd. conducted a regional gravity survey of a large part of the Bowen Basin (Starkey, 1959, and Warren, 1959). The results of the survey in the Springsure Sheet area are shown in Enclosure 5.

Magnetic

An airborne magnetometer survey of the Springsure Sheet area was carried out in 1962 by the Bureau of Mineral Resources, Geophysical Branch. The results of the survey are shown in Enclosure 6.

Exploratory drilling for oil and gas

Four wells have been drilled in the Springsure Sheet area in the search for oil. Many wells have been drilled in areas east and south of the Sheet, and several are being drilled. The electric logs and generalised lithologies of three of the wells drilled in the Springsure Sheet area and five wells outside the Sheet are shown in Enclosure 11. The wells shown in Enclosure 11, and the additional well in the Springsure Sheet area (A.O.E. Reid's Dome No.2) are summarized in the following table:

Name	Year drilled	Total depth (feet)	Hydrocarbon Indications
A.O.E. No.1 (Reid's Dome)	1954	9060	gas show
A.E.E. No.2 (Reid's Dome)	1955	4060	none
A.O.E. No.3 (Consuelo)	1955	4437	none
S.Q.D. Morella No.1	1951	4636	gas show, bitumen show
A.F.O. Bandanna No.1	1963	4040	gas show
A.F.O. Inderi No.1	1963	5433	gas (800 M.c.f./day)
A.F.O. Purbrook No.1	1963	4949	none
Planet Warrinilla No.1	1963	6701	gas (ca. 100 M.c.f/day)
Planet Warrinilla North No.1	1963	6879	gas (ca. 160 M.c.f./day)

Wet gas was found in 1964 by Associated Freney Oilfields N.L. south of Rolleston in the Baralaba Sheet area.

Under the Petroleum Search Subsidy Acts final reports on Commonwealth subsidised drilling and geophysical work become available for general reference six months after the cessation of field operations. Final reports are available for A.F.O. Inderi No.1, A.F.O. Purbrook No.1, Planet Warrinilla No.1, Planet Warrinilla North No.1, and A.F.O. Bandanna No.1. Summary reports on the three unsubsidised A.O.E. bores are in 'Occurrence of petroleum and natural gas in Queensland' (GSQ, 1960).

GEOLOGY

Introduction

The Springsure Sheet area contains parts of three major depositional basins: the Drummond Basin, the Bowen Basin, and the Great Artesian Basin.

The Drummond Basin contains about 15,500 feet of Devonian to Carboniferous mainly non-marine sediments and volcanics which crop out in the north-west quadrant of the Sheet area.Rocks of the Drummond Basin have been folded into broad north trending structures and intruded by a granite stock in the Telemon Anticline. Probable pre-Devonian metamorphics, the basement to the Drummond Basin, crop out in a small area in the core of the Telemon Anticline.

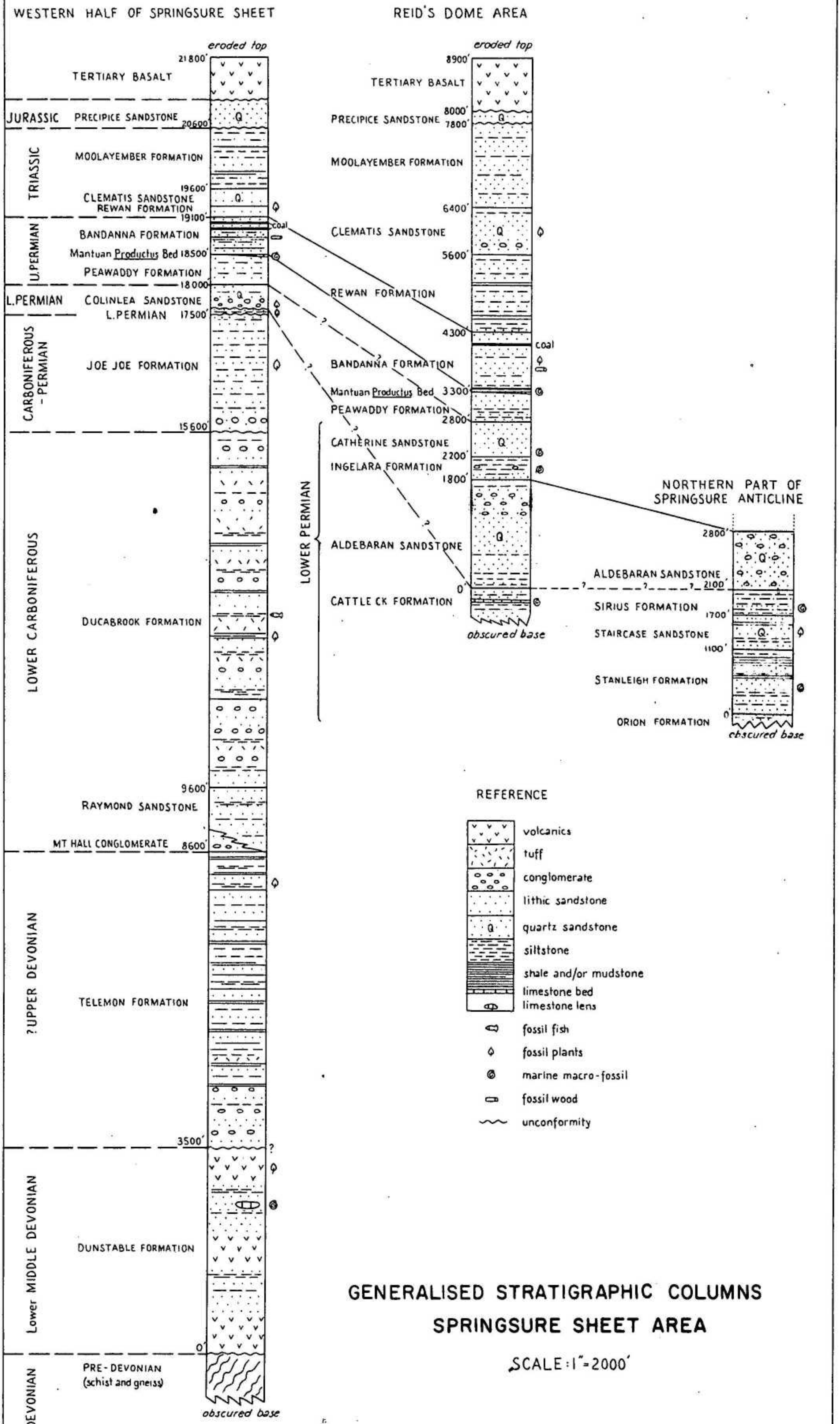
The Bowen Basin consists of two structural units: the Denison Trough (Derrington & Morgan, in Hill & Denmead, 1960) and the Springsure Shelf (Hill, 1951). The Denison Trough contains about 5000 feet of outcropping Lower Permian marine and non-marine, sediments consisting of alternations of lenticular sandstone and siltstone-shale formations; the rocks crop out in the eastern third of the Sheet area. About 9000 feet of probable Lower Permian sediments (1600 feet marine and 7400 feet non-marine) were penetrated in Reid's Dome No.1 Well (Enclosure 11) without reaching basement. The Denison Trough contains at least 12,000 feet of Lower Permian sediments which are intruded by Tertiary volcanics. The Lower Permian sediments are disconformably overlain by about 5000 feet of Upper Permian marine and non-marine sediments and Triassic non-marine red-beds and sandstone.

The Springsure Shelf contains about 500 feet of Lower Permian non-marine sandstone, overlain by about 2000 feet of Upper Permian to Triassic sediments similar to the Upper Permian-Triassic sediments overlying the Lower Permian rocks in the Denison Trough area. The Lower Permian to Triassic sediments of the Springsure Shelf crop out in a wide belt across the central part of the Sheet area.

The sedimentary pile in the Denison Trough is folded into fairly broad, north-trending anticlines and domes of which the Springsure Anticline-Reid's Dome fold is the major feature. In the Springsure Shelf area the Lower Permian to Triassic rocks have a gentle regional south dip and are very slightly warped into north-trending folds.

The rocks in the Springsure Shelf are separated from the beds of the Drummond Basin by about 2000 feet of Carboniferous

Figure 2



GENERALISED STRATIGRAPHIC COLUMNS
SPRINGSURE SHEET AREA

SCALE: 1" = 2000'

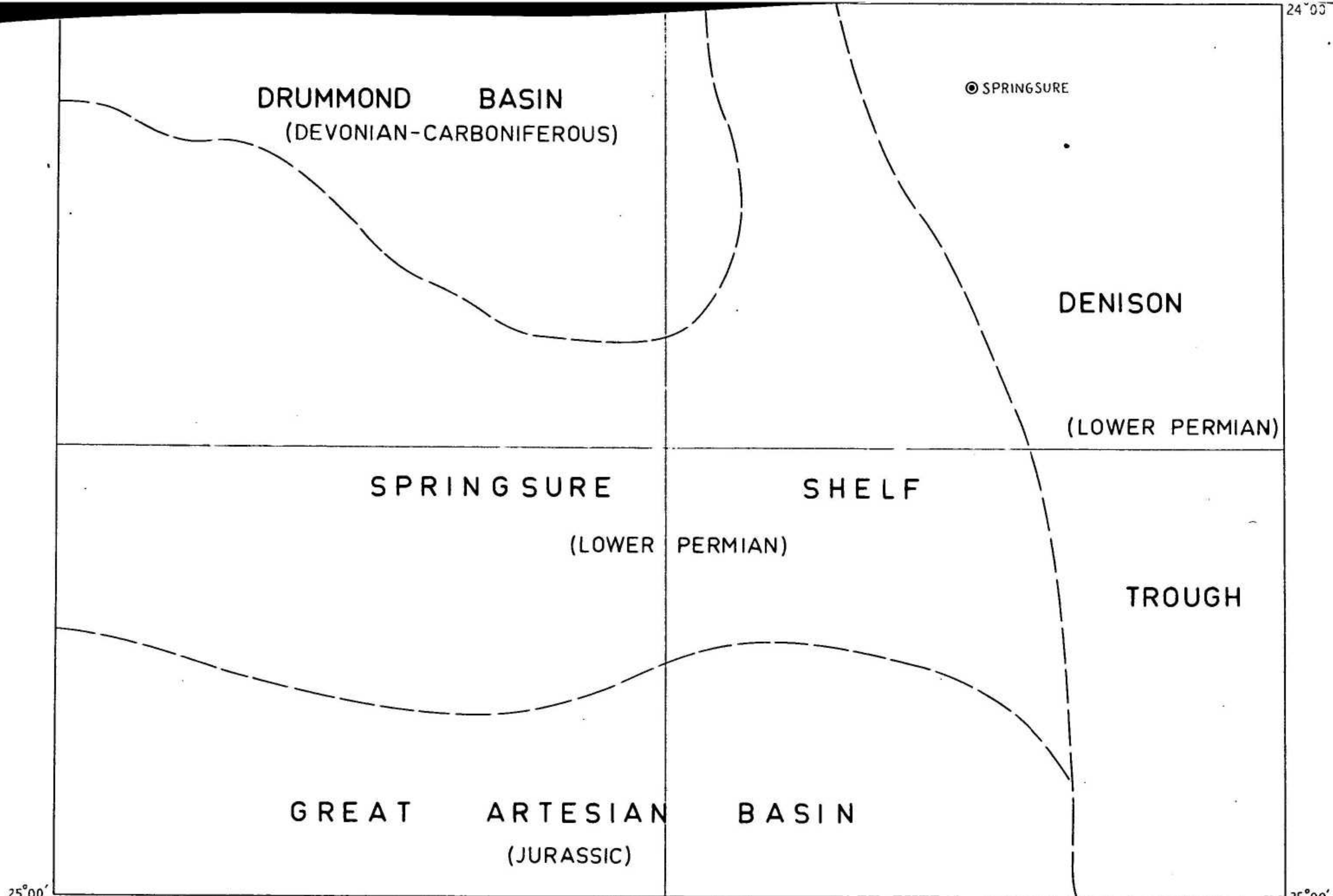
Bureau of Mineral Resources, Geology and Geophysics *March 1964*

To accompany Record No. 1964/27

G 55/A3/1

FIGURE 2a

MAIN GEOLOGICAL DIVISIONS



Bureau of Mineral Resources, Geology and Geophysics
Canberra, May 1964

To accompany Record No. 1964/27   *G 55/A3/41*

SCALE
5 0 5 10 15 MILES

to Permian glacigene sediments, the Joe Joe Formation, which overlap the Drummond Basin rocks and are, in turn, overlapped by the rocks of the Springsure Shelf.

The tectonic relationship between the Springsure Shelf and the Denison Trough is obscured by a sheet of Tertiary basalt which covers much of the eastern half of the Sheet area. Formations above the Lower Permian formations are mapped in both the Springsure Shelf and Denison Trough areas; a probable correlation of Lower Permian rock units is discussed in the Permian section.

The Great Artesian Basin sequence is represented in the southern quarter of the Sheet area by the Jurassic Precipice Sandstone, 200 feet to 500 feet thick, which overlaps the sediments of the Bowen Basin and dips regionally at low angles to the southwest.

Tertiary basalt, with interbedded sediments, covers much of the eastern half of the Sheet area. The Minerva Hills Volcanics are shallow intrusions of acidic alkaline volcanics, petrogenetically related to the Tertiary basalt; they intrude Lower Permian rocks north of Springsure.

Collapsed basalt sheets, 'billy' boulder scree, and thick sandy and heavy-textured dark soils cover large areas. Alluvium is confined mainly to river and creek channels.

Figure 2 shows generalized stratigraphic columns and Figure 2a the main geological divisions in the Springsure Sheet area. During the present survey numerous sections, mainly in Permian rocks, were measured, and are figured throughout the report: Enclosure 2 is a reference to all the measured sections.

PRE-DEVONIAN

The oldest rocks in the Springsure Sheet are metamorphics cropping out in a small inlier, about ¾ mile wide and three miles long, at the southern end of the Telemon Anticline. They were first noted by Jensen (1926), and subsequently mapped by Shell (SQD, 1952).

The inlier forms undulating country with a varying density of scrub and timber cover. Within the inlier gneiss forms fairly open thinly timbered country which has a light-toned pattern in the air photos. Other metamorphic rock-types are not readily distinguished in the air photos from the surrounding rocks of the Telemon and Dunstable Formations.

Much of the inlier is soil covered. The best exposed rock is gneiss which forms the western half of the inlier and a small area along its eastern margin. The gneiss is a strongly foliated coarse quartz-feldspar-mica rock which was probably a granite originally. A belt of biotite-quartz phyllite (locality 36/2 in Enclosure 7, described in Appendix 3) and probable schist, which crop out poorly, lies in the centre of the inlier. The northern margin of the inlier consists of sheared diorite (localities 38, and 39 in Enclosure 7, described in Appendix 3) and other igneous rocks.

The inlier, the strike of the foliation in the gneiss, and the strike of the bedding and schistosity in the phyllite all trend north-easterly. Foliation and bedding dips are to the south-east. Relationships between the gneiss, phyllite, and sheared diorite are obscured.

The metamorphic rocks are unconformably overlain by the Dunstable and Telemon Formations. The contact with these formations is obscured by soil; it is probably faulted in places.

The metamorphic rocks are regarded as pre-Devonian because of their unconformable relationship with the Middle Devonian Dunstable Formation and their probable connection with the pre-Devonian Anakie Metamorphics which crop out to the north, in the Emerald Sheet area. More specific dating is not possible at present.

DEVONIAN

Dunstable Formation

The Dunstable Formation (Hill, 1957) was originally named the 'Dunstable Series' by Shell (SQD, 1952) after Dunstable Telephone Office at Telemon Homestead. The type area is immediately north-west of Telemon Homestead in the west flank of the Nogoa Anticline. The best exposed section of the formation is along a line roughly one and a half miles long, extending north-west from a point in the Nogoa River about half a mile south-west of Telemon Homestead (Enclosure 7).

There are three separate areas of outcrop of the formation:

(i) A slightly sinuous north-trending area, two miles wide by eight miles long, which is dissected by the Nogoa River. This area of outcrop is in the core of the main culmination of the Nogoa Anticline.

(ii) An area of outcrop of three square miles in the core of a culmination along the southern extension of the Nogoa Anticline, four miles north of Hillview Homestead.

(iii) An irregularly shaped area of outcrop, of eight square miles, near the head of Mistake Creek in the core of the Telemon Anticline.

The formation forms rolling grassy downs country with scattered stands of timber. Resistant beds in the formation form rocky knolls, ridges, and scarps. The formation has a light tone in the air-photos and bedding trends are visible in places.

The lithologies in each of the three areas of outcrop are described separately (numbers in brackets are localities shown in Enclosure 7; specimens from the localities are described in Appendix 3).

The thickest exposed section of the formation is exposed in the west flank of the Nogoa Anticline near the Nogoa River. The lowest exposed beds of the formation are found in the culmination of the Nogoa Anticline about half a mile south-west of Telemon Homestead in the Nogoa River. The sequence from this area to the north-west is faulted and it is not clear whether the faults have cut out or repeated much section. The sequence is moderately well exposed, resistant beds standing out as rocky ridges from low area of softer rocks. The sequence can be divided into five members which are described below (estimated thicknesses are shown in brackets, member 1 is the oldest and is exposed at the base of the outcrop and member 5 is the youngest and is overlain by the Telemon Formation):

<u>Nogoa River area section</u>

Overlain by Telemon Formation

member 5 - volcanics dominant (1000 feet)	Interbedded amygdaloidal lavas, including basalt with porphyritic plagioclase, trachyte and andesite (68 A,B,C); some fluidal crystal tuff, and porous coarse quartz sandstone.
member 4 - sediments dominant (700 feet)	Lithic quartz conglomerate; lithic sandstone or greywacke (67 A,B), siltstone, soft multicoloured shale; interbedded trachyte flow.
member 3 - volcanics dominant (1500 feet)	Andesitic lavas and pyroclastics; spherular, amygdaloidal altered trachyte (63); lenses of partly recrystallised coralline limestone; dark green cherty silicified siltstone, indurated black shale, banded green siliceous tuff; greenish andesitic lavas and pyroclastics (60 B,D).

member 2 - sediments (200 feet)	Cross-bedded silicified quartz conglomerate (60E); lithic subgreywacke (?tuffaceous) (60A,C); sheared 'chert-volcanic sediments' (62).
member 1 - volcanics (50 feet)	Deeply weathered vesicular purple lavas.

exposed base

South of this area the formation consists of volcanics only. The second area of outcrop in the Nogoa Anticline four miles north of Hillview Homestead consists of spherular amygdaloidal trachyte (viz.63) andesite, and basalt, similar to the volcanics in member 3 in the Nogoa River area section.

The third area of outcrop in the core of the Telemon Anticline consists almost entirely of interbedded volcanics. Greenish basalt with abundant porphyritic plagioclase (49A, 48A, 48B) crops out in large areas, notably at the northern end of the outcrop, about localities 22, 49, 26, 35, and 48. The basalt occurs near the top of the formation and is closely comparable with the porphyritic basalt (68A) near the top of the formation in the Nogoa Anticline, north of the Nogoa River. The basalt is overlain immediately east of locality 22 by interbedded silicified trachyte (22A), andesite flows reefed with quartz veins, pyroclastics including agglomerate, and siliceous fine-grained sandstone.

Flows of probable spilite (35) and altered (?) andesite (27, 48C) are associated with the basalt which contains thin interbeds of siliceous lithic greywacke (26B). The rocks about localities 27 and 22 are silicified and reefed with veins of lode quartz. Basalt (55), flow-banded trachyte, and porphyritic basalt, similar to 49A, are common lithologies in the central and southern parts of the outcrop. Interbedded with these lavas are pyroclastics, mainly crystal tuff (53B). An outcrop of 'chert-volcanic breccia' (50) probably belongs to the Dunstable Formation and is closely comparable to a 'chert-volcanic sediment' (62) in the Nogoa Anticline.

Probably much less of the formation is present in the Telemon Anticline than in the Nogoa Anticline; lithological comparison of the unit in the two anticlines suggests that only the uppermost volcanic member of the formation in the Nogoa Anticline (member 5) is present in the Telemon Anticline.

The Dunstable Formation is probably unconformable on pre-Devonian metamorphics in the southern part of the Telemon Anticline. The contact with the metamorphics is concealed by soil; it is probably a faulted contact in places. The base of the formation is not exposed in the Nogoa Anticline.

The relationship of the Dunstable Formation to the overlying Telemon Formation is not easy to determine. The boundary between the two formations is commonly faulted. A 'well marked angular unconformity' between the two formations in the north-west flank of the Nogoa Anticline reported by Shell (SQD, 1952, p.19) could not be confirmed despite close examination of the area. The difficulty lies in determining dips in poorly bedded volcanics at the top of the Dunstable Formation and in massive conglomerate at the base of the Telemon Formation. At locality 68 a near-contact between the formations does not appear to be angularly discordant. Inspection of the mapped boundary in the Nogoa Anticline does not reveal an unconformity on a regional scale (Enclosure 7), whereas some aspects of the mapping possibly suggest overlap; this contention is discussed below. In the Telemon Anticline the relationship is equally difficult to determine. At localities 51 and 55 in the Telemon Anticline basal conglomerate of the Telemon Formation contains pebbles and cobbles of volcanics closely similar to volcanics of the Dunstable Formation which underlie the conglomerate. Bedding in the volcanics cannot be discerned but it is suggested that the relationship here is a disconformity. At the southern end of the Telemon Anticline, the Telemon Formation appears to overlap the Dunstable Formation and rest on pre-Devonian metamorphics. Soil unfortunately obscures contacts and the apparent overlap may be due to faulting. In the Nogoa and Telemon Anticlines the boundary between the Telemon and Dunstable Formations is commonly faulted. In conclusion, it seems that there is no marked unconformity between the Telemon Formation and the Dunstable Formation and that the relationship is probably a disconformity with slight local unconformity.

Fairly detailed mapping in the Nogoa Anticline revealed that the sequence exposed north of the Nogoa River contains two members of sediments (members 2 and 4 in Nogoa River area section) which do not crop out south of the river (Enclosure 7). This is due to, faulting, or overlap by the Telemon Formation, or wedging-out of the sediments within the formation, or a combination of these. It is clear from the mapping (Enclosure 7) that the outcrops of the two members are terminated to the south by faults (viz. the lower member along the Nogoa River, and the upper member of sediments about two miles north, and one and a half miles west of "Telemon"). The fault along the Nogoa River, down to the south, accounts for the absence of the lower member south of the river. However, faulting does not appear to fulfill either one, or a combination of, the following conditions which are necessary if faulting is the sole reason for the absence of the upper member of sediments south of the Nogoa River:

(i) the fault along the Nogoa River has a throw, down to the south, of about 2500 feet, the throw necessary to place the upper member of sediments below surface to the south;

(ii) the north-south trending fault which cuts out the upper member of sediments immediately north of the river is immensely overthrust to the west;

(iii) the entire boundary of the Dunstable Formation and Telemon Formation south of the river is faulted.

It seems more probable therefore that either the Telemon Formation overlaps the Dunstable Formation to the south or the upper group of sediments wedges out. Outcrops of spherular trachyte have been mapped and are shown in Enclosure 7. They are probably at the same horizon because they appear to represent an eruption of trachytic lava at a particular time when conditions were favorable to produce a distinct spherular texture. South of the Nogoa River the outcrops are close to the exposed top of the Dunstable Formation whereas north of the river they are below the upper member of sediments. This implies probable overlap of the upper member of sediments, either by the uppermost member of volcanics (member 5) or by the Telemon Formation. The Dunstable Formation sediments contain detritus derived from volcanic rocks similar to the Dunstable Formation volcanics (Appendix 3) which suggests erosional breaks within the formation and supports the idea that the member 4 sediments wedge out to the south and are overlapped by the member 5 volcanics.

The Silver Hills Volcanics in the Emerald Sheet area to the north are probably equivalent at least in part to the Dunstable Formation. The relationship between the Silver Hills Volcanics and the Telemon Formation differs from place to place; it appears to be unconformable in some areas, and conformable in others (Veevers, Mollan, Olgers, and Kirkegaard, in press).

Volcanic rocks in the core of the Telemon Anticline, mapped as Tertiary by Shell (SQD, 1952, p.42), are now regarded as part of the Dunstable Formation for the following reasons:

(i) At localities 51 and 55 basal conglomerate of the Telemon Formation was observed overlying the volcanics (described above).

(ii) The volcanics are not petrographically similar to Tertiary volcanics in the Springsure Sheet area and are similar to volcanics at the top of the Dunstable Formation in the Nogoa Anticline (Appendix 3).

(iii) The volcanics are commonly faulted in contact with the Telemon Formation and are slightly sheared and reefed with quartz. Nowhere in the Springsure Sheet area are similar features observed in Tertiary volcanics.

(iv) "Plagioclase phenocrysts froma basalt (49A) were dated by the Potassium-Argon method at the Department of Geophysics, A.N.U., and an Upper Carboniferous age obtained. This date, on a Middle Devonian rock, may be a reflection of the strongly sericitized nature of the sample; the age of intrusion of a granite mass close by; or the folding which occurred between the Lower Carboniferous and the Permian. The result, however, dispels any idea that this belongs to the Tertiary volcanic province." (A. Webb, pers. comm.).

Alternating groups of volcanics and sediments suggest the Dunstable Formation was deposited in an unstable area. The sediments were deposited in restricted troughs during periods of volcanic quiescence; poorly sorted intraformational conglomerate indicates contemporaneous erosion. Subaqueous volcanic deposition is evidenced in the presence of spilitic lavas and cherty tuff beds. A spherular zeolitised trachyte (63, Appendix 3) is possibly a sub-aqueous lava. Lenses of coralline limestone in the volcanics confirm a marine environment. The Dunstable Formation apparently did not extend west of the ridge of pre-Devonian metamorphic rocks now exposed in the Telemon Anticline.

Shell's reported exposed maximum thickness of at least 3500 feet for the formation in the north-west limb of the Nogoa Anticline (SQD, 1952, p.19) is tentatively confirmed from the present mapping. The formation is much thinner in the Telemon Anticline for reasons discussed above.

Coralline and stromatoporoidal limestone lenses of probable lower Middle Devonian age (Hill, 1957, and Appendix 3 in Veevers, Mollan, Olgers, and Kirkegaard, in press) which crop out in the Nogoa Anticline, one mile north-west of Telemon Homestead and immediately north of Emu Plains Homestead, are about 2000 feet stratigraphically below the top of the Dunstable Formation. No other fossils were found in the formation. The Upper Carboniferous Potassium-Argon age determination on a basalt sample from the Telemon Anticline, already referred to, is probably one of the several ages of folding of the formation.

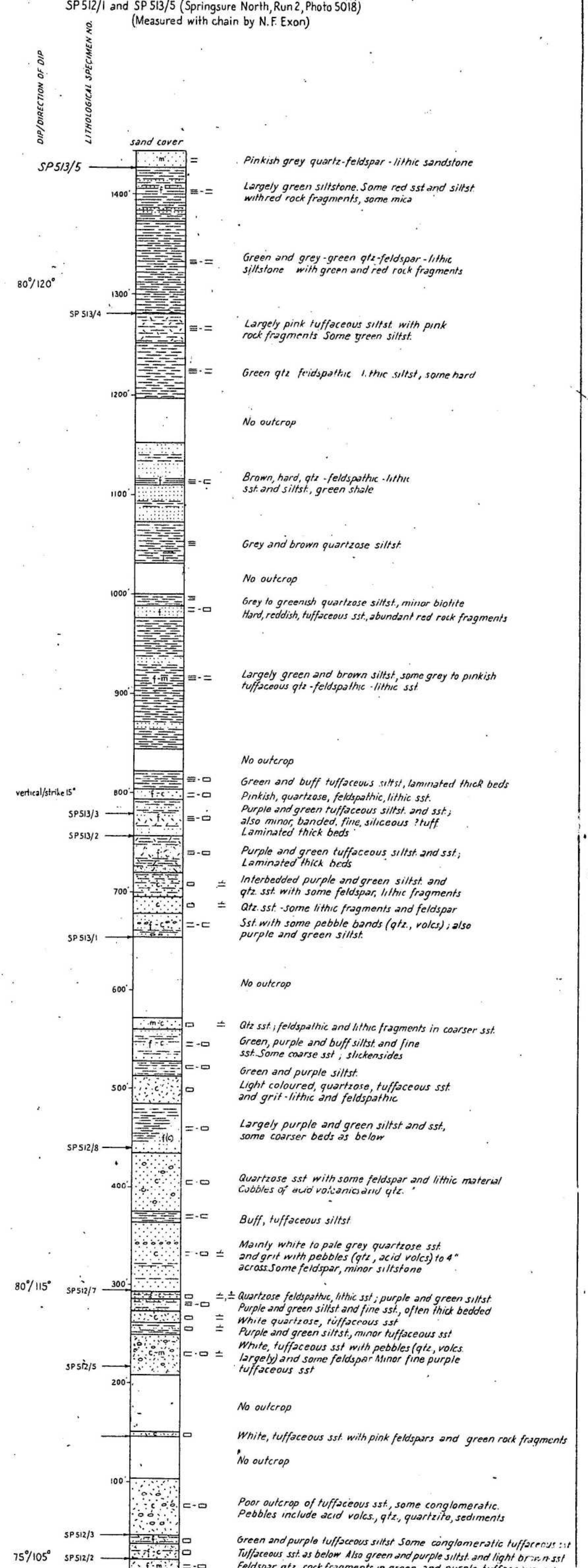
Telemon Formation

The Telemon Formation (Hill, 1957) was originally named the 'Telemon Series' by Shell (SQD, 1952) after Telemon Pastoral Holding, which is the type area. The unit crops out

Figure 3

MEASURED SECTION IN PART OF THE TELEMON FORMATION (SI)

On Tambo Road, one mile east of the "Telemon" turnoff, between points SP 512/1 and SP 513/5 (Springsure North, Run 2, Photo 5018)
(Measured with chain by N.F. Exon)



Bureau of Mineral Resources, Geology and Geophysics, March 1964 To accompany Record No 1964. G 55/A3 extensively in the Nogoa and Telemon Anticlines and a small anticline immediately south-east of the Nogoa Anticline. It also crops out extensively to the north in the Emerald and Clermont Sheet areas.

The formation was subdivided by Shell into a 'lower conglomerate group' and an 'upper multicoloured group'. The conglomerate group is well developed in the Nogoa Anticline and poorly developed in the Telemon Anticline. It forms low, rounded, sparsely timbered ridges which are distinct from the generally fairly flat, soil and scrub covered areas formed by the soft sediments of the multicoloured group. In the air-photos the two groups form distinct patterns in the Nogoa Anticline; the conglomerate group has a light tone in which faint bedding trends can be distinguished, whereas the multicoloured group has a dark tone in which bedding trends are very clear.

Lithology

The lower part of the formation in the Nogoa Anticline consists of massive conglomerate and granular conglomeratic sandstone and will be referred to as the conglomeratic group. The conglomerate is commonly cross-bedded and consist of well rounded pebbles and cobbles of milky quartz, quartzite, schist, and various igneous rocks in a coarse lithic-feldspathic-tuffaceous matrix. The conglomeratic group in the Telemon Anticline area is very thin and contains mainly pebbles and cobbles of volcanics.

Overlying the conglomeratic group is a thick thinly inter-bedded sequence of fairly soft variously coloured shale which will be referred to as the 'multicoloured group'. Lithic-quartz conglomerate persists into this group which is transitional with the conglomeratic group. A section measured in the east limb of the Nogoa Anticline (Fig. 3) shows the characteristics of the multicoloured group. This section was terminated above the conglomeratic group by a fault. The multicoloured group is characterised by thinly interbedded sandstone, commonly pebbly, siltstone, and shale with a few beds of tuff; the fine sediments are dominant towards the top of the group. The sediments, are commonly cross-bedded and festoon-bedded in units of varying thickness; faint graded bedding is evident in some sandstone; sole marks and striations are present.

Lenticular beds of probable algal limestone occur through-out the multicoloured group and several beds are readily recognised in the air photos by their characteristic light tone and lenticularity. Individual colonies of probable algal lime-stone are commonly spheroidal, dome-shaped, and cylindrical. They are commonly about six inches long and one inch wide and range up to five feet long by one foot wide. The cylinders consist of concentric layers with radial fibres; probably several algal types are represented. The algal limestone is rarely found in situ; commonly the individual colonies are found lying on the surface in areas of black heavy-textured soil which suggests they have weathered from a soft marly rock.

The accompanying table (Table 1) summarises the results of thin section examination of sediments from the measured section (Fig.3). Quartz grains are commonly angular and some embayed grains are possibly derived from acid volcanics. Volcanic rock fragments are rhyolitic and andesitic. Sedimentary rock grains are largely fine-grained recrystallised quartz mica rock. Feldspars are commonly fairly fresh and consist of equal quantities of alkali feldspar and plagioclase. Common alteration products are epidote and chlorite. It is not clear whether several clots of biotite flakes in some thin sections are derived or are the result of load metamorphism.

Some compositional features of the sediments are constant throughout the measured section and others vary thus:

(i) Proportions of feldspar and rhyolitic grains are constant.

(ii) In the bottom 200 feet, proportions of sedimentary rock grains and quartz are low, and andesitic grains are high.

(iii) Above 200 feet, proportions of quartz increase rapidly, proportions of volcanic clasts diminish, andesitic grains are negligible, and proportions of sedimentary rock grains increase.

(iv) From 200 feet to the top of the section the relative proportions of the various constituents are constant.

Houston (Appendix 3) describes five rocks from other localities in the formation. Two lithic subgreywackes from localities 54 and 65 (Enclosure 7), near the base of the formation, consist almost entirely of volcanic rock fragments. A quartz-lithic subgreywacke from locality 66, higher in the formation, has a higher proportion of quartz. Sandy calcarenite (locality 41) and vitric tuff (locality 43) are similar to specimens SP513/3 and SP513/2 from the measured section (see Table 1).

Relationships

The relationship of the Telemon Formation to the underlying Dunstable Formation has been discussed (see Dunstable Formation). The Mount Hall Conglomerate and, where the conglomerate is absent, the Raymond Sandstone overlie the Telemon Formation

TABLE I

APPROXIMATE COMPOSITION OF SEDIMENTS FROM MEASURED SECTION (FIG.3) IN PART OF THE TELEMON FORMATION

ESTIMATED PERCENTAGE COMPOSITION

Approx. height in feet from base of section	Specimen Number	Grains				Iron Ore	Cement or Groundmass	Muscovite	Biotite	Epidote	Others	Name
		Quartz inc. qtz. aggregates.	Volcanics mainly rhyolitic and andesitic	Sediments fine recrystallized quartzose	Feldspar (potash feldspar + plagioclase).							
1430	SP.513/5	60	10	10	15	5	-	1	-	Minor	Minor chlorite zircon	Quartz- lithic sandstone
1280	SP.513/4	10	Minor	25	5	Abundant	Glassy 60 ferruginous groundmass	-	Minor	Minor	Minor zircon	Vitric tuff
775	SP.513/3	25	5	15	5	Abundant	50 calcite	Minor	Minor	Minor	-	Calcareous sandstone
750	SP.513/2	30	20	-	10	5	35 calcite	Minor	Minor	-	Minor zircon tourmaline	Calcareous quartz-lithic sandstone
650	SP.513/1	30	15	30	15	5	-	2	Minor (?metamorphic)	2	Minor chlorite	Lithic sandstone
440	SP.512/8	55	10	20	10	3	-	Minor	Minor (?metamorphic)	Minor	Minor chlorite	Quartz-lithic sandstone
290	SP.512/7	75	10	5	5	Minor	-	-	Minor (?metamorphic)	Minor	Minor chlorite	Quartz sandstone
220	SP.512/5	70	Minor	20	5	Minor	-	1	Minor (?metamorphic)	Minor	Minor apatite zircon	Quartz-lithic sandstone
50	SP.512/3	55	25	5	10	Minor	-	Minor	Minor	Minor	-	Quartz-lithic sandstone
25	SP.512/2	45	30	5	10	5	-	2	Minor	3	-	Lithic sandstone

with no apparent discordance. Contacts were observed in the east limb of the Telemon Anticline at Mount Hall, and at the northern end of the anticline where two small creeks have cut gorges through cuestas of the Mount Hall Conglomerate. The lithological change at the boundary is sharp and the relationship is disconformable.

Environment of deposition

The rapid interbedding of clastic rocks of varying grain size suggests that the Telemon Formation was deposited in an unstable basin. The basal conglomerate, which thins rapidly westwards, was probably derived from an uplifted block marginal to the basin to the east of the Nogoa Anticline. The block consisted dominantly of volcanics of the Dunstable Formation, metamorphics, and probably granite. The basin was probably non-marine; algal colonies possibly lived in brackish water. Shell (SQD, 1952) are of the opinion that the probable algal limestone represents tufa originating in playas and salt water lakes. The presence of brecciated lime-mud rocks, suggests the desiccation of a calcareous mud with subsequent immersion in water in a playa or lacustrine environment. Shell report the presence of the branchiopod Leaia, which probably lived in a freshwater environment near the top of the formation. Poorly sorted cross-bedded and festoon-bedded conglomeratic sandstone represent rapid fluviatile deposition. Tuffs and tuffaceous sediments indicate that volcanic activity in the marginal areas of the basin continued during deposition of the Telemon Formation. No lavas are preserved in the Telemon Formation; a marked contrast to the lava sequence of the Dunstable Formation.

Shell reported a thickness of about 7000 feet for the Telemon Formation (SQD, 1952, p.19). Estimates made from the present mapping tentatively support this thickness as a maximum for the type area; the conglomeratic group is about 2000 feet thick and the multicoloured group about 5000 feet thick. In the Telemon Anticline the conglomeratic group is probably not more than 50 feet thick, and the multicoloured group is probably not more than 3000 feet thick. In the south-west flank of the anticline the multicoloured group is probably less than 1000 feet thick. In the Telemon Anticline, the formation rests on pre-Devonian metamorphics which probably formed a ridge during most of Telemon times.

Shell (SQD, 1952) assigned an Upper Devonian age to the Telemon Formation because of their reported 'well-marked angular unconformity' with the underlying lower Middle Devonian Dunstable Formation. The present survey prefer an Upper Devonian age for the formation for the following reasons:

(i) The lower Middle Devonian corals in the Dunstable Formation occur about 2000 feet from the top and, as discussed under the Dunstable Formation, there is a probable break within the formation above the corals. There is also a probable break at the base of the Telemon Formation (discussed under Dunstable Formation).

(ii) The formation is overlain with a sharp disconformity by the Mount Hall Conglomerate and Raymond Sandstone which form a conformable sequence with the overlying Lower Carboniferous Ducabrook Formation.

(iii) The formation contains the fossil plant Leptophloeum australe in the Emerald Sheet area (White, 1962), a probable Upper Devonian form.

CARBONIFEROUS

Mount Hall Conglomerate

The Mount Hall Conglomerate (Hill, 1957) was originally named by Shell (SQD, 1952) after Mount Hall in the Telemon Anticline, which is the type area. It crops out in the Telemon and Nogoa Anticlines, and in an anticline immediately south-east of the Nogoa Anticline. The unit also crops out to the north, in the Emerald Sheet area. The unit characteristically forms prominent cuestas and strike ridges, mainly in the north-west and east limbs of the Telemon Anticline. The outcrops have a dense cover of timber. In the air-photos the unit has a distinctive dark tone.

The Mount Hall Conglomerate is an orthoquartzite conglomerate as defined by Pettijohn, (1957, p.256), consisting dominantly of rounded milky quartz pebbles, a few pebbles of black and very dark green chert, fine quartzite, indurated fine quartzose sediments, and a very few pebbles of jasper and probable fine-grained volcanics; some pockets of cobbles are present. The conglomerate is well sorted, pebbles from one to two inches in diameter are the most common. The pebbles are set in a granular, coarse-grained quartz sandstone matrix with a kaolinitic cement. Interbeds of kaolinitic quartz sandstone with scattered pebble layers are present. The conglomerate is commonly cross-bedded in thick to very thick units. In the Telemon and Nogoa Anticlines conglomerate is dominant, whereas in the anticline immediately south-east of the Nogoa Anticline, where the unit is thickest, about half the unit consists of thin-bedded feldspathic quartz sandstone.

The Mount Hall Conglomerate disconformably overlies the Telemon Formation (see Telemon Formation) and is conformably overlain by the Raymond Sandstone. The boundary with the Raymond Sandstone is transitional; in effect, the Mount Hall Conglomerate is a basal conglomeratic facies of the Raymond Sandstone. The top of the Mount Hall Conglomerate is taken at the top of the highest conglomeratic sandstone or conglomerate. It is represented in the Nogoa Anticline and in the west of the Telemon Anticline only by thin lenses of conglomerate. The conglomerate is an excellent marker within the limits of its outcrop in the Sheet area because of its distinct lithology, prominent outcrops, and distinctive air-photo pattern. It forms a reliable marker despite its lenticularity because where it is present it is always below the Raymond Sandstone which is present everywhere. A narrow ridge of Mount Hall Conglomerate, about 100 yards long was detected in the air-photos at the northern end of the Nogoa Anticline, one mile south-west of Connemarra Homestead. This outcrop proved significant in defining the northern part of the Nogoa Anticline.

The Mount Hall Conglomerate is a basal conglomerate, showing a change in provenance and environment of deposition from the Telemon Formation. It marks the beginning of a period of fluviatile quartzose deposition. No cross-bedding directions were measured, but from the lithologies of the pebbles it seems probable that much of the Conglomerate was derived from the pre-Devonian Anakie Metamorphics, which crop out to the north in the Emerald and Clermont Sheet areas. The conglomerate was probably initially deposited from streams as fans in shallow freshwater depressions. It is possibly related either to uplift of the provenance area or a marked climatic change from Telemon times. The conglomerate was probably reworked and distributed by streams which altered course in response to slight epeirogenic movements in the basin. The disconformity with the Telemon Formation supports the contention of epeirogenic uplift before the Mount Hall Conglomerate was deposited.

The Mount Hall Conglomerate is extremely lenticular; as noted above, it is absent in places. In the Springsure Sheet area it appears to be thickest (about 1500 feet) in the area a few miles west of Euneeke Homestead. In the north-east limb of the Telemon Anticline it is about 1000 feet thick. In the Emerald Sheet area it has a maximum thickness of 2600 feet (Veevers, Mollan, Olgers, and Kirkegaard, in press).

The Mount Hall Conglomerate is regarded as Lower Carboniferous for the following reasons:

i) It disconformably overlies the probable Upper Devonian T on Formation.

(ii) It is conformably overlain by the Raymond Sandstone wh h, in turn, is conformably overlain by the Lower Carboniferous Ducabrook Formation.

(iii) It contains probable Lower Carboniferous plants (see localities SP41 and SP89/1, Appendix 2).

Raymond Sandstone

The Raymond Sandstone (Veevers, Mollan, Olgers, and Kirkegaard, in press) was originally named the 'Flaggy Sandstone Group' by Shell (SQD, 1952) and renamed the Raymond Flaggy Sandstone by Hill (1957). The type area is at the southern end of the Telemon Anticline in the vicinity of Raymond Creek.

The Raymond Sandstone crops out in the Telemon and Nogoa Anticlines, and in an anticline immediately south-east of the Nogoa Anticline. It forms prominent strike ridges and cuestas, in the Telemon Anticline. It supports less timber than the Mount Hall Conglomerate and consequently can be distinguished from the Mount Hall Conglomerate in the air-photos. The Raymond Sandstone crops out to the north in the Emerald Sheet area.

In the type area the Raymond Sandstone consists dominantly of medium bedded, flaggy, fine and medium grained micaceous quartz sandstone, commonly buff-brown and greenish-brown, and, in places, creamy white. The sandstone contains carbonaceous fragments, commonly along bedding planes and abundant mica in thin/bedded sandstone imparts the flaggy fissility. Some sandstone contains significant quantities of feldspar and lithic grains. Thin siltstone interbeds are present. Flaggy quartz sandstone is commonly cross-bedded in units one to two feet thick; the foreset beds are flaggy and shallow dipping. Individual sandstone beds can be traced for several miles in the air-photos.

Chert breccia, noted also by Shell (SQD, 1952) is present at the top of the formation at the southern end of the Telemon Anticline. The breccia consists of fractured, angular to subrounded pebbles, up to two inches across, of milky quartz, chert, and probable volcanics, in an unsorted matrix with a cherty cement.

The Raymond Sandstone overlies the Mount Hall Conglomerate, and disconformably overlies the Telemon Formation where the Conglomerate is absent; these relationships are discussed under the Mount Hall Conglomerate and Telemon Formation. The Sandstone is conformably overlain by the Ducabrook Formation which is lithologically more diverse and contains more lithic and primary volcanic material.

The Raymond Sandstone was probably deposited in a shallow non-marine basin and derived from the basin hinterland by mature streams. It was probably derived from the same provenance which produced the Mount Hall Conglomerate. Conditions in the basin were fairly stable with gentle currents reworking and distributing sand. Flaggy (i.e. micaceous) bedding probably indicates short periods when sand was not being deposited and mica flakes were allowed to settle out slowly before more sand was deposited. The Raymond Sandstone ranges from 100 to 1200 feet thick. It is 1200 feet thick in the southern plunge of the Telemon Anticline and 100 feet thick where Mistake Creek intersects the east limb of the Telemon Anticline.

The Raymond Sandstone contains only indeterminate plant remains. It is probably Lower Carboniferous for the same reasons as the Mount Hall Conglomerate.

Ducabrook Formation

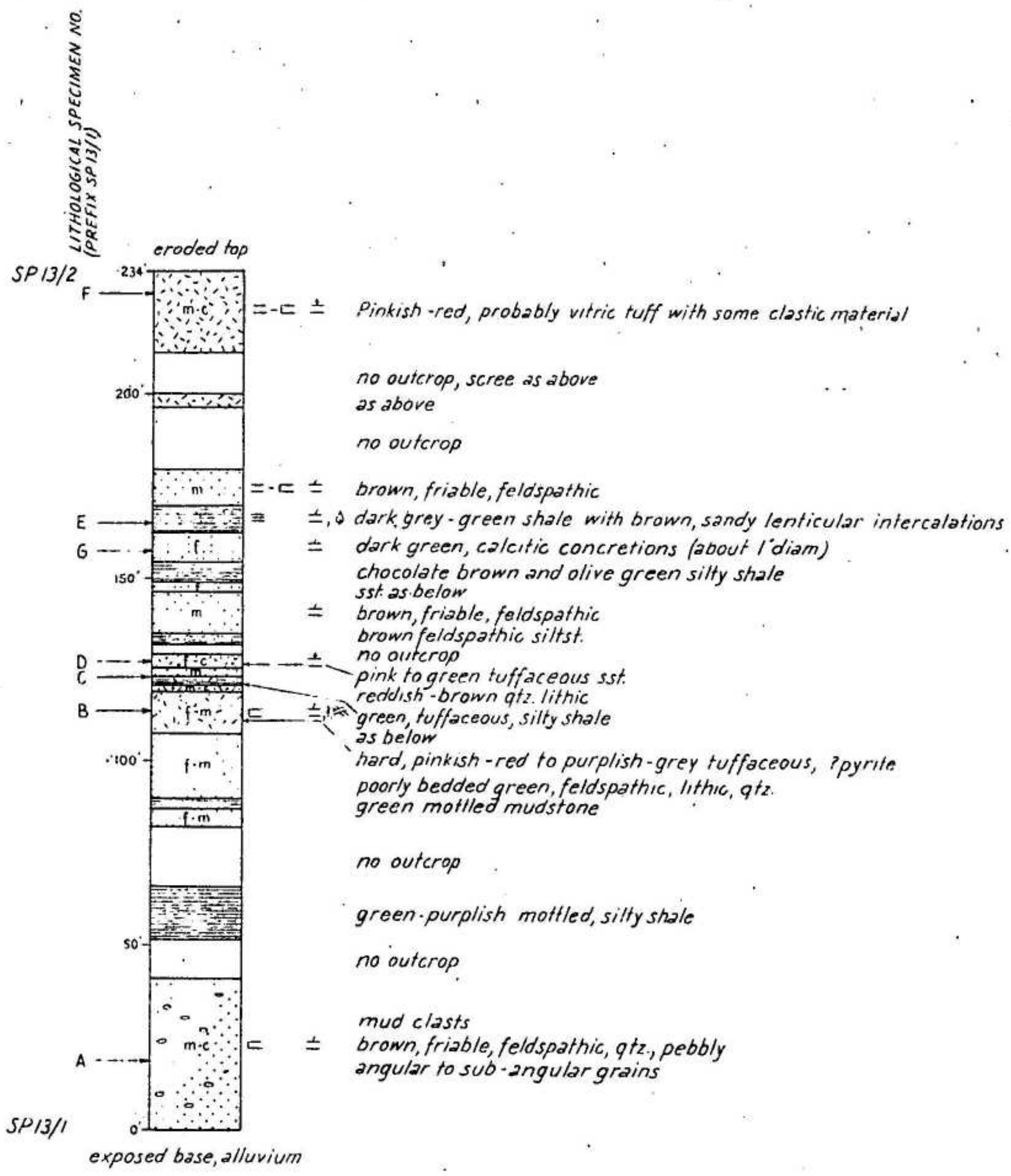
The Ducabrook Formation (Hill, 1957) was originally named the Ducabrook Series by Shell (SQD, 1952) after Ducabrook Pastoral Holding in the Emerald Sheet area.

The formation crops out in large areas of the north-west quadrant of the Springsure Sheet area in the Nogoa, Telemon, and Medway Anticlines and in a small anticline immediately south-east of the Nogoa Anticline. The formation forms fairly flat, soil and scrub covered country with some low outcrop ridges in the Nogoa Anticline area. The country is more undulating between the Telemon and Medway Anticline north and east of Echo Hills Homestead, where closely spaced groups of strike ridges and small scarps are separated by river flats. This area has a less dense scrub cover and the ridges and scarps commonly support only a thin cover of timber. The formation in the Nogoa Anticline area has a dark tone with distinct bedding trend lines very similar to the photo pattern of the upper part of the Telemon Formation. In the Echo Hills area the formation has a varied tone with distinct bedding trends in the air-photos.

The Ducabrook Formation is lithologically similar to the multicoloured group of the Telemon Formation: a thinly interbedded sequence of arenites and argillites with much primary and secondary volcanic material. It is apparent from Shell's work (SQD, 1952), and work by Veevers, Mollan, Olgers, and Kirkegaard (in press), and the present survey that lithological subdivisions of the formation are difficult to make. Pallister (in

MEASURED SECTION IN TOP PART OF DUCABROOK FORMATION (S2)

3/5 mile west of Echo Hills Homestead between points SP 13/1 and SP 13/2
(Springsure North, Run 1/Photo 5111) (measured with Abney Level by R G Mollan)



Schneeberger, 1942) who mapped the Bogantungan-Zamia area of the Emerald Sheet area says: 'For local correlation, subdivisions were made of the Ducabrook Series as follows: 5. Upper Group 1800 feet; 4. Flagstone Group 1900 feet, 3. Purple Shale Group 500-600 feet, 2. Massive Sandstone Group 2000 feet, 1. Basal Group 2000 feet. This division is based on the variable predominance of certain lithological types and no distinct boundary horizons can be traced, therefore the groups are not expected to be of wide application nor are their separate thicknesses closely comparable even within the limits of this area.' Pallister's remarks apply equally well to the formation in the Springsure area, where abrupt changes in lithofacies in both a vertical and lateral sense, in detail and regionally, occur within the formation.

The best exposed section of the Ducabrook Formation is in the west flank of the Telemon Anticline. The sequence contains pebble conglomerate and conglomeratic sandstone near the base and the top, consisting of rounded pebbles of quartz and chert, ranging from ¼ inch to three inches across, set in a feldspathic - quartz sand matrix. Sandstone beds in the formation are deep purplish-brown, khaki-brown, and green; they contain varying proportions of quartz, lithic material (volcanics and low grade metamorphics), feldspar, and matrix-cement (commonly tuffaceous). Some tough green sandstone is dominantly calcareous with fontainebleau texture. Some sandstone beds contain at the base mud clasts and flakes, up to several inches in diameter; other sandstone beds are banded with dark bands of secondary hematite-limonite-pyrite. Sandstone is commonly cross-bedded, and festoon-bedded, with current striations on bedding planes. Other rock-types are mudstone and siltstone, commonly dense tuffaceous and cherty rocks. The mudstone is reddish-purple, olive green, and khaki; it is generally massive rarely showing shaly fissility. Tough pinkish-red beds of rhyolitic vitric tuff which show crude graded bedding are characteristic of the upper part of the formation.

The measured section (Fig.4) illustrates the upper part of the Ducabrook Formation. Specimen SP13/1A is a feldspathic-lithic-quartz sandstone with some mica. The lithic grains are dominantly metasediments; some tuff grains are present also. The small amount of matrix is probably volcanic ash. SP13/1B is a vitric tuff consisting of glass shards in a reddish brown volcanic dust. SP13/1D is a crystal-lithic tuff. Stratigraphic drill holes B.M.R. No.10 and B.M.R. No. 11 penetrated fresh mudstone and siltstone in the upper part of the Ducabrook Formation.

Silty limestone with layers of oolites are present in the formation; individual oolites are commonly less than $\frac{1}{8}$ inch in diameter. Several lenses of probable algal limestone were found; the individual probable algal colonies are commonly cylindrical, about an inch in diameter and several inches long.

Other detailed lithological descriptions of rocks from the Ducabrook Formation are in Appendix 1 in Veevers, Mollan, Olgers, and Kirkegaard (1962) (Emerald Sheet area), and Appendix 4 in Schneeberger (1942) (Emerald and Springsure Sheet areas).

Numerous small-scale folds, ~~about three feet high,~~ with amplitudes of two feet, occur in sandstone at the top of the formation in an area seven miles north of Riverview Homestead in the west flank of the Telemon Anticline. The folds have the form of knick folds with sharp, acute-angled crests, fractured along vertical axial planes. The folds have no common orientation. They are found only in the highest exposed beds in the area in which they occur. Two possible explanations of the folds are suggested:

(i) they were formed during folding of jointed sandstone; compressional forces within the sandstone were released at the joints by the formation of the folds;

(ii) they are permafrost structures, formed in an exposed sandstone bed possibly at the onset of the glacial Joe Joe Formation period. The size and form of the folds compare closely with permafrost structures in Glamorgan, Wales (Bradshaw and Ingle-Smith, 1963).

The Ducabrook Formation conformably overlies the Raymond Sandstone and is unconformably overlain by the Joe Joe Formation; details of the relationship with the Joe Joe Formation are discussed under the Joe Joe Formation.

The Ducabrook Formation was deposited in a shallow, sporadically subsiding, probably non-marine basin. Periods of non-deposition and desiccation followed by renewed inundation are represented by mud clasts and flakes in the base of sandstone beds. Conglomerate and festoon-bedded conglomeratic sandstone are probably fluviatile gravels.

The presence of probable algae, red beds, oolites, fish, and small pelecypods indicate several abrupt changes in depositional environment; rapid variations along strike are the result of rapid changes of environment within the basin. Contemporaneous volcanic activity which persisted throughout the deposition of the formation increased in intensity in the late stages.

Shell (SQD, 1952) report a variation in thickness from 5800 feet to 8500 feet in the Ducabrook Formation. In the east limb of the Telemon Anticline the formation is estimated to be about 5,000 feet thick.

The Ducabrook Formation contains Lower Carboniferous fossil fish remains (Jack & Etheridge, 1892, & SQD, 1952). The probable Lower Carboniferous plant fossil Lepidodendron veltheimianum was found in the formation in the Emerald Sheet area (White, 1962). During the present survey the following fossils were found in the formation:

(i) Several fish scales at locality SP32 (Enclosure 1) a mile south-east of Rooken Glen Homestead.

(ii) Small pelecypods, about one inch long, at localities SP361/6 and SP358/4 (Enclosure 1), about five miles west-south-west of Tresswell Homestead.

(iii) Casts and impressions of Lepidodendroid stems at numerous localities (see Appendix 2).

(iv) Probable megaspores at locality SP352/2 (Enclosure 1), a little over one mile north-west of Tresswell Homestead.

(v) Several lenses of algal limestone at localities SP361/4 and SP773, four miles north-north-east of Riverside Homestead and six miles east-north-east of Echo Hills Homestead respectively.

CARBONIFEROUS-PERMIAN

Joe Joe Formation

The Joe Joe Formation was originally named the 'Joe Joe Creek Series' by Shell (SQD, 1952) and amended to 'Joe Joe Creek Formation by Hill (1957). The name is now abbreviated to Joe Joe Formation. The name derives from Joe Joe Creek in the north-west part of the Springsure Sheet area; the type area is in the vicinity of the creek.

The formation forms a belt of outcrop extending west from the southern part of the Nogoa Anticline to beyond the Sheet boundary. Lobes of outcrop extend from the belt north in synclines but the area of outcrop is less than that mapped by Shell. The upper part of the unit is reasonably well exposed, whereas much of the lower part is concealed beneath gravel deposits. Bedding trends cannot be distinguished in the air-photos in the conglomeratic lower part which forms low rounded hills and has a dendritic drainage pattern; bedding trends are pronounced in the better bedded upper part, within which the more resistant beds form low cuestas.

The lower part of the Joe Joe Formation consists of conglomerate, conglomeratic mudstone, and quartz-lithic sandstone. The conglomerate is mainly cobble conglomerate, but also contains boulders. Alternations of pebble and cobble conglomerates are common. At least 50% of the pebbles, cobbles, and boulders are quartzite and fine-grained indurated quartzitic sediments, commonly quartz-veined; the rest consist of granitic rocks, volcanics (mainly porphyritic acidic types), vein quartz, slates, phyllite, schist, soft shale and siltstone, and fossiliferous limestone (Appendix 4). Fossiliferous limestone boulders, up to three feet across, are common at locality SP600. Most boulders are rounded and a few have striated facets (Fig.9). Slump rolls were observed in interbedded lithic sandstone and conglomerate.

The conglomeratic mudstone is unsorted and lacks bedding features. At least 80% of the rock consists of light-green sandy mudstone, often slightly calcareous, in which cobbles and boulders, similar to those in the conglomerates, are embedded. Most of these are rounded, some are angular or tabular, and a few, faceted and striated. A boulder, of black slaty mudstone, three feet across, with striated facets was found embedded in green sandy mudstone about six miles north-west of Mount Mudge. Scattered on the surface throughout the lower part of the Joe Joe Formation are boulders, mainly of granite and porphyry, up to six feet in diameter. The boulders are generally close to outcrop of conglomeratic mudstone, and have presumably weathered out of it. The tops of conglomeratic mudstone beds are often scoured; similarly, where they rest on sandstone beds scour marks are common in the top of the sandstone. Except for the high percentage of rounded rather than angular cobbles and boulders, the conglomerate fits closely the description of tillite in Pettijohn (1957).

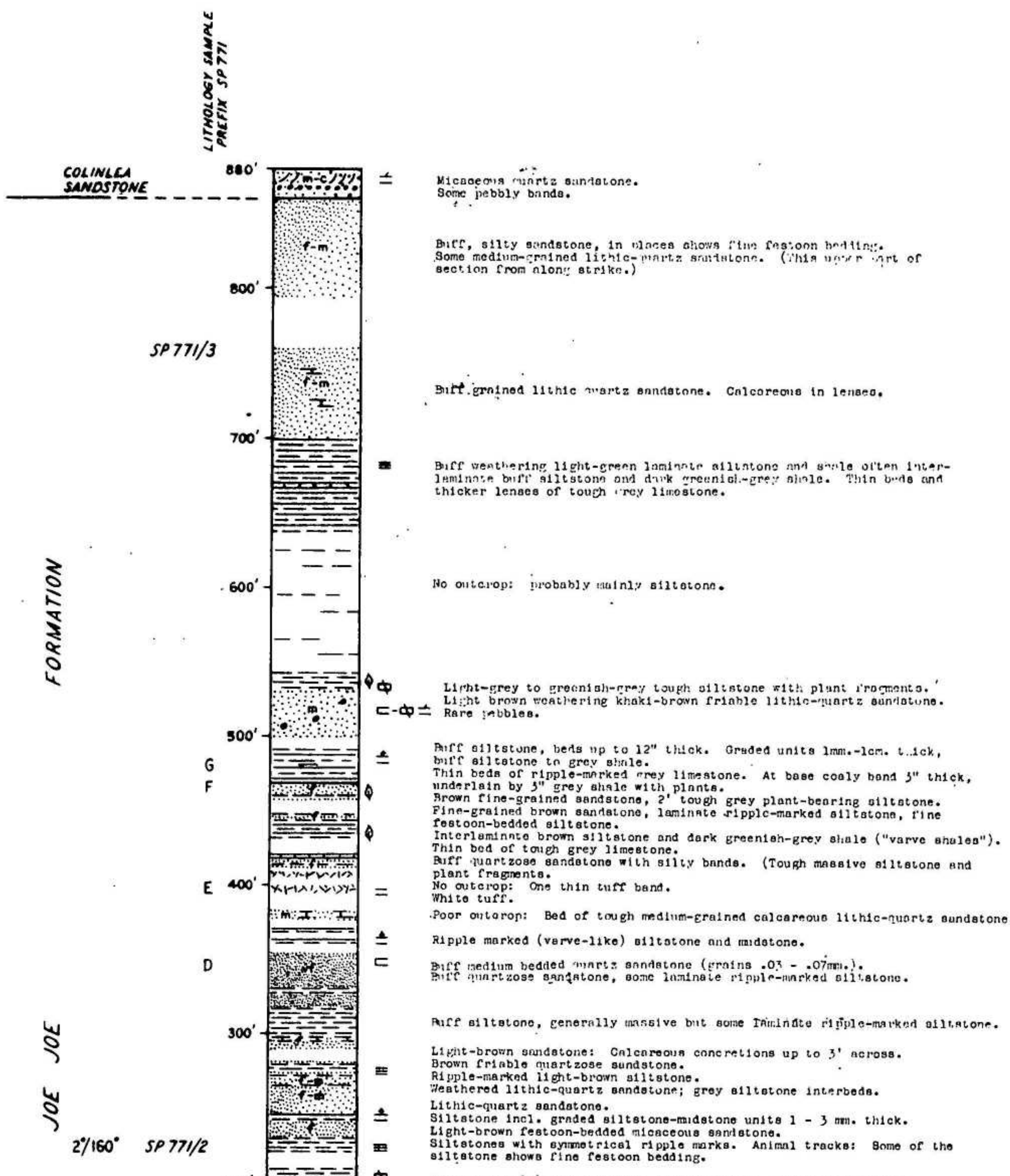
Sandstone is brown, friable, fine to medium grained, poorly bedded to massive, quartz-lithic sandstone. Lithic grains are dominant, consisting of fine-grained volcanics and tuff, schist and metasediments. Quartz grains are very strained and cracked. About 10% of the grains consist of perthitic potash feldspar and oligoclase. Most of the intergranular spaces are void, and the sandstone is porous in surface samples; the grains have a film of argillaceous (chloritic) material which forms a weak cement.

The uppermost part of the formation consists of very fine-grained sandstone and siltstone, fine-to-medium grained quartz-lithic sandstone, carbonaceous shale with thin coal bands, and

Figure 5

MEASURED SECTION OF UPPER PART OF JOE JOE FORMATION (S 3)

Measured in tributary of Joe Joe Creek, 1 mile west of "Echo Hills",
from SP771/1 to SP771/3 (Springsure North, Run 2, Photo 5026)
(Abney section measured by A.G. Kirkegaard)



fine-grained grey limestone; Figure 5 is a measured section through this interval. The dominant lithologies are fine-grained sandstone and siltstone, in which most grains of angular and sub-angular quartz are about 0.05 mm. in diameter (i.e. about the sand-silt boundary). They are set in a chloritic matrix. These sediments are thinly-bedded to laminated, finely festoon-bedded, and symmetrically ripple marked. The bedding surfaces commonly show two types of tracks (Fig. 10 and 11) which are probably worm and arthropod tracks. In places the siltstone contains laminae and thin beds of greenish-grey clay shale, mostly at irregular intervals; siltstone and clay shale are also finely interbedded. The beds are very similar to varves (Fig.8). The fine to medium grained sandstone beds are similar to those in the lower part of the formation. Lithic grains are dominant, and consist mainly of fine-grained sediments, phyllite and schist; volcanic grains are rare. The sandstone is calcareous in part and contains rare pebbles. Thin beds and thin discoidal concretions of limestone, up to 3 feet across occur in the siltstone. The thin limestone beds are ripple marked in places. Beds of tough, light greenish-grey siltstone with numerous plant fragments are common in the upper part. A bed of creamy to pale pink vitric tuff, 20 feet thick, occurs near the middle of the Joe Joe Formation; in places it contains thin interbeds of indurated blue-grey mudstone with well preserved plant remains, especially near Joe Joe Homestead (SP606, Appendix 2.) Tuff beds occur higher in the sequence.

White fine-grained sediments, which Shell considered to be the basal part of the Colinlea Sandstone, are now considered to be a leached zone at the top of the Joe Joe Formation, because they contain the same flora as the Joe Joe Formation. The leached zone is shown in Figure 13; it is underlain by a strongly ferruginised ripple-marked siltstone which is persistent over several square miles in the area where the section was measured. The ferruginisation probably represents a period of non-deposition and desiccation.

Many of the pebbles, cobbles, and boulders in the formation are lithologically similar to older rocks exposed to the west and north in the Springsure, Emerald, and Clermont Sheet areas as follows:

(i) Probable lower Middle Devonian coralline limestone (Appendix 4) - the only known outcrops are in the Dunstable Formation in the Nogoa Anticline, in a small inlier near Glendarriwell Homestead in the Emerald Sheet area (Veevers, Mollan, Olgers, and Kirkegaard, in press), and near Douglas Creek Homestead in Clermont Sheet area (Veevers, Randal, Mollan and Paten, in press).

(ii) Slate, phyllite, schist, vein quartz, and possible gneiss - the Anakie Metamorphics, which crop out in large areas of the Clermont and Emerald Sheet areas, consist of similar rocks; a pre-Devonian inlier in the Telemon Anticline consists of similar rocks also, but was probably not exposed during deposition of the Joe Joe Formation.

(iii) Soft shale and siltstone fragments - similar rocks occur in the Ducabrook and Telemon Formations.

(iv) Porphyritic volcanics- similar volcanics occur in the Dunstable Formation (see Appendix 3).

(v) Granite - some granite, in the Retreat Granite in the Emerald Sheet area, and in a granite stock in the Telemon Anticline, is petrographically similar.

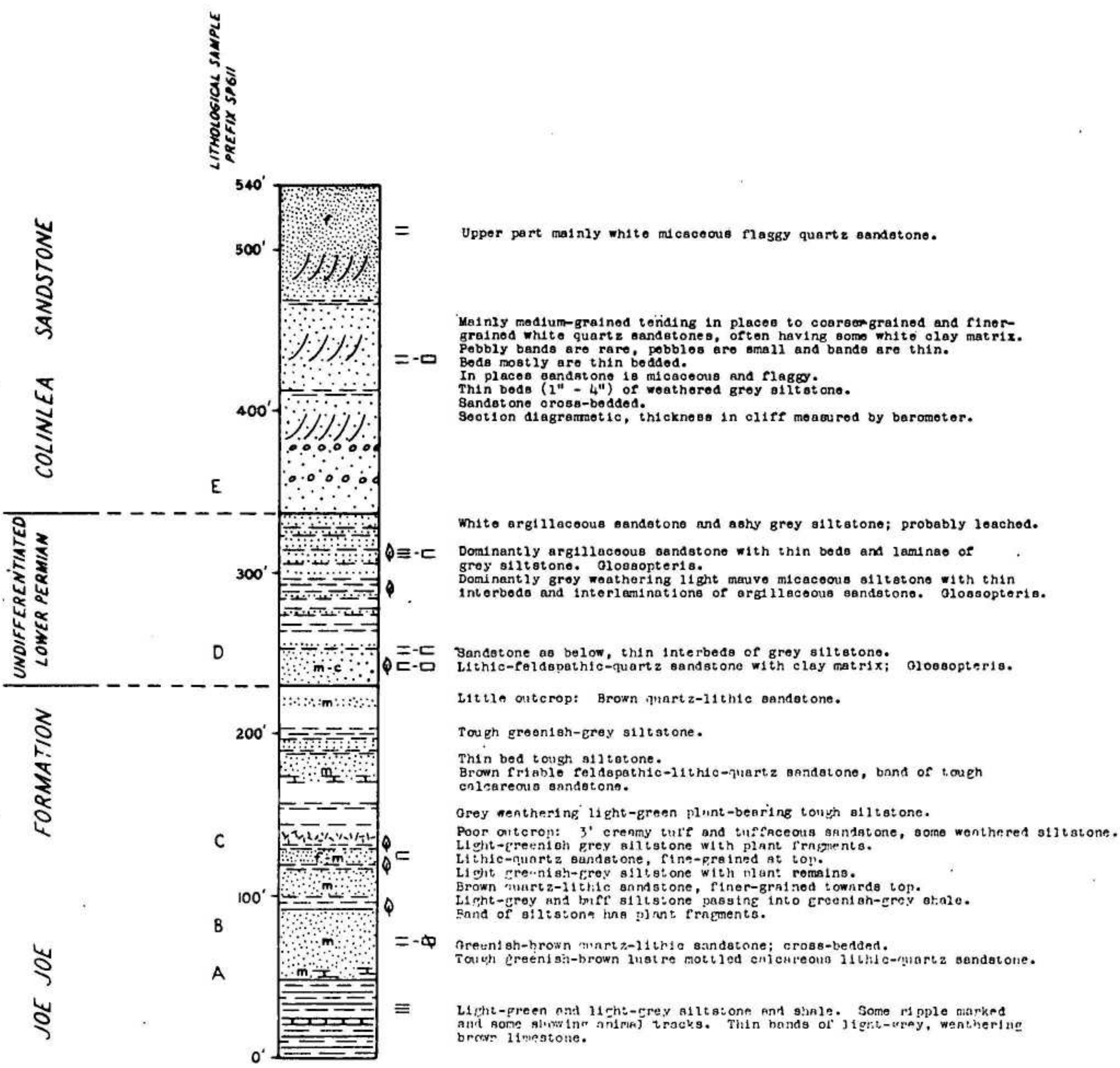
Pebbles and bolders of quartzite, and indurated, quartz-veined, quartzose sediments are possibly derived from a pre-Joe Joe Formation siliceous duricrust ('billy').

The Joe Joe Formation unconformably overlies the Ducabrook Formation. The unconformity was observed in the southern nose of the Medway Anticline. The unconformity is also apparent on a regional scale at the southern end of the Telemon Anticline and is more obvious in the area between Nandowrie Needle and Hillview Homestead where conglomerate of the Joe Joe Formation overlaps the Ducabrook Formation and Raymond Sandstone, and rests on the Telemon Formation (Enclosure 1). No contacts with the underlying formations were observed in these areas. At the southern end of the Mistake Syncline and in the syncline immediately west of the Telemon Anticline there is apparent conformity between the Joe Joe and Ducabrook Formations. The impression gained is that the deposition of the Joe Joe Formation was controlled by folding in the Ducabrook Formation. Because the lower part of the Joe Joe Formation was deposited mainly from streams, depositional dips would tend to parallel the limbs of synclines.

The relation of the unit to the overlying Colinlea Sandstone is less clear. Where observed, the contact appears to be conformable, but since the top part of the Joe Joe Formation appears to be missing along the Fairview Anticline, the relationship is probably unconformable. The Colinlea Sandstone overlaps the Joe Joe Formation along the southern part of the Nogoa Anticline axis; in this area the Colinlea ~~Formation~~ Sandstone rests unconformably on the Ducabrook Formation, the Raymond Sandstone, the Telemon Formation, and the Dunstable Formation. The Joe Joe Formation apparently thins eastwards and east of the Nogoa Anticline forms only isolated outcrops. The overlap of the Colinlea Sandstone is thus more pronounced eastwards. The

MEASURED SECTION FROM JOE JOE FORMATION TO COLINLEA SANDSTONE (S4)

Measured on cliff section 6 miles west of Joe Joe Hut from SP 611/1 to SP 611/4
(Springsure North, Run 1, Photo 5107)
(Measured by A.G. Kirkegaard using Abney Level and Barometer)



relationship between the Joe Joe Formation and the Colinlea Sandstone is similar to the relationship between the Joe Joe Formation and the Ducabrook Formation: there is unconformity in structurally high areas and disconformity in structurally low areas.

In three areas, a few miles south of Mount Paddy, two miles west of Connemarra Homestead, and two miles south-east of Nandowrie Needle, the Joe Joe Formation is overlain by a thin sandstone and siltstone unit, containing Glossopteris (Fig.6). At the locality near Nandowrie Needle this unit appears to be unconformable on the Joe Joe Formation; elsewhere the relationship is not apparent. The Joe Joe Formation has a low regional dip to the south and south-south-west in the area west of the Telemon Anticline. Dips in the southern parts of the Telemon and Nogoa Anticlines, and in the Mistake Syncline are steeper. Some dips are probably depositional dips as discussed above; others are probably due to post-Carboniferous folding of the Nogoa and Telemon Anticlines.

Numerous current features and the presence of local erosional disconformities suggest that the Joe Joe Formation was deposited mainly in shallow water with currents (Fig.10). Conglomerates contain rounded, as well as faceted and striated cobbles and boulders suggesting that they represent water-transported and reworked morainic materials. Tillite is interbedded with the conglomerate and sandstone probably representing several advances and retreats of ice sheets. During the deposition of the upper part of the formation the ice had retreated, and deposition continued in shallow basins fed by glacial melt streams, permitting the development of varved sediments (Figure 8). Vitric tuff beds show that there was some contemporaneous volcanic activity.

Contorted mudstone beds with dispersed, faceted cobbles were observed about three and a half miles south-west of Echo Hills Homestead; tongues of mudstone, about five feet high, project into overlying beds. The features appear to be similar to permafrost structures studied by Bradshaw and Ingle-Smith in Glamorgan, Wales (1963).

Shell (SQD, 1952) state that the Joe Joe Formation is 2500 feet thick. This thickness could not be verified because of poor and inconsistent bedding in the lower part of the formation. However, Shell's estimate seems to be excessive compared with an estimate computed from regional dip and air-photo distance. The unit is probably not more than 2000 feet thick in the type area.

The formation, and particularly the upper non-conglomerate part, thins eastwards from the type area. The upper part is absent east of the Nogoa Anticline; only isolated outcrops of the conglomeratic lower part occur in this area.

The formation contains well preserved plant remains, notably the fern Cardiopteris polymorpha which, according to White, is Carboniferous (see Appendix 2). The formation apparently does not contain Glossopteris. Spores from the formation indicate that it is partly Permian (Evans, 1964).

Figure 7: Conglomerate in the basal part of the Joe Joe Formation, two miles north-west of Mount Mudge. (Neg.No.G/6262).

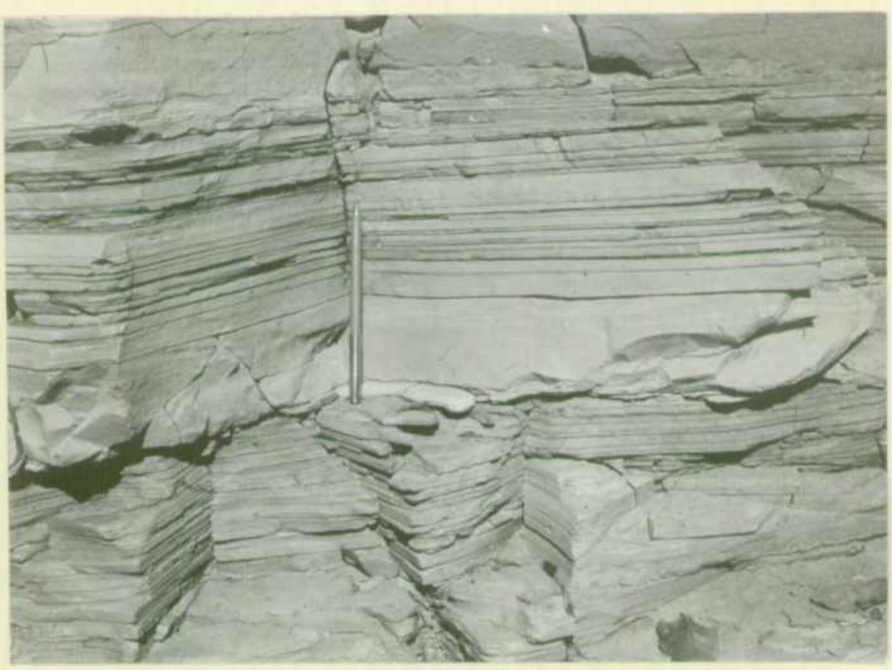


Figure 8: Varved fine-grained sediments, four miles south of Joe Joe Homestead. (Neg.No.G/6259)

Figure 9: Striated and faceted boulder from the Joe Joe Formation, three miles north of Joe Joe Homestead. (Neg.No.G/6263)

Figure 10: Animal tracks and current striations in the lower surface of a siltstone bed in the Joe Joe Formation (natural scale). (Nog. No. F/3814)

Figure 11: Animal tracks in the lower surface of a siltstone bed in the Joe Joe Formation (natural scale). (Nog.No. F/3813)

PERMIAN

Introduction

The thick Permian Sequence of the Springsure Sheet area, fairly well exposed in the Springsure Anticline and Reid's Dome, has attracted the attention of numerous geologists. The sequence lends itself to subdivision because it consists of alternating quartz sandstone and intervals of siltstone and shale. Some formations contain marine macrofossils which in the past have been regarded as standards for correlation throughout the Bowen Basin. Recent work, however, has shown that the sequence in the Springsure Sheet area is atypical for the basin as a whole; some parts of the sequence contain fewer fossil horizons than do the same parts of the sequence in other parts of the basin (for information on the fossils see Appendix 1).

Wherever possible original definitions and usages of formations have been followed. Several formations are only loosely defined by earlier workers, and different workers have applied these loose definitions to different parts of the sequence. These formations are more precisely defined in this report and type sections are proposed for some. Several modifications and additions have been made to the published Permian stratigraphy of the area, namely:

(i) In the Springsure Shelf the Colinlea Formation (Hill, 1957) has been subdivided into three units; a thin unnamed sandstone and siltstone unit at the base, the Colinlea Sandstone, and the Peawaddy Formation (a new name).

(ii) In the Denison Trough, the Catherine Sandstone of Hill (1957) has been subdivided into the Catherine Sandstone, which is probably the same Catherine Sandstone as that originally defined by Reid (1930), and the Peawaddy Formation.

(iii) Shell's Cheshire Formation (Hill, 1957) in the Springsure Shelf, has been subdivided into the Bandanna Formation and the Rewan Formation, established formations in the Denison Trough.

(iv) The Mantuan Productus Bed (Hill, 1943) is retained for fossiliferous and coquinitic lenses in the top of the Peawaddy Formation. During the present survey it was noted that the top of the Peawaddy Formation is commonly lithic sandstone. It seems possible that with further detailed work the Mantuan Productus Bed and the sandstone could be mapped jointly as a member of the Peawaddy Formation. In the accompanying Springsure 1:250,000 geological Sheet (Enclosure 1) outcrops of the Mantuan Productus Bed are represented by points.

(v) The Dilly Beds (Hill, 1957), previously mapped in the area north of Springsure, have been divided into the non-marine Orion Formation (Webb, 1956) and marine Stanleigh Formation (Phillips, in Hill & Denmead, 1960).

The correlation of the Permian formations in the Reid's Dome area of the Denison Trough with the Middle Bowen Beds and Units A, B & C (Dickins, *et al*, in press) is considered to be as follows:-

Middle Bowen Beds	Unit C (Fauna IV)	Lower part of Bandanna Formation (Mantuan Productus Bed) Peawaddy Formation
	Unit B (Fauna III)	Catherine Sandstone Ingelara Formation Aldebaran Sandstone
	Unit A (Fauna II)	Cattle Creek Formation

This correlation is used in Enclosure 11, which is a tentative correlation of formations in eight exploratory oil wells in the Springsure, Baralaba, Taroom, and Eddystone Sheet areas.

Probable correlations between Permian units in the Springsure Sheet area are discussed separately at the end of the Permian section.

Lithological specimens, collected from many of the measured sections of the Permian formations, are being petrologically studied by L.V. Bastian of the Bureau of Mineral Resources and A. Fehr of the Institut Francais du Petrole, Mission in Australia. An interim unpublished report is being prepared by Bastian on specimens he has already studied at the time of writing (Bastian, 1964). Resumes of his petrological results are given under relevent sections. All specimens collected from measured sections are indicated in the appropriate figures. The detailed logs of several Permian formations penetrated by stratigraphic bores are shown in the section on stratigraphic drilling.

Lower Permian sandstone and siltstone

A thin sequence of interbedded siltstone and sandstone crops out in cliff sections, immediately below the Colinlea Sandstone, in the following areas:

(i) West of Connemarra Homestead;
(ii) North-West of Hillview Homestead;
(iii) West of Joe Joe Homestead.

In areas (i) and (ii) the dominant lithologies are purplish sandy siltstone and shale. In area (iii) the unit consists of interbedded purplish micaceous, carbonaceous sandy siltstone and medium-grained quartz-lithic sandstone (Fig.6). The lithic grains in the sandstone are mainly of schist, phyllite and metasediments. Siltstone contains irregular bands, lenses, and thin interbeds of fine-grained sandstone. Two one inch thick coal seams,were observed at locality SP 607. The sandstone is similar to that in the Joe Joe Formation except that the intergranular spaces are filled with an argillaceous matrix.

In area (i) the unit unconformably overlies the Ducabrook Formation and is apparently unconformably overlain by the Colinlea Sandstone. In area (ii) it unconformably overlies the Joe Joe Formation. In area (iii) the unit appears to be conformable between the Joe Joe Formation and the Colinlea Sandstone; the dips in the three units in this area are very low and the relationships are probably disconformable.

The unit was probably deposited in shallow depressions in the Ducabrook and Joe Joe Formations. It probably has a much greater extent beyond the western boundary of the Sheet area.

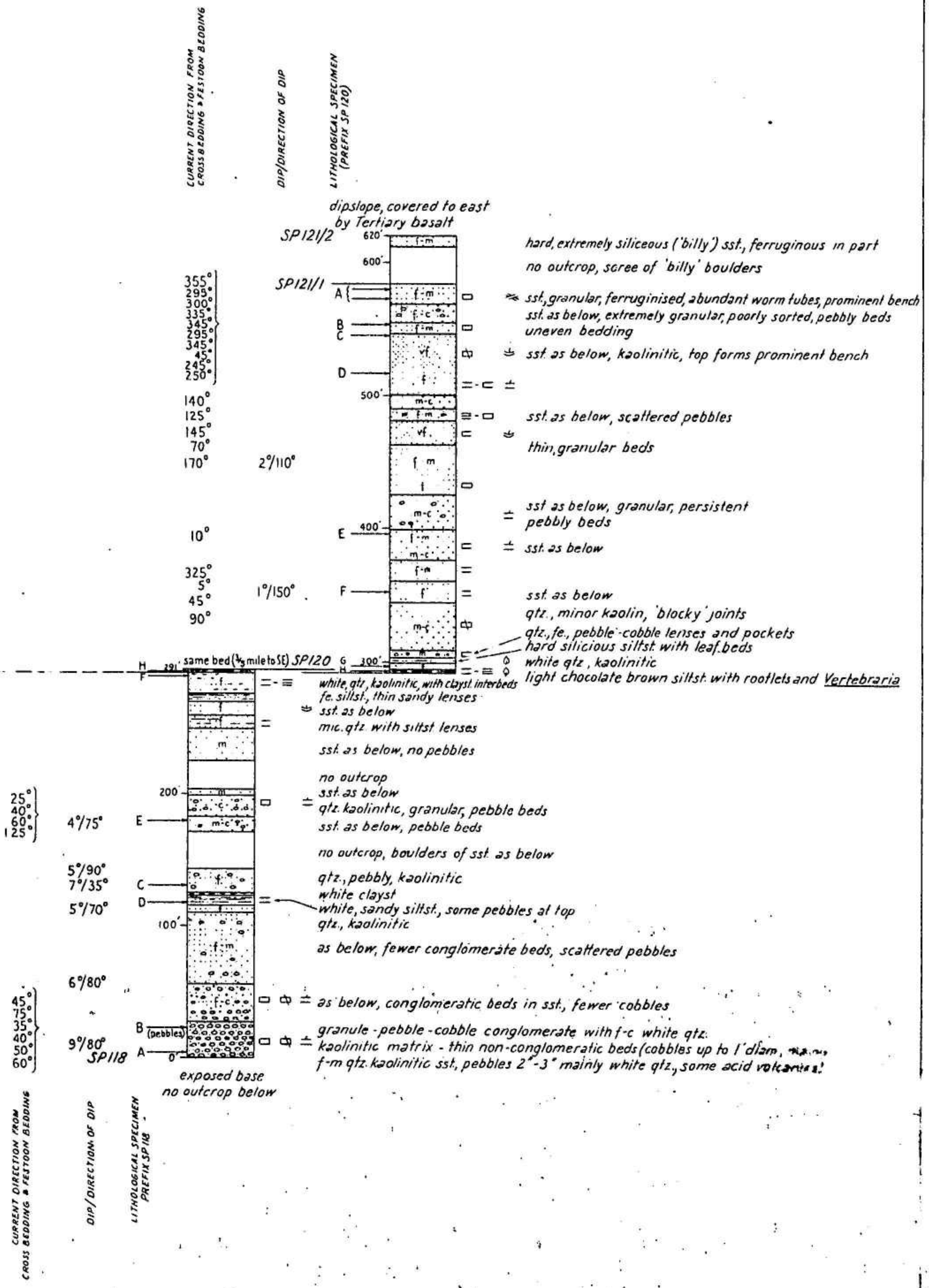
The unit is only about 15 feet thick in areas (i) and (ii) and is 120 feet thick in area (iii).

The unit contains abundant plant remains including several species of <u>Glossopteris</u> indicating a Permian age (Appendix 2). Because it occurs below the Colinlea Sandstone it is probably Lower Permian.

Figure 12

MEASURED SECTION IN COLINLEA SANDSTONE (S5)

Measured along the Central Western Highway, immediately north of Vandyke Homestead, and in a hill immediately south of the highway, between points SP 118 and SP 121/2 (Springsure North, Run 1/Photo 5119, Run 2/Photo 5016) (Measured with Abney Level by R.G. Mollan, A. Fehr and L.V. Bastian).



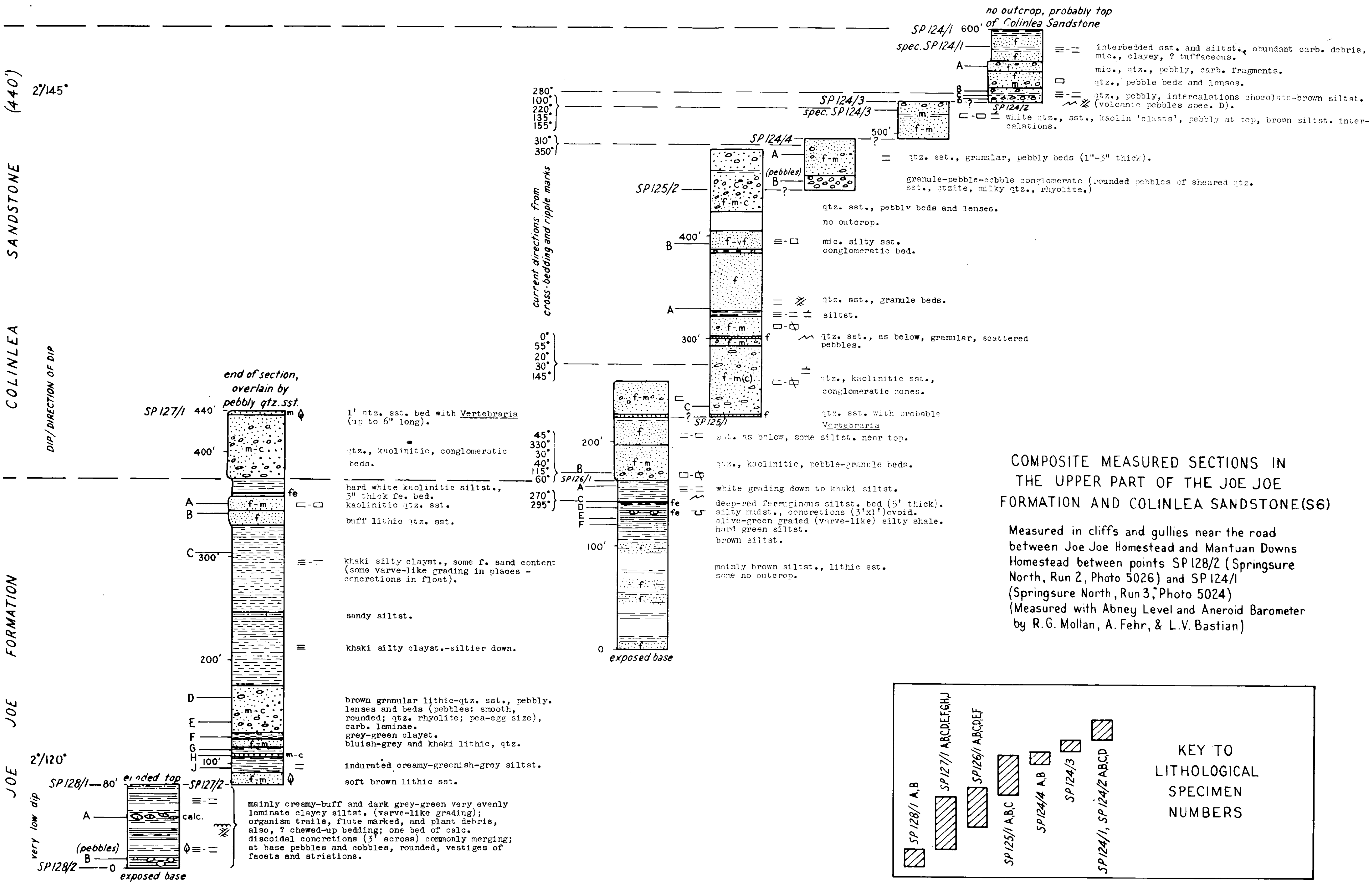
Colinlea Sandstone

Shell (SQD, 1952) used the term 'Colinlea Series' for beds between the Joe Joe Formation and the Mantuan *Productus* Bed. Hill (1957) published the name 'Colinlea Formation' for the same unit. During the present survey the upper part of the 'Colinlea Formation' including the Mantuan *Productus* Bed, was identified as the Peawaddy Formation (defined in the Reid's Dome - Consuelo Anticline area) and the lower part of the 'Colinlea Formation', consisting dominantly of quartz sandstone, is now proposed as the Colinlea Sandstone. The type area of the Colinlea Sandstone is along the Central Western Highway immediately north of Vandyke Homestead and lies within a land division known as Colinlea Holding. Figure 12 is a section measured in the type area.

The Sandstone crops out extensively in the northern half of the Sheet area; its eastward extent is obscured by Tertiary basalt. It crops out farther northwards and westwards in the adjoining Emerald and Tambo Sheet areas. The unit forms prominent white cliffs several miles south of Echo Hills and Joe Joe Homesteads; the basal part of the unit forms the upper part of the cliffs, up to 600 feet high; numerous outliers form mesas immediately north of the cliffs. Deeply incised drainage south of the cliffs produces herring-bone ridges. The air-photo tone is dominantly dark due to dense growth of small trees. Dipslopes and bedding trends are readily discernible in the airphotos.

The Colinlea Sandstone consists dominantly of fine to medium grained quartz sandstone and granule-pebble-cobble conglomerate, grading to pebbly sandstone; conglomerate beds are most common near the base but occur at intervals throughout the section; they are rare in the unit near the western boundary of the Sheet area. Pebbles and cobbles are mainly milky quartz and fine quartz sandstone; quartzite, chert, and acidic volcanics occur in lesser amounts. The sandstone is porous in outcrop and commonly contains some kaolinitic matrix; sandstone cuttings from stratigraphic drill hole BMR 6 contain a high percentage of white kaolinitic matrix. Thin interbeds of soft purplish siltstone commonly contain plant fossils. South of Nanowrie Needle a basal conglomerate contains ferruginised logs. The sandstone is commonly thick to medium bedded, particularly near the base, and tends to be thinly-bedded to laminated towards the top; cross-bedding and festoon bedding are common.

In the type section (Fig.12) the upper part contains very thick bedded, fine and even grained festoon-bedded sandstone which forms prominent benches. A sandstone bed at about 530 feet



COMPOSITE MEASURED SECTIONS IN THE UPPER PART OF THE JOE JOE FORMATION AND COLINLEA SANDSTONE (S6)

Measured in cliffs and gullies near the road between Joe Joe Homestead and Mantuan Downs Homestead between points SP 128/2 (Springsure North, Run 2, Photo 5026) and SP 124/1 (Springsure North, Run 3, Photo 5024)
(Measured with Abney Level and Aneroid Barometer by R.G. Mollan, A. Fehr, & L.V. Bastian)

in Figure 12 forms a rock pavement bench around a low dipping mesa. The down-dip face of the bench is covered with an encrustation of alunogen, about ½ inch thick. The alunogen appears to be deposited as a residual concentrate as the sandstone weathers away. Water, percolating down dip through the sandstone, has probably helped concentrate the mineral. Alunogen at this locality was first investigated for its economic potential by Richards (1918b). A two feet thick sandstone bed about 60 feet above the base of the formation and exposed in cliffs south of Joe Joe Homestead characteristically contains the plant fossil Vertebraria (Fig.13).

Bastian (1964) has examined thin sections of specimens collected from the Colinlea Sandstone at the measured section shown in Figure 13. His work has shown a marked change in the feldspar, quartz, and metaquartzite proportions between specimens SP 124/3 and SP 124/4A. Details of the change are set out below.

	Feldspar	Quartz	Metaquartzite
Specimen SP 124/3 and specimens above	3-15%	30-65%	2-8%
Specimen SP 124/4A and specimens below	Nil	50-90%	10-15%

In the type section (Fig.12) a similar break was not detected, most specimens containing no feldspar; the section is comparable to the lower part of the section described above. It is clear from the mapping that the type section is not a complete section of the Colinlea Sandstone; upper additional section being obscured by Tertiary basalt. The upper feldspathic sandstone of the section in the west (fig.13) although probably present, is obscured by Tertiary basalt east of the type area. The significance of the two-fold lithologic division of the Sandstone is discussed under the section on the correlation of Permian formations.

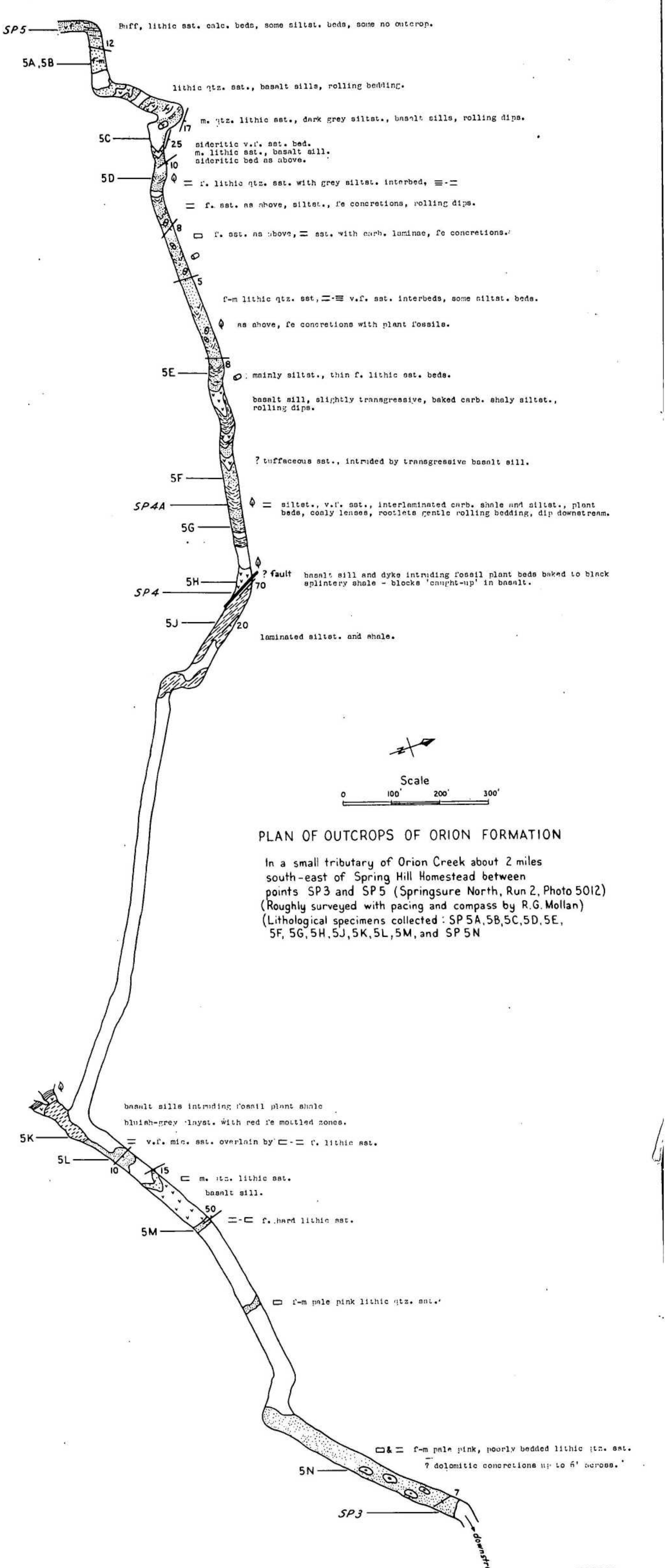
The Colinlea Sandstone has a regional dip of one to two degrees to the south and south-south-west; it is broadly folded in the Fairview Anticline and at the southern end of the Nogoa Anticline. It overlaps the Joe Joe Formation, Ducabrook Formation, Raymond Sandstone, Telemon Formation, and the Dunstable Formation. The relationship with all those units is unconformable except in the area west of the Nogoa River where it is disconformable on the Lower Permian siltstone and sandstone unit and the Joe Joe Formation. The contact with the overlying Peawaddy Formation has not been observed but the two units appear to be conformable. Correlation with units in the Springsure Anticline is difficult as the intervening area is covered by Tertiary basalt (see Correlation of Permian formations).

The Colinlea Sandstone was deposited in the fairly stable, gently subsiding, Springsure Shelf. It was probably deposited as fluvial and deltaic sands in shallow fresh water. In the west, cross-bedding measurements indicate currents from the west and south-west during deposition of the lower part of the Sandstone, changing to south and south-east during deposition of the upper part. The changes in current direction coincide with the lithological changes outlined above (Fig.13). In the type area a few cross-bedding measurements indicate currents from the south-west in the lower part and from the north-west and east in the upper part (Fig.12). Insufficient cross-bedding measurements have been read to give a reliable picture of dominant current directions. The abundant fine-grained quartzose sandstone pebbles in the Sandstone were possibly derived from the Raymond Sandstone, and the volcanic pebbles possibly come from the Dunstable Formation. Many pebbles may have been derived from conglomerate in the Joe Joe Formation. The "Vertebraria bed" (see Fig. 13) probably indicates a pause in deposition. In the type area 620 feet of section is exposed (Fig.12). Along the road between Mantuan Downs Homestead and Joe Joe Homestead the unit is 440 feet thick (Fig. 13) indicating gradual thickening eastwards.

The implications of this thickening are discussed in the section on the Correlation of Permian formations.

Plant fossils collected from the unit are listed in Appendix 2. They indicate a probable Lower Permian age. Spores from stratigraphic drill hole B.M.R. No.6 which penetrated the unit are Lower Permian (Evans, 1964).

Figure 14



PLAN OF OUTCROPS OF ORION FORMATION

In a small tributary of Orion Creek about 2 miles south-east of Spring Hill Homestead between points SP3 and SP5 (Springsure North, Run 2, Photo 5012)
(Roughly surveyed with pacing and compass by R.G. Mollan)
(Lithological specimens collected : SP 5A, 5B, 5C, 5D, 5E, 5F, 5G, 5H, 5J, 5K, 5L, 5M, and SP 5N

G55/A3/21

Orion Formation

The term 'Orion Shale' was first used by Patterson (1956), and published by Webb (1956), for about 200 feet of interbedded sandstone and carbonaceous shale exposed near the head of Orion Creek which is the type area (Figs. 14 and 15). Orion Formation is used as a synonym for 'Orion Shale' because the unit is not dominantly shale and contains much sandstone.

The Orion Formation crops out in two areas along the axis of the Springsure Anticline near the head of Orion Creek, and six miles north of Springsure near the old 'Dilly' railway siding. Between the two areas it is obscured by Tertiary basalt. It is not exposed outside the Springsure Sheet area. The unit is exposed only in creeks; elsewhere, it forms flat soil covered areas. Bedding trends are faintly visible in the air-photos only in the Orion Creek area; elsewhere it has no distinct air-photo pattern.

The Orion Formation consists of interbedded granular lithic quartz sandstone, containing scattered pebbles, siltstone, and shale with abundant plant remains. Details of lithologies near the head of Orion Creek are shown in Figures 14 and 15. It was found impossible to measure the section exposed in the unnamed creek shown in Figure 14, mainly because of rolling bedding and faulting, resulting from the intrusion of numerous Tertiary basaltic dykes and sills. About eight miles north of Springsure, the Orion Formation, exposed in Springsure Creek, is lithologically similar to the type area.

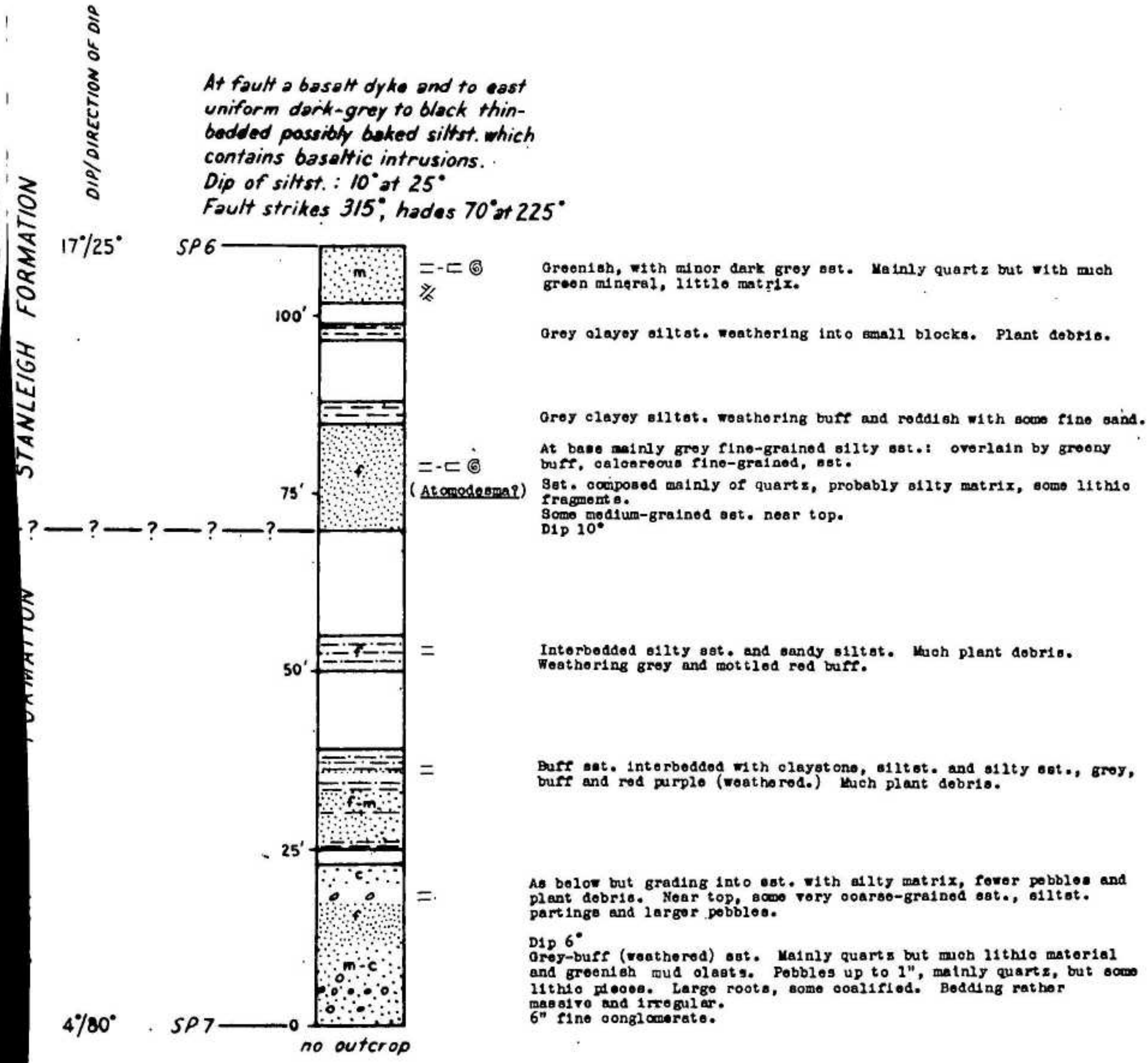
The sandstone is cross-bedded, festoon-bedded, and contains coalified roots in places (Fig. 15). Shaly beds, consisting of layers of fossil leaves are black and splintery within several feet of Tertiary basaltic dykes and sills

commonly contain fragments of the shale. Siltstone and shale contain rootlets (Fig. 14) and rare thin coaly bands. Ferruginous beds and concretions are present in places (Fig. 14).

The Orion Formation, containing rootlets, grades upwards into the Stanleigh Formation which contains marine macrofossils. Similar lithologies occur in both formations (see Fig. 15). Patterson (1956) and Phillips (1959) believed there was an unconformity between the Orion Formation and the overlying Stanleigh Formation. It is thought that contortions of bedding, due to faulting and intrusion of dykes and sills, near the top of the Orion Formation misled Patterson and Phillips into describing the relationship as unconformable.

MEASURED SECTION IN THE UPPER PART OF THE ORION FORMATION AND THE LOWER PART OF THE STANLEIGH FORMATION (S7)

Measured in a small tributary running east into Orion Creek 1⅔ miles west-north-west of Spring Hill Outstation, between points SP6 and SP7
(Springsure North Run 2, Photo 5012)
(Measured by R.G. Mollan and J.M. Dickins using an Abney Level)



Webb (1956), interpreting Patterson's unconformity, correlated the Orion Formation with the 'lower shales and mudstones' in A.O.E. No.1 (Reid's Dome) well (Enclosure 11) because the 'lower shales and mudstones' are unconformably overlain by the 'undivided freshwater beds' in this well. Phillips thought Webb's interpretation to be further support for the existence of an unconformity at the top of the Orion Formation. It is now thought that the Orion Formation is equivalent to the top part of the 'undivided freshwater beds' which grades into the overlying Cattle Creek Formation (see Correlation of Permian formations). The base of the Orion Formation is not exposed. The Lower Permian sandstone and siltstone unit in the western half of the Sheet area is possibly a thin equivalent of the Orion Formation (see Correlation of Permian formations).

The Orion Formation was deposited mainly in the Denison Trough, which was a relatively small area of rapid subsidence. The shape of the trough and the amount of downwarping is apparent from great thickness variations of the 'undivided freshwater beds' in oil bore logs (see Enclosure 11). The lack of marine fossils, and the regular occurrence of coal in bores, and plant beds and rootlets in outcrop suggest a shallow freshwater or swampy environment. Recurrent epeirogenic movements possibly partly controlled variations in the depth of water. The incoming of sand in the later stages of deposition coincides with transition to the marine environment of the Stanleigh Formation.

The maximum exposed thickness of the Orion Formation is probably of the order of 300 feet in the Orion Creek area. About 200 feet of Orion Formation are exposed in the creek shown in Figure 14. The 'undivided freshwater beds' are apparently very variable in thickness (Enclosure 11); in A.O.E. No.1(Reid's Dome) the beds are 4600 feet thick and in A.F.O. Bandanna No.1 and Planet Warrinilla No.1 at least 2000 feet thick, whereas the beds are absent or intercalated with volcanics in S.Q.D. Morella No.1, and are absent in A.F.O. Purbrook No.1. The implications of these thicknesses and the relationship of the beds to rocks older than the Cattle Creek and Stanleigh Formations in other wells shown in Enclosure 11 are discussed in the "Sketch of the Geological History."

The Orion Formation contains a Permian, (probably Lower Permian) plant fossil assemblage (Appendix 2) and lies below the Lower Permian Stanleigh Formation. It is therefore Lower Permian.

Stanleigh Formation

The name 'Stanleigh Shale' was first published and defined by Phillips (in Hill and Denmead, 1960). The type locality is at Stanleigh Homestead (Phillips, 1959). The proposed term 'Stanleigh Formation' is more appropriate because the unit contains several sandstone beds and much siltstone. The section in Orion Creek, several miles north of Stanleigh Homestead, as shown in Figures 16 and 17, is proposed here as the type section. Phillips, in his original definition, did not cite a type section.

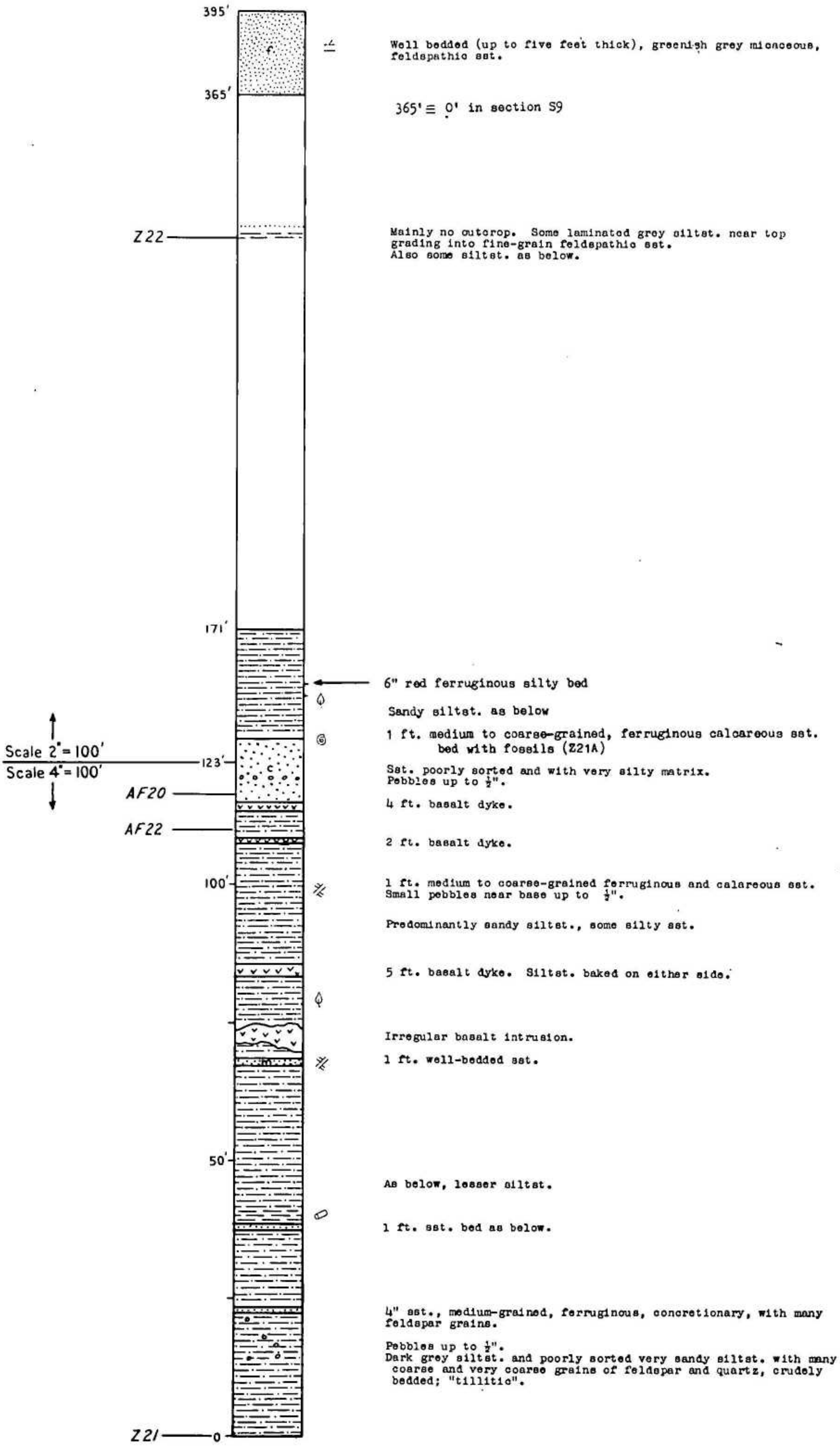
The 'Dilly beds' (Jack and Etheridge, 1892) and the 'Dilly Marine Stage' (Reid, 1930) were terms used for Permian rocks exposed about six miles north of Springsure near the old 'Dilly' railway siding. Patterson (1956) used the term 'Dilly Shales' synonymously for the Stanleigh Formation and in the Springsure Anticline,including the area north of Springsure,separated the 'Dilly Shales' from the 'Orion Shales'. Similarly, during the present survey, the 'Dilly beds' were subdivided into the Stanleigh Formation and the Orion Formation. Phillips (1959), on the other hand mapped the 'Dilly beds' as 'Cattle Creek Shale' on the supposition that the structure exposing the 'Dilly Beds' is separate from the Springsure Anticline and, being supposedly a smaller anticline, exposes a higher part of the section than the Stanleigh Formation, which he presumed was the Sirius Formation and equivalent to the upper part of the Cattle Creek Formation.

The Stanleigh Formation crops out in the Springsure Anticline in both the Springsure and Emerald Sheet areas, and is extensively obscured by Tertiary basalt. The formation is poorly exposed owing to the dominance of soft rocks which weather readily, and generally form soil covered, featureless country. Sandstone beds stand out as low strike ridges. On the airphotos the formation is not readily distinguished from the underlying Orion Formation, whereas it contrasts with the dark tone of the overlying Staircase Sandstone. Bedding trend lines are emphasised by alternating vegetational differences in the different finely interbedded lithologies of the unit.

Figure 16

MEASURED SECTION IN LOWER PART OF STANLEIGH FORMATION (S8)

Measured in a south branch of Orion Creek (Springsure North, Run 2, Photo 5011)
(Measured by J. M. Dickins, P. R. Evans and A. Fehr using chain, pace, and Abney Level)

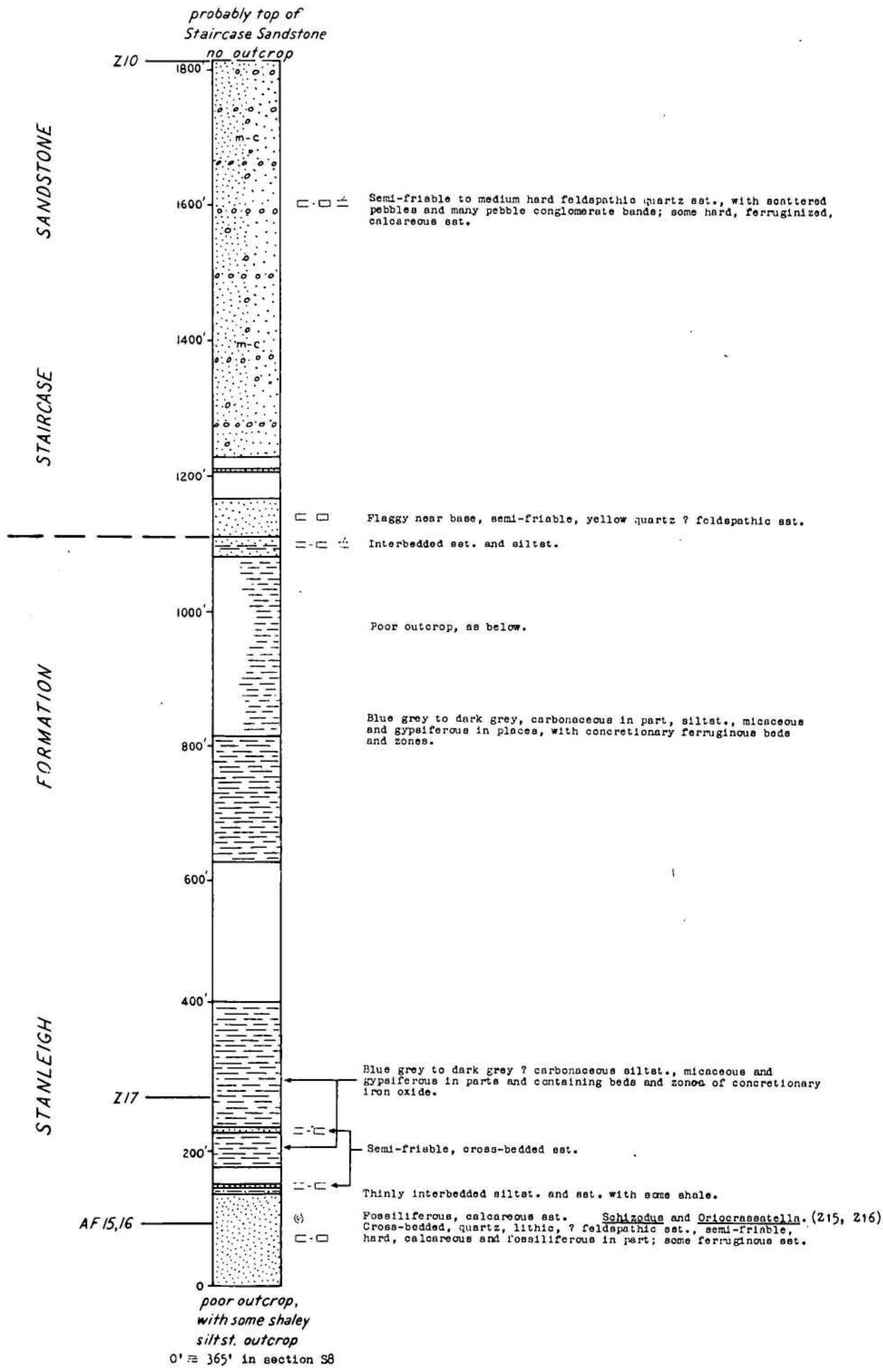


G 55/

Figure 17

GENERALIZED MEASURED SECTION IN STANLEIGH FORMATION AND STAIRCASE SANDSTONE (S9)

Measured in Orion Creek (Springsure North Run 2, Photo 5011)
(Measured by E. J. Malone, B. Sell (Minad) and R.W. Stephens (Minad) using dip and pace and compass)



The best exposures are in the type section (Figs. 16 and 17) along the Orion Creek, in Springsure Creek about eight miles north of Springsure, and in Little Oaky Creek (Fig. 27). In these areas, sandstone forms the most common outcrop; it is apparently dominant near the base and the middle of the formation. The sandstone consists of lithic and quartz grains, some tuff, and little feldspar; biotite is a significant accessory; some sandstone is calcareous. The sandstone is granular and pebbly in places, and commonly cross-bedded (Fehr, 1962). The large areas with no exposures are probably underlain by soft argillaceous rocks, which are exposed only in creek cuttings. The argillaceous rocks consist dominantly of dark grey to dark blue, poorly bedded silty carbonaceous shale. Some beds are micaceous; others contain gypsum and yellow jarosite along bedding planes and joints; other beds contain iron-rich accretions (up to 2 feet across) which include pebbles and fossil shells. A coquinitic limestone bed, commonly referred to as the '*Eurydesma* limestone', is exposed in the area of outcrop about six miles north of Springsure near the old 'Dilly' railway siding.

The relationship of the Stanleigh Formation to the underlying Orion Formation is discussed under the Orion Formation. In brief there is a transition from the freshwater beds of the Orion Formation to the marine beds of the Stanleigh Formation. Similarly, the Stanleigh Formation appears to grade into the overlying Staircase Sandstone (Fig. 17).

On palaeontological evidence (Appendix 1) the Stanleigh Formation is equivalent to at least the lower part of the Cattle Creek Formation. The possibility that the Stanleigh Formation is wholly equivalent to the Cattle Creek Formation is discussed under the section on the Correlation of Permian formations.

The Stanleigh Formation was probably deposited in a dominantly marine environment which gradually replaced the freshwater conditions of the Orion Formation. Dark gypsiferous shale was probably deposited in a restricted basin. Cross-bedded sandstone was probably deposited in shallow deltas subject to marine incursions. The interbedding of sandstone and shale probably indicates a fluctuation of the position of sand deltas, caused by slight movements in the basin.

In the type area the formation is 1100 feet thick (Figs. 16 and 17). It probably thickens northwards because nearly 1000 feet of section were measured in Little Oaky Creek (Fig.27) and on structural considerations it seems that probably several hundred feet of additional section are obscured by Tertiary basalt immediately west of the measured section.

Marine fossils from the formation indicate a Lower Permian age (Appendix 1). Glossopteris plants were also collected from the formation.

Staircase Sandstone

The term Staircase Sandstone was first used by Reid (1930) for sandstone exposed in the Staircase Range, from which the formation derives its name. The term Staircase Sandstone, published by Fletcher (1947), is used synonomously for Reid's 'Staircase Sandstones'. The type area is in the Staircase Range and the type section is along the Springsure-Duaringa Highway where it crosses the range near Staircase Creek (Fig. 18).

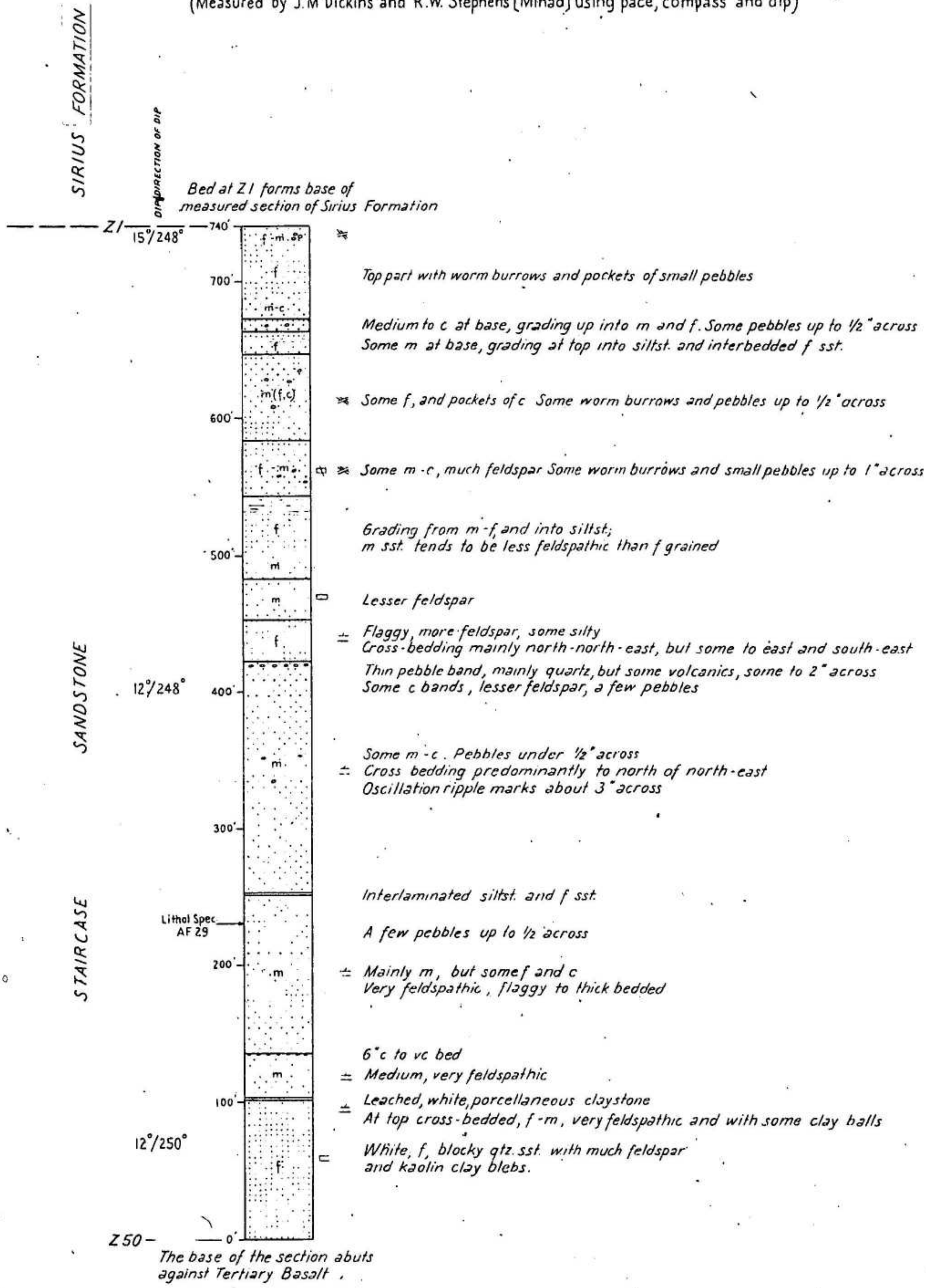
The formation crops out in the Springsure Anticline, and probably extends in outcrop into the Emerald Sheet area though towards the northern boundary of the Springsure Sheet area it is less well exposed. The formation in the west limb of the Springsure Anticline is covered by Tertiary basalt from Dalmally Homestead to near Dilly Pinnacle, several miles north of Springsure. The sandstone forms rocky dip slopes in Staircase Creek, which are cut by a set of joints parallel to strike and normal to the dip. Weathering along the joints has produced a natural staircase, hence the name of the range and creek. The formation has a dark tone in the air photos in the Staircase Range because of dense timber cover; northwards the photo pattern becomes progressively less distinct from the Sirius Formation and the Stanleigh Formation.

The formation consists dominantly of quartz sandstone in the type area (see type section, Fig. 18). Fehr (1962) has described the petrology of the formation in this section and at other localities. North and south of the type-area the formation is less sandy, containing numerous soft silty and shaly intervals (Figs. 19 and 27). Bastian made a petrological study of sandstone and conglomerate specimens SP 111/1A to H (section S11, Fig.19), and describes the sandstone as follows:

Figure 18

MEASURED SECTION IN STAIRCASE SANDSTONE (S 10)

Measured along road ascending Staircase Range adjacent to Staircase Creek (Springsure Nth. Run 2, Photo 5011)
(Measured by J.M Dickins and R.W. Stephens (Minad) using pace, compass and dip)

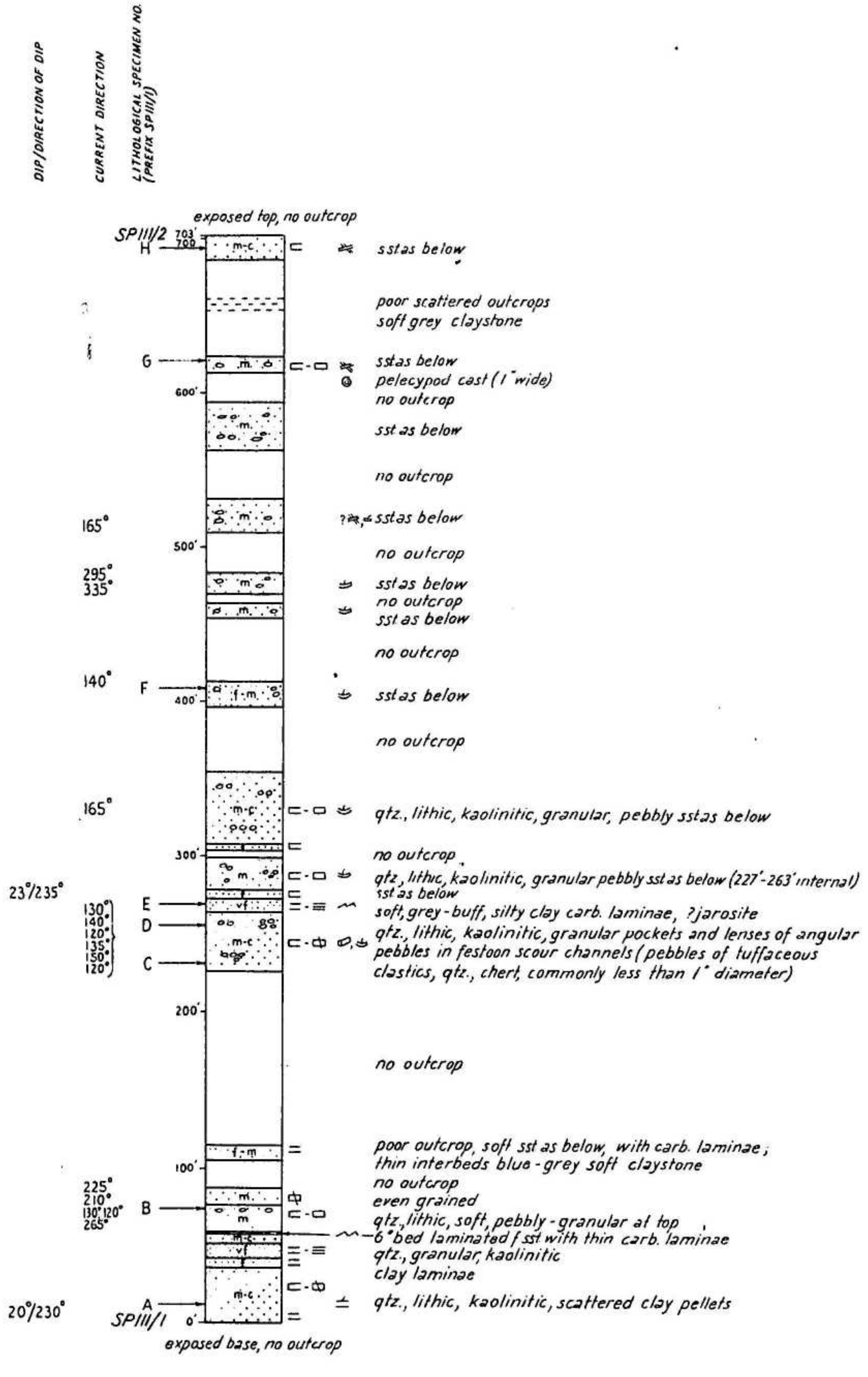


Thickness based on dips of finer grained beds
which are slightly less than those of coarser grained beds.

Figure 19

MEASURED SECTION IN STAIRCASE SANDSTONE (SII)

Aldebaran Creek (South Branch) on the west flank of the Springsure Anticline, between points SP III/1 and SP III/2 (Springsure North Run 4/Photo 5068). (Measured with Abney Level by R.G. Mollan, A. Fehr, and L.V. Bastian).



"The sandstone of the formation in this section is cream and pale grey, medium to fine grained, well cemented, and moderately well sorted. Sorting improves towards the top of the unit.

Quartz ranges from about 40% to 65%, increasing up the section; generally about 10% of grains have metaquartzitic textures. The quartz commonly contains abundant fluid inclusions and some show undulose extinction due to strain. Microcrystalline siliceous grains ("chert") are abundant, ranging up to 30% (in SP 111/1B), but decreasing in an irregular manner towards the top, making up less than 10% in SP 111/1H. "Chert" grains have some textural features to suggest that they are probably devitrified glassy rocks from volcanics. K-feldspar does not exceed 5% in any specimen. Muscovite is present only in accessory amounts in a few specimens and is absent from others. Rock fragments of fine quartz sandstone, siltstone, and volcanics are common. The main matrix material is kaolinite, generally from 5% to 10% of the rock.

Grains are generally subrounded to rounded, few are subangular. Most of the specimens have grains with a fairly high average sphericity. Overgrowths on quartz grains are prominent, especially in the upper half of the section (where quartz is more abundant). Pressure solution is present throughout and is more easily seen in the upper half where there are more contacts between quartz grains.

Pebbles from a conglomerate (SP 111/1 D) include quartz porphyry, vitric tuff, and very fine-grained quartzitic sandstone of a type similar to those occurring as lithic fragments in the sand grade."

The Staircase Sandstone appears to grade into the Stanleigh Formation (see Stanleigh Formation). The sandstone is overlain by the Sirius Formation with apparent conformity; the sharp boundary between these two formations is seen in Staircase Creek (see Fig. 20).

The Staircase Sandstone possibly wedges out southwards and is not recognised south of the southern plunge of the Springsure Anticline. Wedging-out of the formation, generally accepted by previous workers, is maintained in the present mapping (Enclosure 1). It will be suggested later in this report that the lower part of the Aldebaran Sandstone in Reid's Dome may be equivalent to the Staircase Sandstone (see Aldebaran Sandstone). The implications of this possibility are discussed in the section on the Correlation of Permian formations.

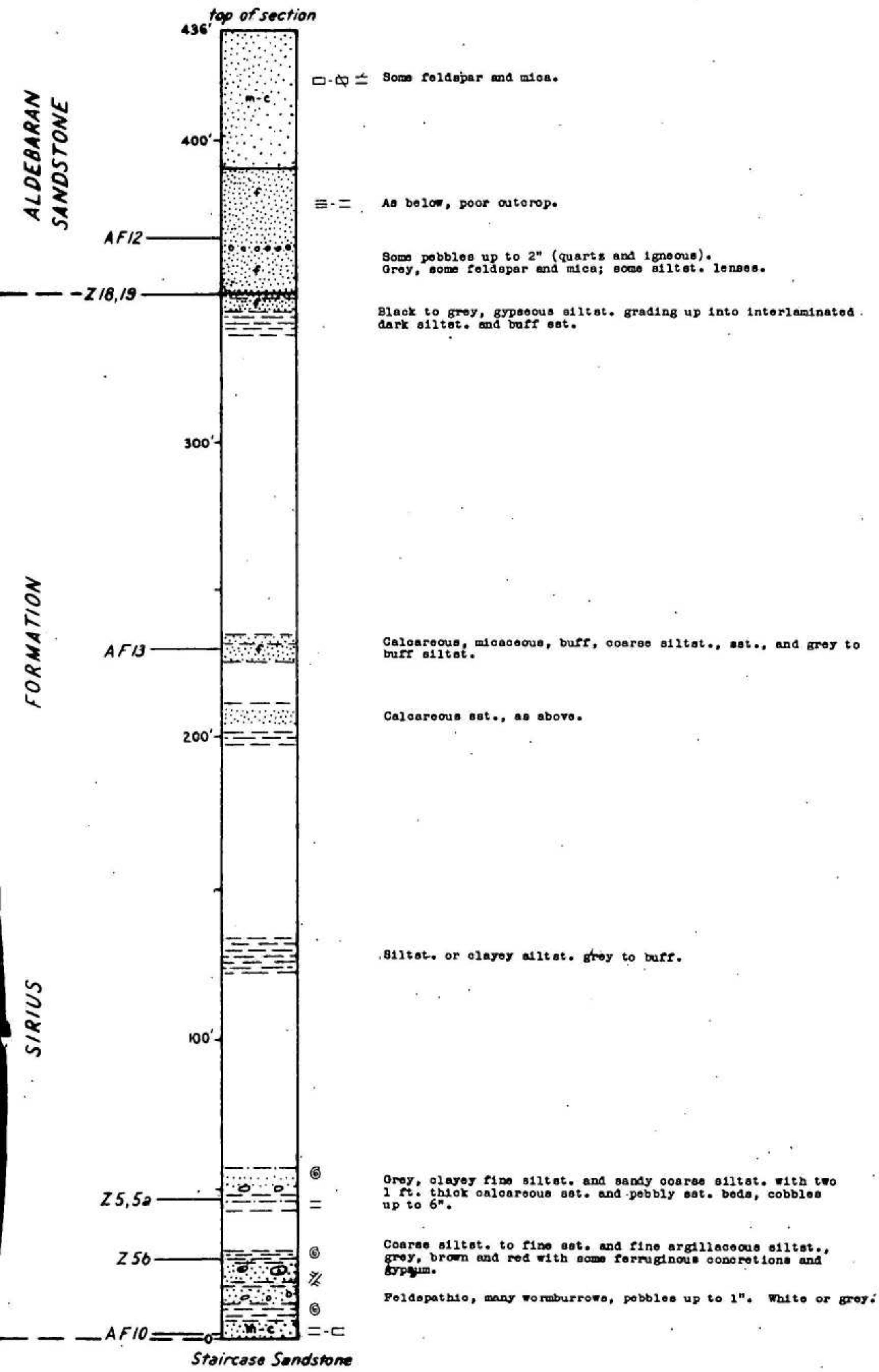
The Staircase Sandstone is probably restricted to the Denison Trough. The dominantly sandstone sequence of the type area becomes more argillaceous northwards and southwards (see Figs, 18, 19 and 27). Current direction measurements indicate that, north of the type area the unit was derived from the south-east, whereas farther south it was derived from the north-west; in the type section, currents were from the west. Sandstone in the area south of the type area is well sorted and contains very little feldspar. It is suggested that the unit was deposited in the type area as a deltaic sand, derived from land several miles west. Argillaceous material was probably winnowed out of the delta sand to the north and south by currents flowing parallel to the north-south axis of the Denison Trough. At regular intervals stronger depositional currents carried sand over a wider extent than the delta, and the sand was deposited in areas north and south of the type area interbedded with finer sediments. This sand is now represented in strongly festoon-bedded sandstone beds (Figs. 19 and 27). The dominance of festoon bedding in these sandstone beds compared with the dominance of planar cross bedding in sandstone in the type area supports the depositional picture suggested, because festoon bedding is evidence of weaker currents than required for planar cross-bedding.

The Staircase Sandstone appears to be uniformly about 700 feet thick in the Springsure Anticline between Aldebaran Creek and Little Oaky Creek (see Figs. 18, 19 and 27).

The only marine fossils found in the Staircase Sandstone are a few pelecypod casts near the top of the formation (Fig. 19). Casts of logs and plants of Lower Permian age are present (Appendix 2). The Lower Permian age of the formation is confirmed by its position between two Lower Permian formations, the Stanleigh Formation and the Sirius Formation.

MEASURED SECTION OF SIRIUS FORMATION (S12)

Measured in Staircase Creek at foot of Staircase Range (Springsure North Run 2, Photo 5011)
(Measured by J. M. Dickins, P. R. Evans, and A. Fehr using dip and paced distance across strike. Distances checked on serial photographs. Basal part of Aldebaran Sandstone measured by Abney Level, overall dip taken as 15°)



Sirius Formation

The term 'Sirius Shales' was first published by Webb (1956) in a review based mainly on work by Patterson (1956), who had defined the unit as the interval between the Staircase and Aldebaran Sandstones. The term 'Gypseous Marine Stage' was first used by Reid (1930) for the unit. Reid, inferred that the type area was in Staircase Creek and the type section in Staircase Creek immediately south of the Springsure-Duaringa Highway (Fig. 20). The term 'Sirius Formation' is preferred to 'Sirius Shale' because the unit contains much siltstone and sandstone. The name derives from Mount Sirius, a basalt mesa, near the type area.

The unit crops out in the limbs of the Springsure Anticline. It forms a corridor between ridges of the Staircase and Aldebaran Sandstones. The formation is poorly exposed but the corridor between the two Sandstones confirms its continuity. The formation is best exposed in meanders of entrenched creeks. In the air-photos the formation is distinct from the dark pattern of the enclosing sandstones, forming a soft grey tone; bedding trends are rarely visible.

The unit consists of interbedded shale, siltstone and fine-grained lithic-quartz sandstone. The sandstone is commonly brown and soft with fine argillaceous laminae. Some of the sandstone is very thick bedded, light coloured, and friable. Grey and buff siltstone beds commonly contain gypsum and jarosite; some of the siltstone is calcareous. Light to dark grey, and bluish shale is commonly interbedded and interlaminated with siltstone. Pebbles and cobbles are scattered in basal beds. Worm burrows are present, generally in siltstone. Fehr (1962) reported a low feldspar content, but up to 50% tuff fragments in poorly sorted sandstone in the base of the type section (Fig. 20). In general, bedding is poorly defined in the unit.

The unit conformably overlies the Staircase Sandstone with an apparently sharp lithological break (see Staircase Sandstone). The Sirius Formation is apparently conformably overlain by the Aldebaran Sandstone. The boundary, where seen, is sharp but it is mostly obscured. In the type section (Fig. 20), there is a rapid transition (over a few feet) from siltstone into quartz sandstone of the Aldebaran Sandstone.

The correlation of the Sirius Formation with the Permian sequence in Reid's Dome is not clear, and the alternatives are discussed in the section on the correlation of Permian formations.

The Sirius Formation was deposited in a marine basin. Gypsum in the upper part of the Sirius Formation probably indicates a restricted shallow water basin environment in that depositional period. The poor sorting of much of the sediment suggests rapid deposition by sediment-laden currents. The origin of the cobbles and pebbles in the basal beds is not clear; several authors, including Phillips (1959) suggest they were dropped from floating ice. Possibly they were derived from a nearby eroding landmass and transported by dense, sediment-laden currents. Similar 'erratics' in the Ingelara and Cattle Creek Formations probably have a similar origin to those in the Sirius Formation. There is a close similarity between the depositional environment of the three formations.

The formation is 350 feet thick in the type area. North and south of the type area it apparently thins (see Fig. 27). Southward thinning can be readily seen on the air photos. The significance of the thinning is discussed in the correlation of Permian formations.

Forms from several marine fossil collections from the formation are listed and their implications discussed, in Appendix 1. The age of the formation is Lower Permian.

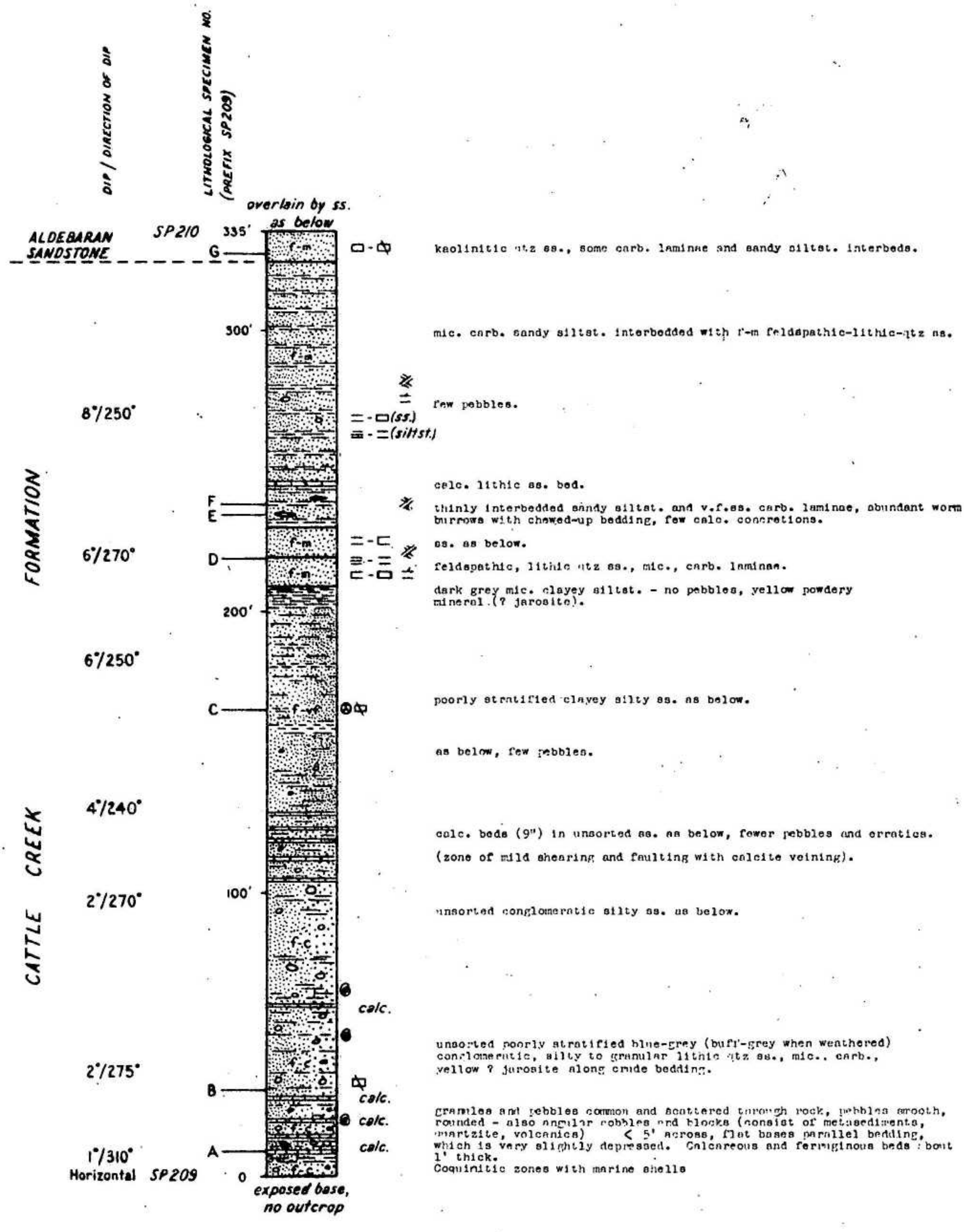
Cattle Creek Formation

The Cattle Creek Formation (Hill, 1957) was originally named the 'Cattle Creek Series' by Shell (SQD, 1952) after Cattle Creek, a tributary of Consuelo Creek in Reid's Dome. Three hundred feet of nearly continuous exposure in Cattle Creek (Fig. 21) in the west limb of Reid's Dome is proposed as the type section. The term 'Cattle Creek Shale' was used by Phillips (in Hill and Denmead, 1960) but Cattle Creek Formation is preferred because the unit is not dominantly shaly. The formation crops out only along the axis of Reid's Dome, occupying an elongate depression ten miles long and two miles wide, surrounded by cliffs of Aldebaran Sandstone. Sandstone beds within the unit form low hills, but mostly the formation forms flat areas with an even cover of timber.

Figure 21

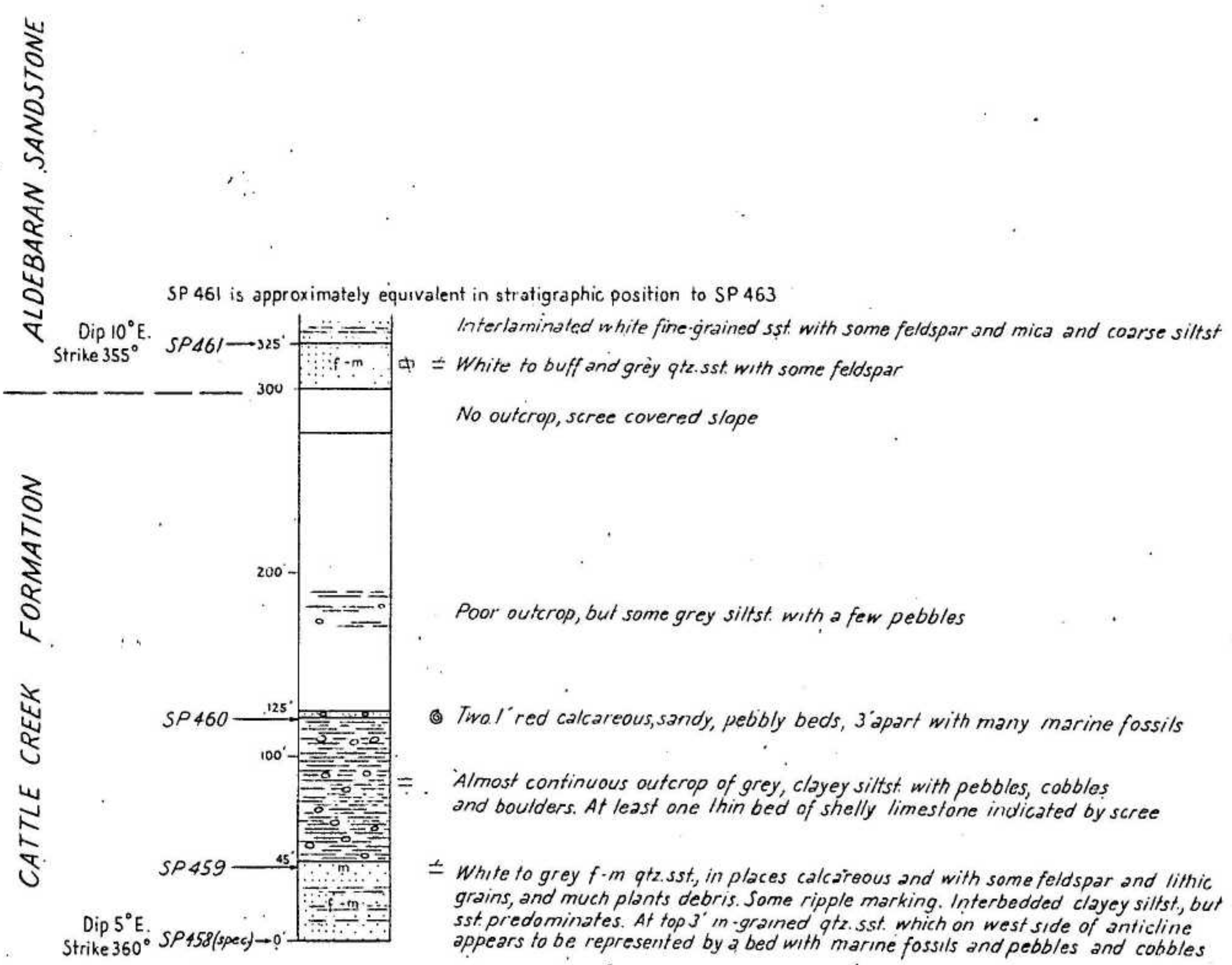
MEASURED SECTION IN CATTLE CREEK FORMATION (S13)

Upper part of Cattle Creek on the west flank of Reid's Dome between points SP 209 & SP 210 (Springsure, Run 4, Photo 5231) (Measured with Abney Level by R.G. Mollan & E.J. Malone)



MEASURED SECTION IN CATTLE CREEK FORMATION AND ALDEBARAN SANDSTONE (S14)

In small creek running west into Little Gorge Creek about 1 mile south of south end of old airstrip at north end of Reid's Dome. (Springsure, Run 4, Photo 5231)(Measured by J.M. Dickins and N.F. Exon, using dip and photo distance with correction for elevation.)



Overlies 10' grey, hard, very fossiliferous "Eurydesma Limestone" at culmination from which it is separated by an interval the thickness and nature of which is not clear because of poor outcrop. Webb (1956) records about 100' of "siltstones, silty shales and thinly bedded sandstones" in this interval.

The air-photo tone is variable due mainly to scree of basalt and 'billy' boulders. Faint bedding trends can be distinguished in places.

In the type section, the Cattle Creek Formation consists dominantly of dark grey, poorly sorted conglomeratic silty sandstone in which bedding is poorly defined; thin calcareous sandstone beds reveal the bedding (Fig. 21). The sandstone contains mica, carbonaceous material, and lenses and bands of gypsum along bedding planes; yellow jarosite is generally associated with the gypsum. Pebbles, cobbles and boulders of quartz, quartz-veined metagreywacke, slate, phyllite, and porphyritic volcanics occur throughout the section. Boulders up to five feet across are present, but most are much smaller. Pebbles and cobbles are smooth and rounded, whereas the boulders are mostly angular, although some show slight rounding. Figure 23 shows a slightly rounded, tabular erratic boulder in Cattle Creek with its longest axis parallel to the bedding; many similar boulders are scattered throughout the sequence. Marine fossils occur throughout the sequence, varying from scattered shells to coquinite bands and lenses.

White to light grey, fine-medium grained, carbonaceous, lithic-quartz sandstone occurs in beds up to 30 feet thick. Thin section examination showed that the sandstone contains mainly quartz grains with some lithic grains, set in an argillaceous (hydromica) matrix. The sandstone is mainly thin to medium bedded. Slumping of some sandstone beds was observed. Sandstone near the exposed base of the formation is calcareous and fossiliferous in the upper few feet (Fig. 22).

Limestone beds up to one foot thick occur throughout the poorly sorted sandstone and siltstone. The limestone is grey, when fresh, but generally weathers purple, and often contains pebbles; some beds are fossiliferous. A limestone bed ten feet thick, the '<u>Eurydesma</u> Limestone' (Reid, 1930, and Webb, 1956), occurs near the exposed base of the formation. At locality SP 732 (Enclosures 1 and 9) it consists of eight feet of bryozoan limestone with some shells, and two feet of coquinite at the top. The '<u>Eurydesma</u> limestone' was found at several localities near the culmination of Reid's Dome (see Enclosures 1 and 9, and Appendix 1).

The base of the formation is not exposed. In A.O.E. Nos. 1 and 2 (Reid's Dome) bores, the base of the formation is transitional to the 'undivided freshwater beds'. The transition is similar to that seen in outcrop in the Springsure

Figure 23: Large boulder embedded in poorly sorted dark grey conglomeratic sandstone in the Cattle Creek Formation, in Cattle Creek, Reid's Dome. (Neg. No. G/6260)

Anticline between the freshwater Orion Formation and the marine Stanleigh Formation with which the 'undivided freshwater beds' and the Cattle Creek Formation are correlated (see Correlation of Permian formations). The relationship to the overlying Aldebaran Sandstone appears to be conformable and tends to be gradational. However, Phillips (1959) states that 'there is sufficient evidence of overlap of the former (the Aldebaran Sandstone) on the Cattle Creek (Formation) to suggest the existence of a possible unconformity'. Palaeontologically, the Cattle Creek Formation is equivalent, at least in part, to the Stanleigh Formation. It is not certain that the upper part of the Cattle Creek Formation is equivalent to the Sirius Formation (see Appendix 1 and Correlation of Permian formations).

Marine fossils are sufficiently abundant to indicate that the Cattle Creek Formation is dominantly a marine unit; the presence of gypsum suggests the formation was deposited partly in a restricted basin. Sediments are dominantly poorly sorted indicating rapid deposition with little reworking of material. The '*Eurydesma* limestone' indicates a period of shallow water deposition when little sediment was being deposited. The origin of the boulders is not clear. Previous workers have readily stated that the boulders are glacial erratics dropped from floating ice. However, there appears to be no or only little depression of bedding beneath boulders and commonly they rest with long axes parallel to bedding (see Fig. 23). It is suggested the boulders were derived from eroding cliffs of a nearby shoreline and transported by currents, laden with sediment, in the Cattle Creek depositional area. Some volcanic boulders were possibly derived from a postulated volcanic mass of the 'Morella High' (Webb, 1956) immediately east. The provenance areas to the west during deposition of the Cattle Creek Formation may have contained rocks of the Drummond Basin sequence and basement low-grade metamorphics.

The exposed thickness of the Cattle Creek Formation is about 400 feet (see Fig. 22). The measured section in Figure 22 is roughly the same stratigraphic interval as that in Figure 21; by comparison with Webb (1956) it appears that there is about 100 feet of section beneath the section in Figure 22 to the '*Eurydesma* limestone'. In A.O.E. No.1 (Reid's Dome) Well (Enclosure 11) the formation is 1625 feet thick.

The Cattle Creek Formation is richly fossiliferous, and determination of collections made during the present survey are listed in Appendix 1. The forms belong to Fauna II, (Dickins et al. in press), and indicate a Lower Permian age for the formation.

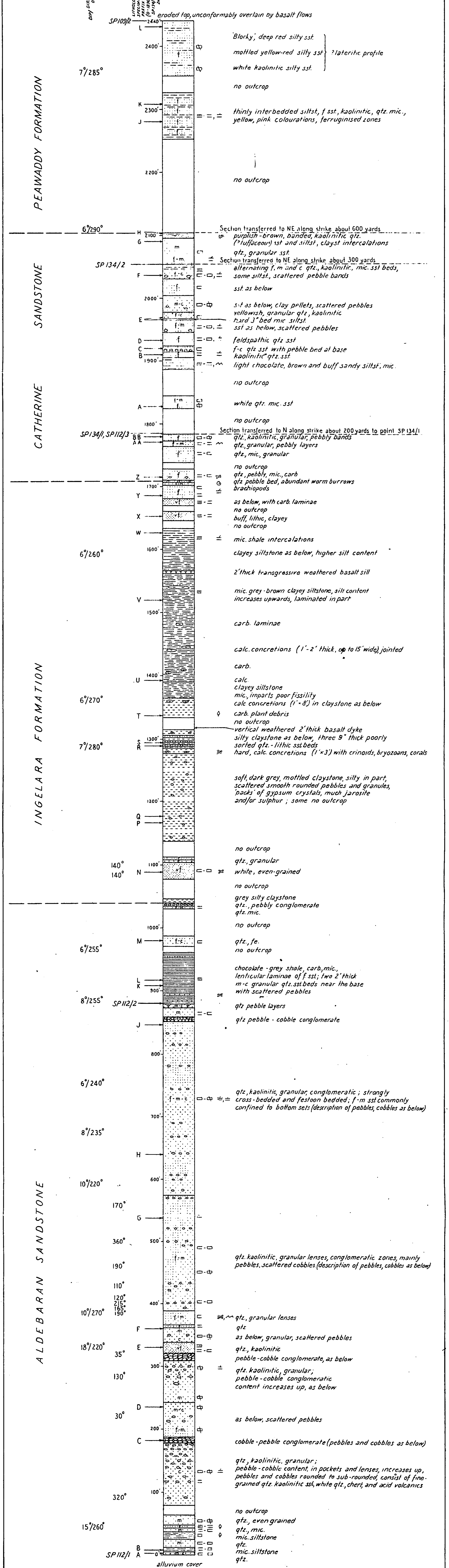
Aldebaran Sandstone

The term 'Aldebaran Sandstones' was first used by Reid (1930) for 'essentially massive, siliceous sandstones ... between Aldebaran and Staircase Creeks'. Reid mapped the 'Aldebaran Sandstones' in the Springsure Anticline only. He believed the 'Aldebaran Sandstones' to be older than the 'Serocold Sandstones' which he mapped in the Reid's Dome and Consuelo Anticline areas. He did not equate the two 'Sandstones' because he postulated a transverse fault, the 'Consuelo Fault', between Reid's Dome and the Springsure Anticline and, because he did not recognise the structure at Consuelo Anticline. Reid's 'Serocold Sandstones' are roughly equivalent to his 'Aldebaran Sandstones'. Since Reid's work the name Aldebaran Sandstone has been used for Reid's 'Aldebaran Sandstones' and 'Serocold Sandstones' by most workers, apart from Phillips (1959, and in Hill & Denmead, 1960) who used the name 'Serocold Sandstone'. In the east limb of the Springsure Anticline Reid mapped the interval from the Aldebaran Sandstone to the Catherine Sandstone as 'Aldebaran Sandstones', Phillips mapped the same interval as Serocold Sandstone. The name Aldebaran Sandstone is used in this report as a synonym of Reid's 'Aldebaran Sandstones' as defined in the type area, between the Sirius and Ingelara Formations. The type area is in the Springsure Anticline where it is traversed by Aldebaran Creek and the type section is in Aldebaran Creek (south branch)(Fig. 24).

The sandstone crops out in the Springsure Anticline in a small culmination immediately south of the Springsure Anticline, in Reid's Dome, and in the Consuelo Anticline. The outcrop in the west limb of the Springsure Anticline a few miles north of Mount Catherine is obscured by Tertiary basalt but in the east limb it is continuous into the Emerald Sheet area. It does not crop out east or south of the Springsure Sheet area.

Figure 24

MEASURED SECTION IN PERMIAN FORMATIONS IN THE WEST LIMB OF THE SPRINGSURE ANTICLINE (S15)



Measured in Aldebaran Creek (south branch), a small tributary, and small escarpment to the north of the tributary, south of Mt. Catherine between points SP109/2 (Springsure Nth Run 4/Photo 5068) (Measured with Abney Level by R.G Mollan, A. Fehr, R.L.V. Bastian)

SP 112/1 and

Bureau of Mineral Resources, Geology and Geophysics, March 1964 To accompany Record No 1964/27 G 55/A3/6

The Aldebaran Sandstone forms prominent long rocky cuestas and ridges, particularly in Reid's Dome. The sandstone is exposed in magnificent white cliffs and gorges. Dipslopes commonly support a dense cover of timber which has a dark tone in the airphotos, quite distinct from the lighter tones of the underlying and overlying softer formations. The structure in the Aldebaran Sandstone is readily delineated in the air-photos.

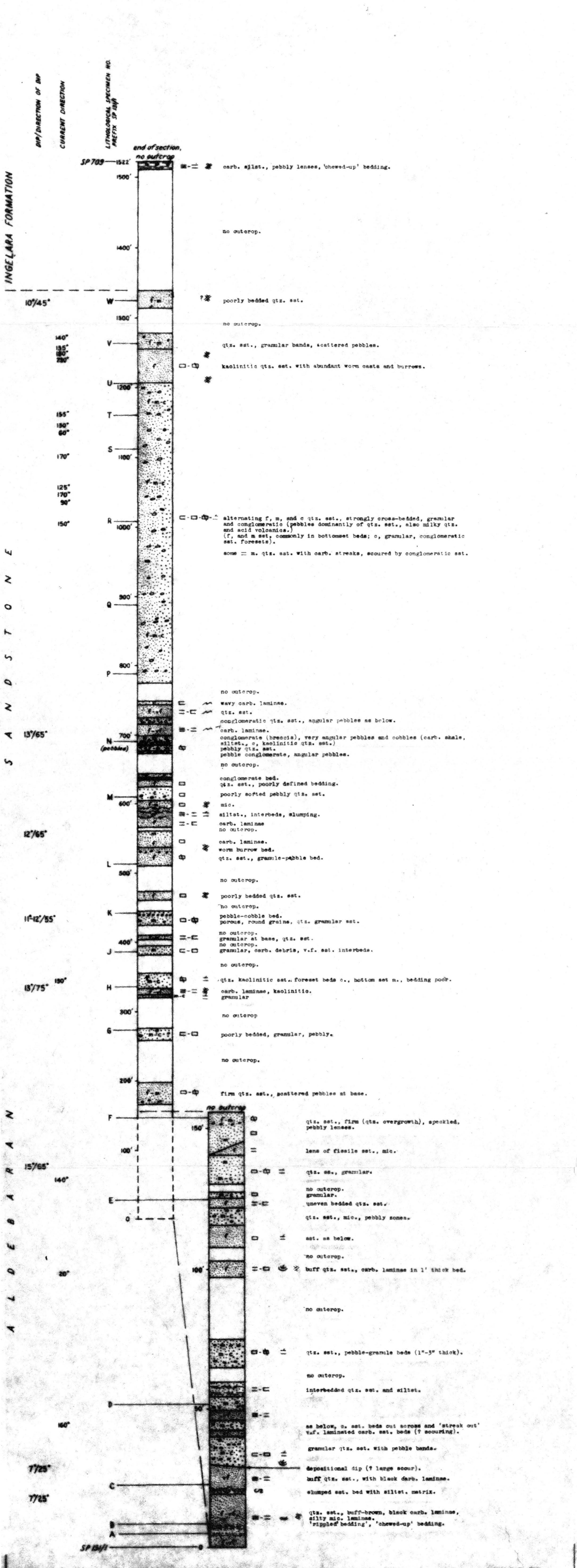
The Aldebaran Sandstone is dominantly conglomeratic cross-bedded quartz sandstone; some siltstone and shaly beds are present. Two coal seams, one six inches, and the other three inches thick, were found in the sandstone in Rocky Creek in the west limb of Reid's Dome. Specimens SP 112/1A to M, collected from the type section of the Aldebaran Sandstone (Fig. 24) have been petrologically studied by L.V. Bastian. Briefly, he describes the unit in this section as consisting of fairly firm to friable cream to pale grey, fine to medium grained, poorly to well sorted sandstone with pinkish grey to brown shaly beds. Pebbles in the conglomeratic sandstone are dominantly fine grained quartzose sediments and milky quartz. Conglomerate specimen SP 112/1C contains in addition pebbles of siltstone, trachy-rhyolite, crystal-vitric tuff, and vesicular rhyolite. Sorting of sandstone is better near the middle of the formation and in thin sandstone beds in the transition to the Ingelara Formation. Quartz content ranges from about 40% to 80%, and is higher in the upper half, averaging about 75%, as against 50% in the lower half. Up to 10% of grains have metaquartzitic textures; the quartz grains contain abundant fluid inclusions and some show undulose extinction, as do some in the Staircase Sandstone. K-feldspar is common near the base of the unit, amounting to 10% in specimens SP 112/1A and B; above the basal part of the unit the rocks are very poor in feldspar with none at all in many specimens. "Chert" (probably mainly devitrified glass) is common, amounting to 20% in the specimens which are poorer in quartz; lower amounts are present in the higher part of the unit. In specimen SP 112/1M, which contains the highest percentage of quartz, "chert" is virtually absent. Small amounts of muscovite are present in all specimens. The matrix is mainly kaolinitic, and large clumps of kaolinite are characteristic. Specimen SP 112/1M has a montmorillonitic matrix.

Record 1964/027

Figure 25

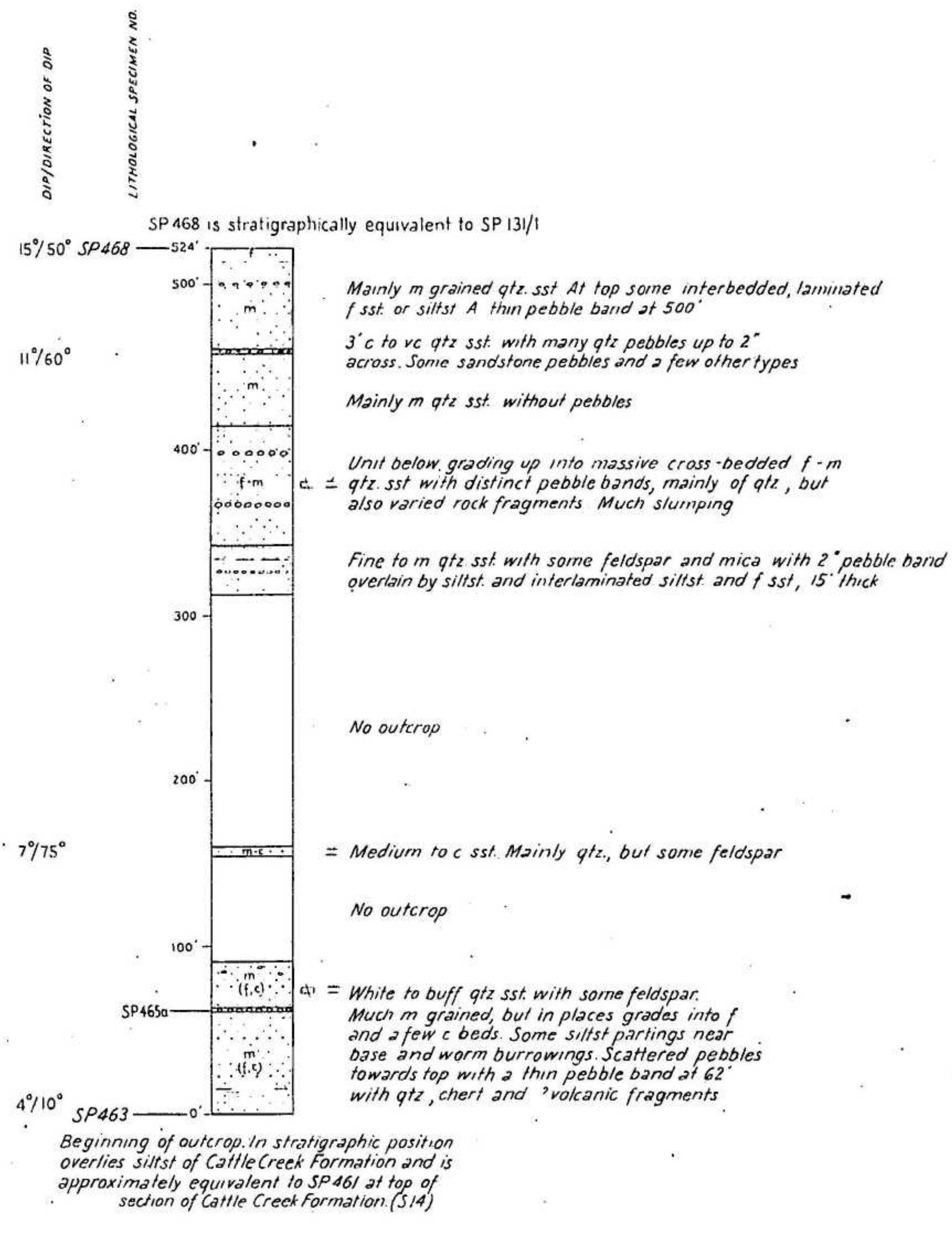
MEASURED SECTION IN PART OF ALDEBARAN SANDSTONE (S16)

Measured in Little Gorge Creek in the east limb of Reid's Dome between points SP 131/1 & SP 709 (Springsure, Run 3, Photo 5145) (Measured with Abney Level by R.G. Mollan, A. Fehr, & L.V. Bastian)



MEASURED SECTION IN ALDEBARAN SANDSTONE (S17)

Section in Little Gorge Creek, beginning ½ mile north-north-west of A.O.E., Reid's Dome No.1 bore site (Springsure Run 3, Photo 5147) (Measured by J.M. Dickins and N.F. Exon, using dip, chain and compass)



Grains range from subangular to subrounded, except in the finer sediments where they are angular (a function of grain-size). In some specimens grains are markedly elongated; long axes of the grains commonly parallel bedding planes. Overgrowths on quartz and pressure solution quartz grains are present.

The measured section in the Aldebaran Sandstone in Little Gorge Creek in the east flank of Reid's Dome (Figs. 25 and 26, the top of section S17, Fig. 26, is equivalent to the bottom of section S16, Fig. 25) shows some differences compared with the type section. The lower 1200 feet of section from the base of the formation (Fig. 26) to 680 feet in section S16 (Fig. 25) appears to differ from the upper 600 feet of the section which is lithologically similar to the type section. The two differing parts of the section in Little Gorge Creek are separated by a breccia-like conglomerate containing angular pebbles and cobbles of carbonaceous shale, siltstone, coarse kaolinitic quartz sandstone, and volcanics (Fig. 25). The sediments below this conglomerate compare closely with the Staircase Sandstone. The possible significance of the angular conglomerate and the difference in the lower part of the Aldebaran Sandstone in Reid's Dome is discussed in the section on the correlation of the Permian formations. The lithology of the Aldebaran Sandstone in the northern part of the Springsure Anticline is shown in section S 18 (Fig. 27).

The Aldebaran Sandstone appears to be conformable on the Sirius Formation in the Springsure Anticline; in Reid's Dome it grades into the Cattle Creek Formation, which contains sandstone in its upper part (Fig. 21). The relationship to the Sirius Formation is apparently transitional over a short interval (see Sirius Formation). The Aldebaran Sandstone is probably disconformable on the Sirius Formation southwards (see Correlation of Permian formations). The relationship to the overlying Ingelara Formation is transitional. The transition zone consists of thinly interbedded and interlaminate siltstone and sandstone with thin quartz sandstone beds. The top of the Aldebaran Sandstone is taken at the highest quartz conglomerate or distinctly conglomeratic quartz sandstone. In the type area the highest conglomerate occurs above the transition zone (Fig. 24); the conglomerate coincides with a marked air-photo tone break and is therefore a most suitable boundary. In Reid's Dome, however, 200 feet to 300 feet of the transition zone lie above the highest quartz conglomerate bed and are included in the Ingelara Formation in this area (Fig. 29).

The Aldebaran Sandstone was deposited in the Denison Trough and probably in the Springsure Shelf (see Correlation of Permian Formations). The trough was probably subsiding during Aldebaran Sandstone times, and receiving material dominantly from the north-west (see current direction readings in Figs. 24, 25, and 27). Sand and pebbles were probably deposited by streams in a deltaic environment. The origin of quartzose sandstone pebbles throughout the unit is not clear; possibly they were derived from the Lower Carboniferous Raymond Sandstone and Mount Hall Conglomerate. The Colinlea Sandstone is at least partly equivalent to the Aldebaran Sandstone for various reasons discussed in detail in the section on correlation of Permian formations.

The Aldebaran Sandstone is 1050 feet thick in the type section (Fig. 24). In Little Gorge Creek, in Reid's Dome, it is about 1850 feet thick which includes 1200 feet of possible Staircase Sandstone equivalent (Figs. 25 and 26) (see Correlation of Permian formations). In Little Oaky Creek, in the northern part of the Springsure Anticline, the formation is only 640 feet thick. Along the Springsure-Duaringa Highway in the east limb of the Springsure Anticline the formation is 1650 feet thick. Thick sandstone sections were penetrated at A.O.E. No.3 Consuelo (about 2000 feet), A.F.O. Inderi No.1 (probably about 2000 feet) and Planet Warrinilla North No.1 (1600 feet); much of the sandstone sections are probably Aldebaran Sandstone. South and east of these wells the unit thins rapidly (Enclosure 11). The thickness of the Aldebaran Sandstone is thus very variable within the Denison Trough, and thins rapidly towards the margins.

No marine fossils have been collected from the Aldebaran Sandstone. Plant fossils occur in silty and shaly interbeds (Appendix 2). The unit lies between Lower Permian formations.

Ingelara Formation

The term 'Ingelara Stage' was first published in a table in Raggatt and Fletcher (1937); they show the Ingelara Stage as the interval between the Catherine and Aldebaran Sandstones. The term 'Ingelara Formation' was first published by Hill (1957) as a synonym of 'Ingelara Stage'. Reid (1930) used the term 'Coral Stage' originally as the interval between his Aldebaran and Catherine Sandstones. The name of the unit is derived from Ingelara Homestead, and Hill (1957) states that it 'is well exposed on the Ingelara Property', thus implying that this is the type area. However, as the term 'Ingelara' was originally defined as the interval between the Aldebaran and Catherine Sandstones, and the Catherine Sandstone is missing in the implied type area, it is suggested that an area farther north, where the Catherine Sandstone is present be adopted as the type area. It is proposed that the area about one mile south-east of Mount Catherine be taken as the type area and that the type section be the section shown in Figure 24. In the implied type area the Ingelara Formation lies between the Aldebaran Sandstone and the Peawaddy Formation, from which it is difficult to distinguish (see Fig. 28).

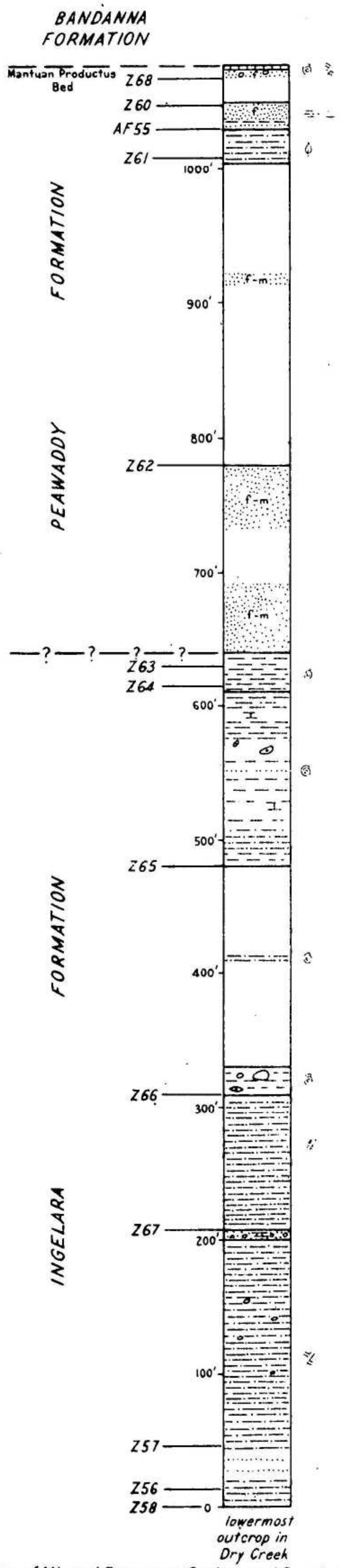
The formation crops out in the flanks of the Springsure and Consuelo Anticlines, and Reid's Dome, forming a narrow corridor between cuestas of the Aldebaran and Catherine Sandstones. The formation is poorly exposed, except in deeply entrenched creeks, but the corridor between the two Sandstones indicates its continuity. In the air-photos the formation forms a distinct break between the dark tones of the Aldebaran and Catherine Sandstones.

The formation consists dominantly of sandy siltstone and silty claystone with thin interbeds of fine-grained quartzose sandstone. Siltstone and silty claystone are poorly sorted, containing scattered granules and pebbles, and irregular lenses and laminae of sandstone; the pebbles are, in places, concentrated into lenses. The siltstone and claystone are generally carbonaceous, with carbonized plant fragments and coal grains; in places they are pyritic, and also contain lenses, bands and crystal aggregates of gypsum and bands of jarosite. Calcareous concretions, occasionally fossiliferous, are common; boulder erratics of granite, porphyritic volcanics, and low grade metamorphics occur only in the southern part of Reid's Dome. The siltstone mostly

Figure 28.

MEASURED SECTION OF INGELARA AND PEAWADDY FORMATIONS (S19)

Measured in Dry Creek (Springsure 1:50,000, 1955, Run 8, Photo 5011)
(Measured by J. M. Dickins, B. Sell (Minad) and R.W. Stephens (Minad), based on pace and photo distance). Upper part of section in Eddystone Sheet area.



Grey-green, f. sst. micaceous, feldspathic, ? glauconitic, ? with rock fragments, rather unsorted pebbles up to 1". 2 ft. hard calcareous bed with many worm burrowings at top, overlain by 2 ft. greenish-yellow puggy clay and calcareous whitish lithic sst. Mainly sandstone with much feldspar and mica. 2 ft. bed of fine to medium-grained calcareous sst. and some grey sst.

Siltst., grey, micaceous, sandier towards top.

With feldspar and mica, calcareous.

Khaki or buff, soft weathering, mainly quartz with some feldspar and mica and possibly rock fragments. Some massive weathering; incompletely exposed especially in middle part.

Siltst.; 2 calcareous beds, one with corals and crinoids.

Predominantly claystone or shale, some sandy and with fine sandy interbeds.
A few concretionary calcareous beds and some cobbles and boulders up to 2 ft.

Macrofossils sparse.

Poor outcrop as below. Calcareous, fossiliferous beds and only a few cobbles and boulders.
Macrofossils sparse.

Claystone or shale and sandy siltst. In places sand predominates. Poorly sorted, crudely bedded; cobbles and boulders up to 2 ft. Very fossiliferous concretionary lens up to 2 ft. thick.

Mainly grey siltst. and sandy siltst. with some fine sand. Very micaceous.

Sst., calcareous, ferruginous, with pebbles. Pebbles and cobbles up to 4" across, mainly quartz, many of fine sand and some chert and volcanics.

Interlaminated black carbonaceous siltst., grey sandy siltst. and very fine white sst. Micaceous, scattered pebbles up to 1".

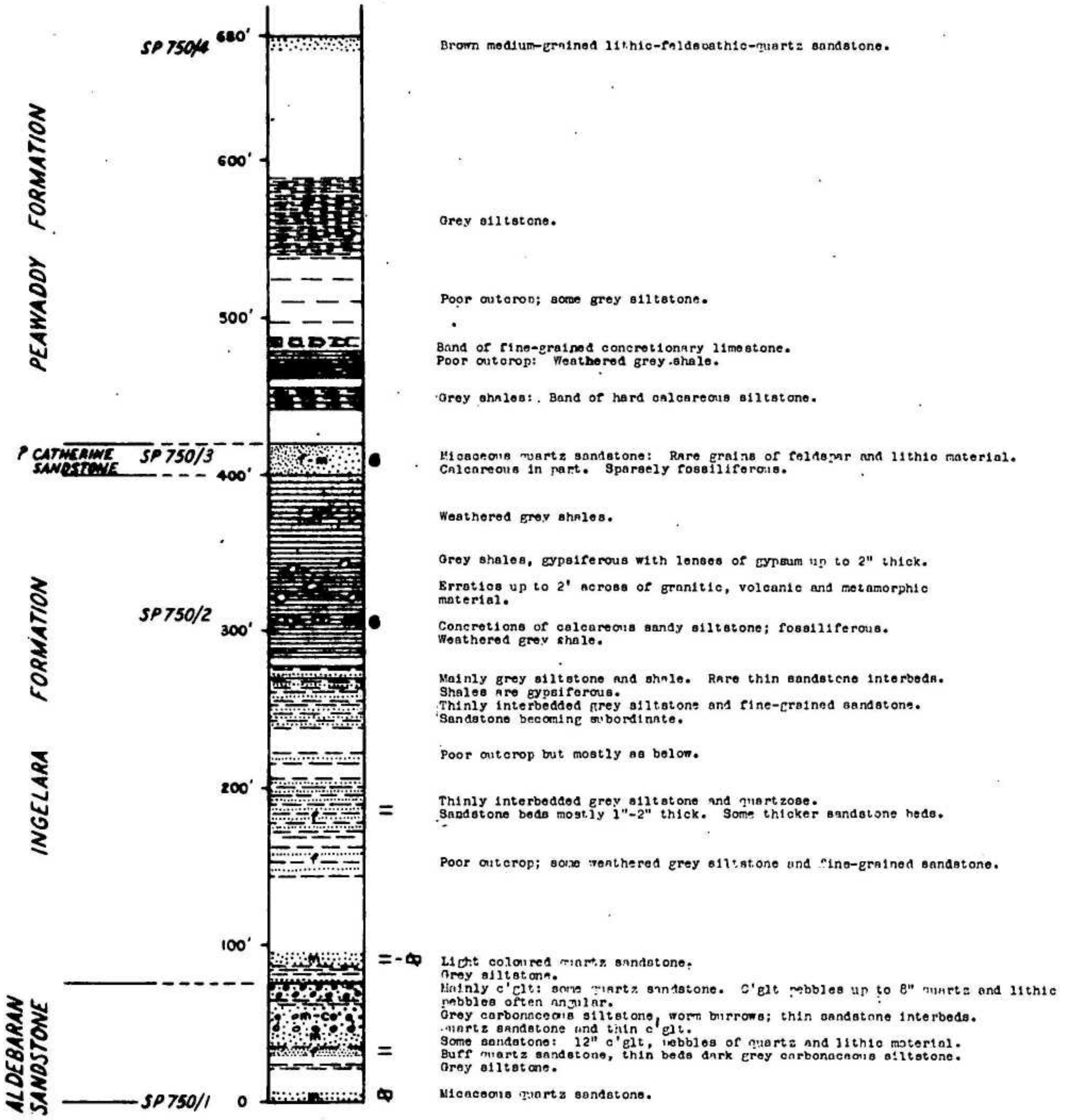
Estimated height above Aldebaran Sst. not more than 50 ft.

Figure 29

MEASURED SECTION FROM ALDEBARAN SANDSTONE TO PEAWADDY FORMATION (S20)

Measured in creek 4 miles west of Rewan H.S. from SP 750/1 to SP 750/4. (Springsure, Run 4, Photo 5231)

(Measured by A.G. Kirkegaard using Abney Level)



lacks bedding; it is rarely laminate or fissile. The boundary with the Aldebaran Sandstone is transitional (see Aldebaran Sandstone). The Ingelara Formation is conformably overlain through a transitional zone, by the Catherine Sandstone (see Figs. 24 and 29). In the southern part of Reid's Dome, south of the wedge-out of the Catherine Sandstone, it is overlain by the Peawaddy Formation. The two formations are lithologically similar and difficult to separate. It seems most probable that the Peawaddy Formation overlaps the Ingelara Formation (see Catherine Sandstone).

The Ingelara Formation represents a marine incursion due to increased rate of subsidence in the depositional area following the deltaic and fluviatile deposition of the Aldebaran Sandstone. Its characteristics are similar to those of the Cattle Creek Formation and it probably had a similar mode of deposition.

The Ingelara Formation is 650 feet thick in the Mount Catherine area (Fig. 24). In the air-photos the formation appears to thicken locally in this area. In the Reid's Dome area the formation is 300 feet thick (Fig. 29).

The measured thickness of 690 feet for the formation at the southern end of Reid's Dome in Dry Creek (Fig. 28), where the Catherine Sandstone is absent, requires confirmation owing to problems of mensuration. Also in this section, the boundary between the Ingelara and Peawaddy Formations is probably much lower, probably between the 300 feet and 400 feet interval in the section.

Fossils collected during the present survey are listed in Appendix 1. The fossils indicate a Lower Permian age.

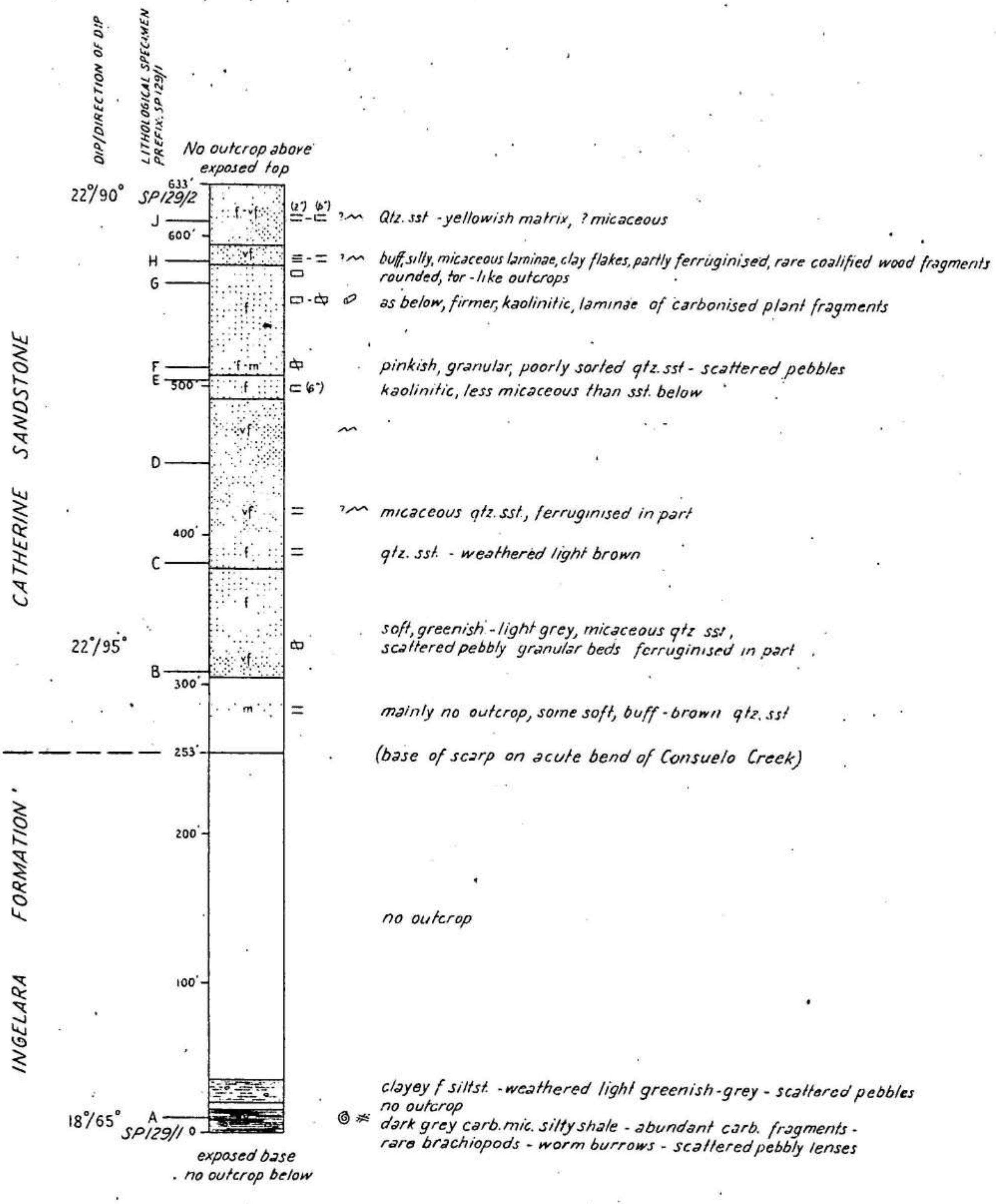
Catherine Sandstone

The term 'Catherine Sandstones' was first used by Reid (1930) for 'grey and red sandstone ... about 4 miles S.S.E. of Mount Catherine ... About 500 feet of strata are exposed in broken cliffs (ferruginous laminated sandstones, etc.)'. Shell (SQD, 1952) used the term 'Catherine Series'. Hill (1957) reverted to the name 'Catherine Sandstone' but applied it to Shell's 'Catherine Series'. It is evident from the present work that Shell's 'Catherine Series' includes more section than was originally defined by Reid, as belonging to his 'Catherine Sandstones'. In addition to about 500 feet of quartz sandstone seen by Reid, four miles south-south-east of Mount Catherine, Shell included 400 to 500 feet of silt, shale, and lithic sandstone (the Peawaddy Formation) in their 'Catherine Series'. Shell's additional section crops out in Reid's Dome but is mainly obscured by Tertiary basalt at Reid's locality (during the present survey several hundred feet of this section were measured in this area (Figs. 24 and 34)). In this report the name 'Catherine Sandstone' is used synonymously with the 'Catherine Sandstones' defined by Reid. It consists of about 400 feet of dominantly quartz sandstone in the type area; Figure 24 includes the measured type section of the Catherine Sandstone, about a mile north of Reid's type locality. The additional 400 to 500 feet of section, which Shell included in their 'Catherine Series', and which overlies the Catherine Sandstone, is now called the Peawaddy Formation. This formation contains at the top the lenticular, coquinitic Mantuan Productus Bed, which is absent in places, including the Mount Catherine area. Thus, the 'Catherine Sandstone' of Hill is now subdivided into the Catherine Sandstone, and the Peawaddy Formation. A tabulated comparison of the various authors' stratigraphic nomenclature is shown below:

Northern part of Reid's Dome			Mount Catherine area	
Shell (SQD, 1952)	Hill (1957)	Present Survey	Present Survey	Reid (1930)
Bandanna Formation	Bandanna Formation	Bandanna Formation	Tertiary basalt	
Mantuan *Productus* bed	Mantuan *Productus* bed	Peawaddy Formation (including Mantuan *Productus* bed at top).	Peawaddy Formation (Mantuan *Productus* bed either obscured or absent).	Tertiary basalt
'Catherine Series'	'Catherine Sandstone'	Catherine Sandstone	Catherine Sandstone	'Catherine Sandstones'
'Ingelara Series'	Ingelara Formation	Ingelara Formation	Ingelara Formation	'Coral Stage'

MEASURED SECTION - INGELARA FORMATION TO TOP OF CATHERINE SANDSTONE (S21)

Measured in Consuelo Creek and in a hill immediately north of the creek on the east flank of Reid's Dome, between points SP 129/1 and SP 129/2. (Springsure, Run 4, Photo 5231)
(measured with Abney Level by R.G Mollan, A.Fehr, and L.V. Bastian)



The Catherine Sandstone forms narrow dissected ribbons of outcrop in the flanks of Reid's Dome, the Springsure Anticline and the Consuelo Anticline. Several miles north of Mount Catherine, in the west flank of the Springsure Anticline, the Catherine Sandstone is concealed beneath Tertiary basalt and does not crop out farther north in the west flank of the anticline. South of Mount Catherine inliers of the Sandstone appear through the dissected basalt sheet. The Sandstone crops out in the Springsure Sheet area and northwards in the Emerald Sheet area, in the east flank of the Springsure Anticline. The Catherine Sandstone commonly forms low rocky ridges and cuestas, several hundred feet high, in the north part of Reid's Dome. It has a fairly dark tone in the air-photos, owing to fairly dense timber cover; bedding trends are prominent where the formation forms ridges and cuestas.

The Catherine Sandstone consists dominantly of quartz sandstone, in part granular and pebbly. In the type section (Fig. 24) there are several poorly exposed soft silty and shaly intervals, whereas in Reid's Dome the formation consists entirely of quartz sandstone (Fig. 30). Bastian described the Sandstone from specimens , SP 129/1B to J, collected in section S21 (Fig. 30) as follows :

The sandstone is pale grey or cream, with yellowish streaks in some specimens, and orange to light brown where weathered. The majority of specimens are rather friable, but SP 129/1C and SP 129/1H are firm. Grain sizes are mostly fine; only in SP 129/1F is there an appreciable number of medium grains, and several specimens are very fine-grained. Sorting is generally good, but tends to get poorer upwards. SP 129/1C is very well sorted.

Quartz ranges from about 60% to 70%, and the proportion changes only slightly throughout the section. Metaquartzitic textured grains are very minor, but features seen in the Staircase and Aldebaran Sandstones, such as fluid inclusions and undulose extinction, are common. K-feldspar is present in amounts ranging from 5% to 10%; plagioclase is rare. Muscovite is present in all specimens, ranging up to 5%, and there is biotite in some. "Chert" (devitrified glass from volcanics) is prominent at the base, but becomes minor through most of the unit. There are significant amounts (up to 15%) of sericitic grains, but the rock types from which these were derived are not known; some may be from siltstone, others from schist or other metamorphics. Matrices of both Kaolinite and illite in patches, make up 20% of the rock. In some specimens weathering (Fe-oxides) has occurred.

Glauconite occurs as a minor accessory in specimens SP 129/1B and SP 129/1D. Other accessory minerals, such as tourmaline and zircon, are common, and in some specimens they are abundant (e.g. SP 129/1E and SP 129/1H).

Grains range from angular to subrounded, and become more rounded towards the top of the unit. Overgrowths on quartz are common in most specimens; pressure solution is common.

The formation overlies the Ingelara Formation; the two formations are transitional in the northern part of the Springsure Anticline (Fig. 24) but distinct in the Reid's Dome area. The Catherine Sandstone is overlain by the Peawaddy Formation, with a sharp structurally conformable boundary (Fig. 31). The Catherine Sandstone wedges out at the southern end of Reid's Dome about five miles south of Consuelo Creek and eight miles south of Mount Serocold; the wedge-out was observed on the ground and is also evident in the air-photos. Figure 29 shows a measured section immediately north of the wedge-out and includes twenty feet of Catherine Sandstone. The Sandstone does not reappear at the surface south of these points and it is apparently not present in S.Q.D. Morella No.1 well, and Planet Warrinilla No.1 well (see Enclosure 11). It is not clear whether the wedge-out is erosional, in which case the overlapping Peawaddy Formation disconformably overlies the Sandstone or whether it represents the limit of deposition of the Sandstone. Collectively, the following three factors support an erosional wedge-out;

(i) The overall thinning of the interval from the Peawaddy Formation to the Ingelara Formation towards the southern end of Reid's Dome corresponds to the thinning of the Catherine Sandstone.

(ii) The Peawaddy Formation is laterally persistent, resting in turn on the Catherine Sandstone and, south of the wedge-out, on the Ingelara Formation. The contact between the Catherine Sandstone and the Peawaddy Formation is sharp, suggesting a disconformity.

(iii) There is no evidence in the field or in the air-photos of any lateral equivalent of the Catherine Sandstone.

Where the Peawaddy Formation rests on the Ingelara Formation the relationship is not clear. The lithologies of the two formations are similar, and are difficult to separate because of poor outcrop.

The Catherine Sandstone represents a sand body of restricted extent deposited in the Denison Trough and Springsure Shelf (see Correlation of Permian Formations). The dominance of fairly well sorted massive sandstone beds and the absence of silt and shale in the unit in the Reid's Dome area (Fig.30) suggest a marginal environment of deposition. In this area also there is little cross-bedding and current ripple marks are fairly common. Northwards the unit is less homogeneous (Fig. 24); silty intervals are common, sandstone is commonly granular and pebbly and cross-bedding is common, suggesting that the unit in the northern area was deposited in a paralic environment. Marine conditions were present during the deposition of at least part of the Catherine Sandstone.

The Catherine Sandstone varies in thickness; it is nearly 400 feet thick in the type area, about a mile south of Mount Catherine (Fig. 24) and in Consuelo Creek (Fig. 30). As already noted, the formation does not persist to the south into the Eddystone and Taroom Sheet areas, and it thins eastwards in the Baralaba Sheet area (see Enclosure 11). In A.F.O. Inderi No.1 (Enclosure 11) there is probably some Catherine Sandstone present, but it is difficult to distinguish from the rest of Unit B (Dickins _et al_, in press) in the electric logs.

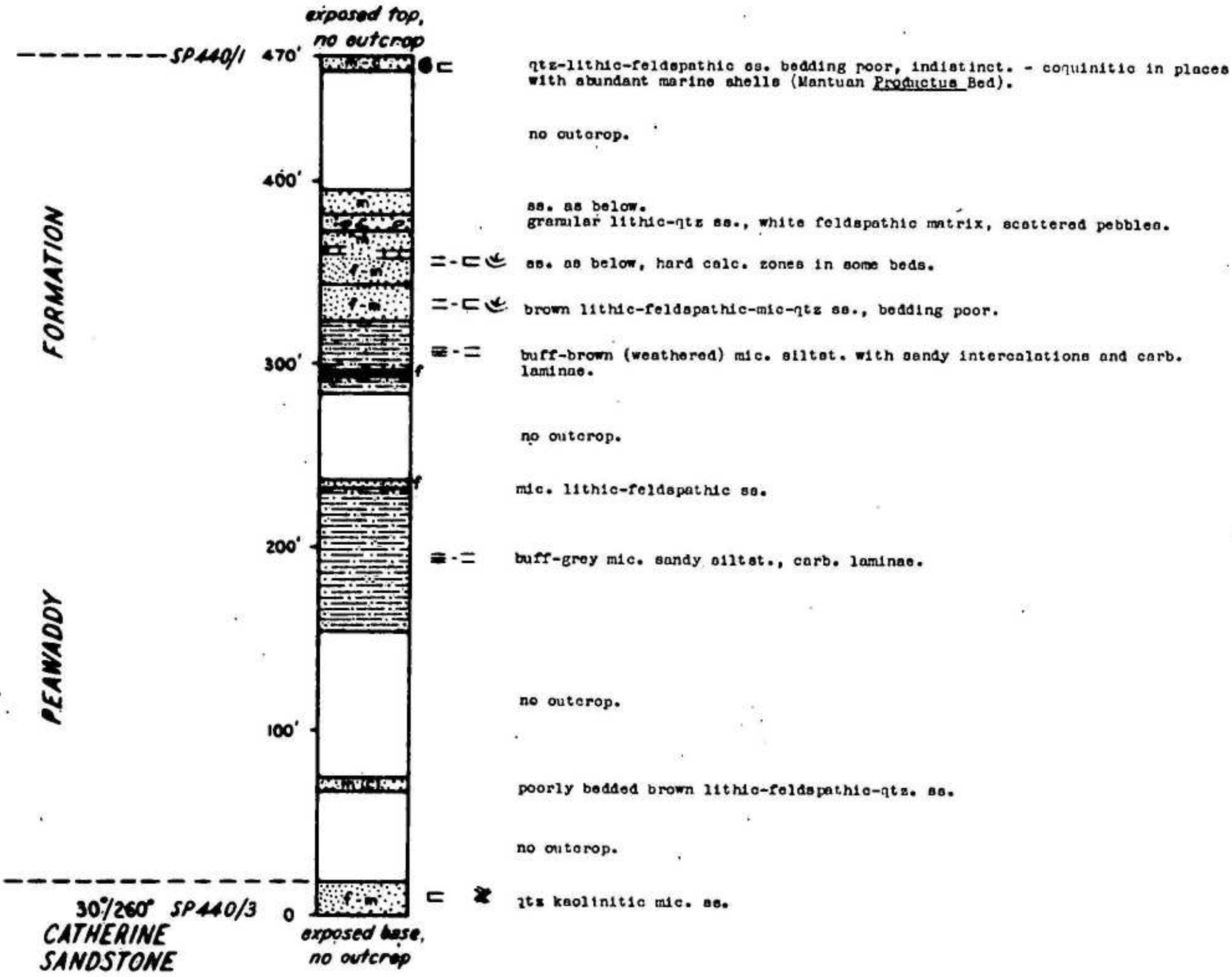
The Catherine Sandstone contains several marine fossil horizons (see Appendix 1) which are referable to the Lower Permian Fauna III (Dickins _et al_, in press).

Figure 31

MEASURED SECTION IN THE PEAWADDY FORMATION (S22)

Peawaddy Creek on the west flank of the Consuelo Anticline between points SP440/3 and SP440/1 (Springsure, Run 2, Photo 5131)

(measured with Abney Level by R.G. Mollan)



Peawaddy Formation

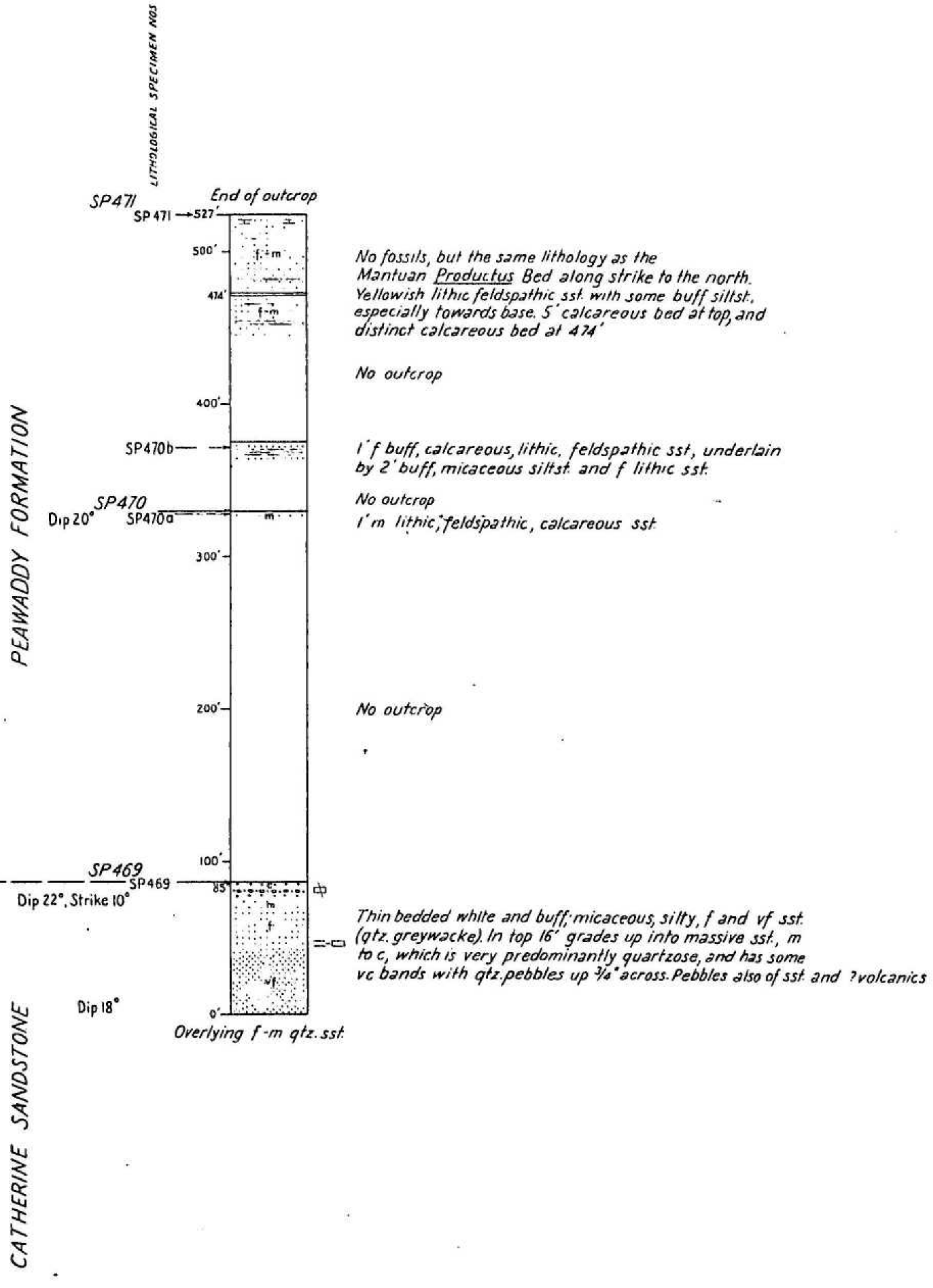
The Peawaddy Formation is a new name for about 500 feet of lithic sandstone and siltstone above the Catherine Sandstone in the eastern part of the Sheet area, and above the Colinlea Sandstone in the western part of the Sheet area. It is overlain by the Bandanna Formation. The Peawaddy Formation contains the very fossiliferous, coquinitic sandstone and siltstone lenses of the Mantuan Productus Bed at, or near the top. The type area is Reid's Dome and Consuelo Anticline; the type section is in Peawaddy Creek, after which the unit is named, in the west limb of the Consuelo Anticline (Fig. 31). The relationship of the Peawaddy Formation to Hill's 'Catherine Sandstone, Shell's 'Catherine Series', and Reid's 'Catherine Sandstones' is outlined in the section on the Catherine Sandstone.

The formation crops out in the Springsure Anticline, Reid's Dome, the Consuelo Anticline, and in a sinuous belt between Wealwandangie and Fairview Homesteads. In the east the strips of outcrop form low, smoothly rounded ridges with a fairly even cover of timber, and contrast, particularly in the east flank of Reid's Dome, with the sharp, rocky densely timbered cuestas of the Catherine Sandstone. In the air-photos this contrast is obvious; the Peawaddy Formation forms a light even tone with faint bedding trends, in contrast to the dark tone of the Catherine Sandstone. A dendritic drainage pattern is developed on low dipping sheets at the southern end of Reid's Dome, about two miles north-west of Ingelara Homestead. West of the Springsure Anticline, the Peawaddy Formation forms gently undulating country covered by areas of timber, scrub, and grassy downs. In the air-photos the formation has a variable tone, ranging from dark, in areas of timber, to light in areas of grassy downs. Bedding trends in the lower part of the formation can be traced for several miles in the area of outcrop west of Tanderra Homestead where the formation is readily distinguished from the Colinlea Sandstone in the airphotos; east of Tanderra Homestead, the two units are less easily distinguished.

The Peawaddy Formation is poorly exposed; the rocks weather deeply, and fresh exposures are found only in gullies and creeks. The unit consists mainly of siltstone, carbonaceous shale, and quartz lithic sandstone: characteristically only lithic quartz sandstone, commonly calcareous, and rarely conglomeratic is exposed. Lithic sandstone is commonly dominant at the top of the formation. The lithic grains in

MEASURED SECTION OF TOP PART OF CATHERINE SANDSTONE AND PEAWADDY FORMATION (S 23)

Two miles south-south-west of small quarry on road to Reid's Dome on the east limb of the Dome between points SP471 and immediately west of point SP469 (Springsure, Run 3/Photo 5145)
(Measured by J. M. Dickins and N. F. Exon, using dip and photo distance and Abney Level.)



MEASURED SECTION OF THE PEAWADDY FORMATION (S.24)

In Sandy Creek, 1⅓ miles south-west of junction with Consuelo Creek (Springsure, Run 4, Photo 5231)
(Measured by J.M. Dickins and N.F. Exon, using dip and photo distance and Abney Level)

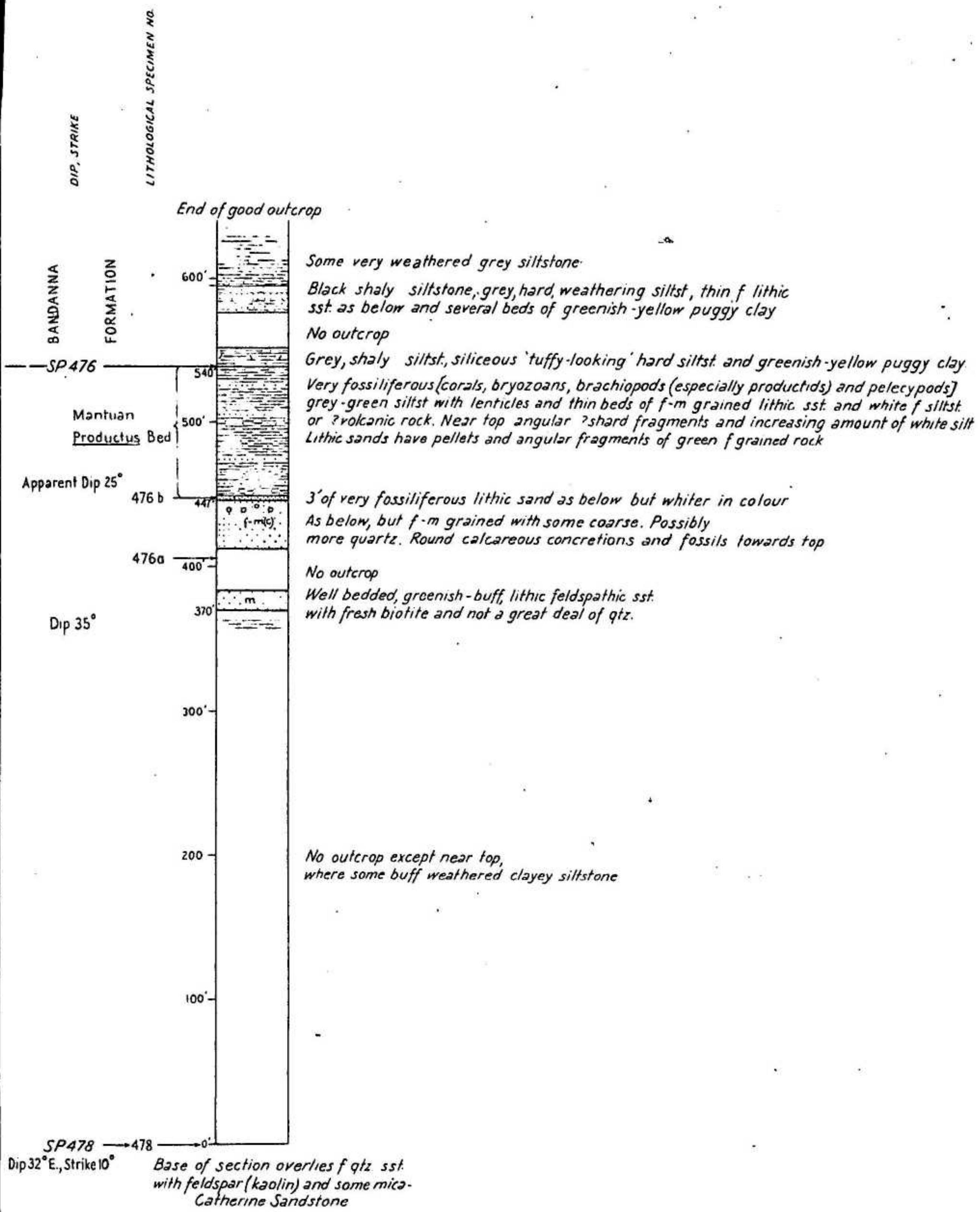
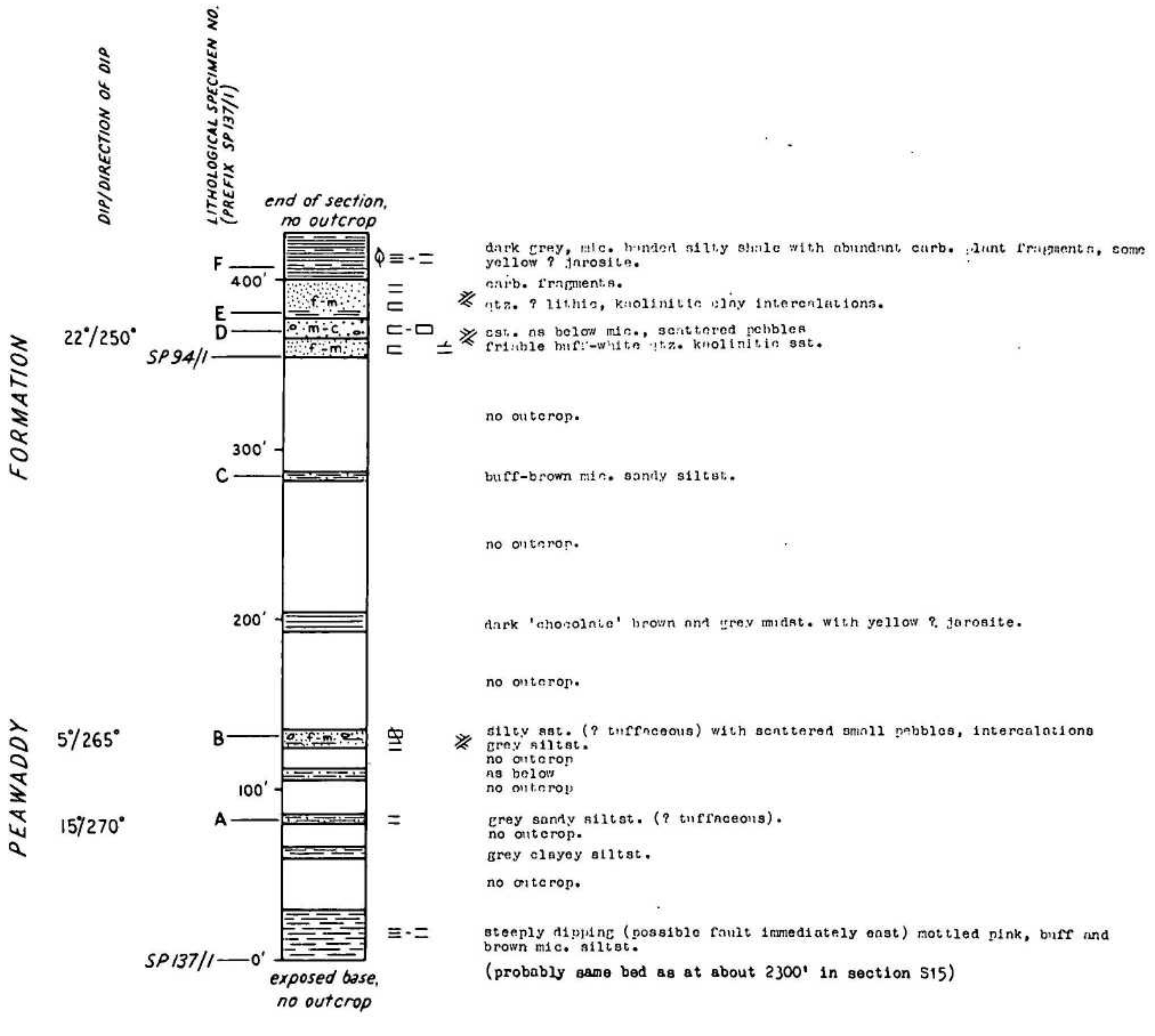


Figure 34

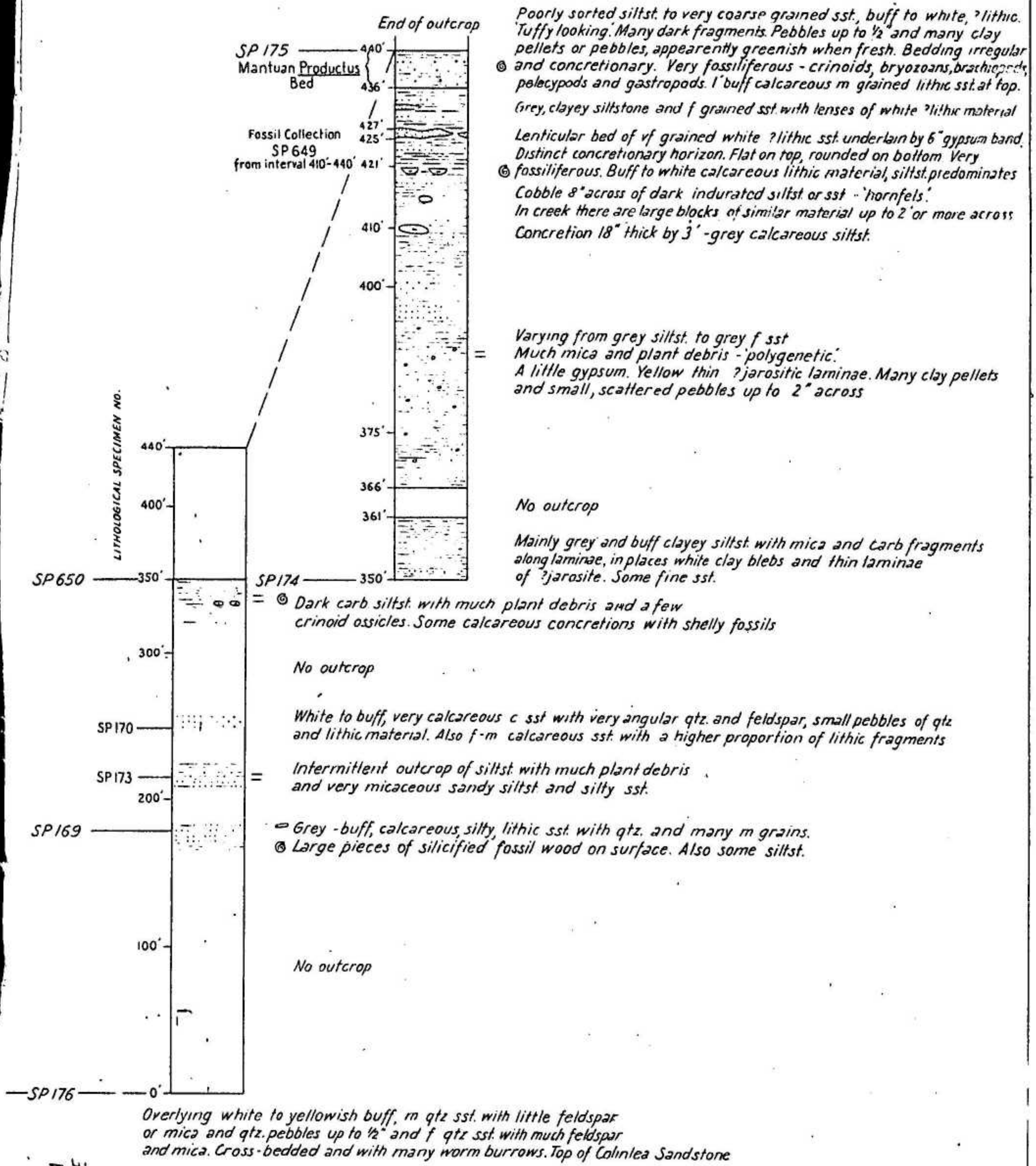
MEASURED SECTION IN THE PEAWADDY FORMATION (S 25)

At the head of a small tributary of Freitag Creek, 2½ miles south of Mount Catherine, between point SP 137/1 and about ½ mile west of point SP 94/1 (Springsure North, Run 4, Photo 5068)
(Measured with Abney Level by R.G. Mollan, 0-80' estimated because of steep slope)



MEASURED SECTION OF THE PEAWADDY FORMATION (S26)

Section beginning 3¼ miles north-east of Tanderra Homestead and ending 2 miles south-south-east of the homestead (Springsure, Run I, Photo 5114) (Measured by J.M. Dickins and R.G. Mollan, using Abney Level for the top 90' and calculation with the aid of Abney Level and aerial photos for the bottom 350')



COLINLEA SANDSTONE

Dip taken as 1° to the south, based on measurements of bedding and dip slopes. Checked from field and aerial photo identification of beds.

the sandstone are mainly volcanics; they include some schist and indurated sediments. In some sandstone there is about 10% feldspar, small amounts of mica and possibly glauconite. The matrix is commonly chloritic and calcareous.

Much of the unit is thinly interbedded and interlaminated siltstone and carbonaceous shale, commonly micaceous and containing much plant debris. In the western part of the Sheet area as shown in the measured section in Figure 35, clayey siltstone contains cobbles of indurated silicified sediments (probably hornfels), slate, and fine-grained greenish volcanics. Similar boulders were encountered in stratigraphic hole B.M.R. No.1. Gypsum and probable jarosite occur along bedding planes of siltstone and in the interlaminated shale notably in the western area (see Fig. 35). Vertical worm burrows filled with black mudstone are common in siltstone and sandstone beds. Calcareous concretions are typically developed in some siltstone. Details of the lithology of the formation are shown in the measured sections (Figs. 31, 32, 33, 34, and 35) and in the logs of stratigraphic holes B.M.R. No.13 and B.M.R. No.14.

The Peawaddy Formation contains, at the top, very fossiliferous, coquinitic lenses with brachiopods, pelecypods, corals, and bryozoans. The fossils occur commonly in lithic quartz sandstone which is the dominant lithology in the top 100 feet of the formation. In Sandy Creek, however, in the east flank of Reid's Dome (Fig. 33), the fossils occur mainly in siltstone. The very fossiliferous to coquinitic lenses are known collectively as the Mantuan Productus Bed, named after the type exposure of a coquinite lens, four miles north of Mantuan Downs Homestead, near Maori Gully Bore. The fossiliferous lenses of the Mantuan Productus Bed probably occur within a thin stratigraphic zone, which is dominantly lithic quartz sandstone. It may be possible with further detailed work to separate and map the lithic quartz sandstone from the Peawaddy Formation and regard it as a member. The name Mantuan Productus Bed should be applied only to the fossiliferous, coquinitic lenses.

It seems relevant here to point out some differences in the mapping of the present survey and that of Laing (1961). In the northern half of Reid's Dome, Laing's stratigraphic units would correlate with the present survey's units in the following way:

Present Survey		Laing
Bandanna Formation		Bandanna Formation
Mantuan *Productus* Bed	)	Dry Creek Shale
Peawaddy Formation	)	
Catherine Sandstone		Early Storms Sandstone
Ingelara Formation		Ingelara Shale

At the southern end of Reid's Dome and in the Early Storms Homestead - Carnarvon Creek Gorge area, immediately south of the Springsure Sheet area, Laing's units apparently correlate with the present survey's units in the following way:

Present Survey	Laing
Bandanna Formation	(Bandanna Formation (Dry Creek Shale
Peawaddy Formation (top lithic-quartz sandstone part of the formation only is exposed in this area)	Early Storms Sandstone
Ingelara Formation	Ingelara Shale

At locality SP 483 along the road into Carnarvon Creek Gorge (see Figure 37) the junction between the Peawaddy Formation (equivalent to Laing's Early Storms Sandstone in his map) and the Bandanna Formation (equivalent to Laing's Dry Creek Shale in his map) was observed. The lithic-feldspathic-quartz sandstone at the top of the Peawaddy Formation contains rare marine macrofossils and is probably a sparsely fossiliferous equivalent of the Mantuan *Productus* Bed; the overlying rock is dark tuffaceous shale with greenish-yellow clay beds, typical of the lower part of the Bandanna Formation. The differences between Laing's stratigraphy and the present survey's from one area to the other appear to hinge on the following factors:

(i) The wedge-out of the Catherine Sandstone towards the southern end of Reid's Dome. The present survey, mapping the northern part of the Springsure Anticline, was able to examine the Catherine Sandstone in the type area and map it continuously to the wedge-out, whereas Laing, working from the area south of Reid's Dome, mapped the top lithic sandstone part of the Peawaddy Formation (Laing's Early Storms Sandstone) and equated it northwards with the Catherine Sandstone without establishing continuity.

(ii) The lenticularity of the Mantuan _Productus_ Bed; no lenses of the bed were found south of Reid's Dome. In the northern half of Reid's Dome, Laing's Dry Creek Shale is marked at the top by the Mantuan _Productus_ Bed (outcrops of the bed are not shown on his map but the boundary at the top of the Dry Creek Shale coincides with outcrops of Mantuan _Productus_ Bed shown in Enclosure 1 of this report) whereas, south of Reid's Dome, because the Mantuan _Productus_ Bed is absent, and, believing there to be only one sandstone (i.e. Early Storms Sandstone equivalent to Catherine Sandstone), Laing has mapped the lower part of the Bandanna Formation as Dry Creek Shale.

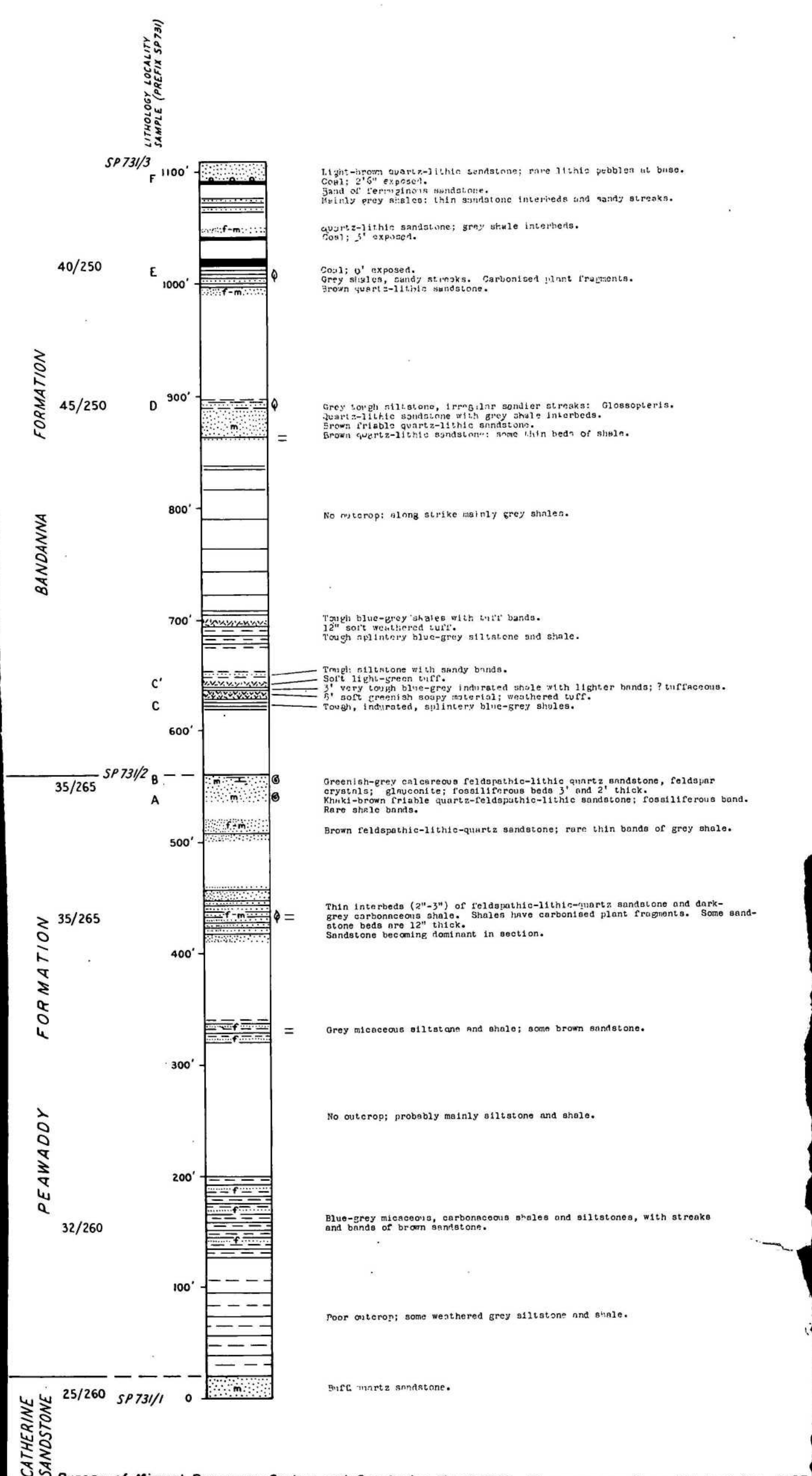
The Peawaddy Formation is probably disconformable on the Catherine Sandstone in the east and disconformable on the Colinlea Sandstone in the west; details of the relationships are discussed under the Catherine Sandstone and Colinlea Sandstone. The contact between the Peawaddy Formation and the overlying Bandanna Formation was observed at several localities (see Fig. 37); at the contact the lithological break between the formations is sharp and the relationship is possibly a disconformity.

The Peawaddy Formation is an extensive unit of fairly uniform thickness in the Springsure Sheet area. As discussed above, it transgresses the Catherine Sandstone and rests on the Ingelara Formation at the southern end of Reid's Dome; the unit appears to transgress the Ingelara Formation eastwards and southwards (see Enclosure 11). The Peawaddy Formation was deposited in a shallow basin of much greater extent than the Denison Trough; marine conditions prevailed for at least part of its deposition, particularly in the last stages when the Mantuan _Productus_ Bed was deposited. Sandstone in the formation appears to have been derived from a granitic and volcanic terrain because it contains much feldspar, and granite and volcanic rock grains. Some primary tuff is possibly present. Siltstone with black shale laminations, and commonly cross-laminated, contains abundant carbonaceous materials and carbonised plant debris, mica, pyrite and, notably in the Tanderra Homestead area (see Fig. 35), gypsum and probable jarosite along bedding planes. Worm tubes are common in some siltstone. These features suggest a probable shallow brackish water, at times, restricted environment. The origin of cobbles and boulders of probable hornfels, granite, and schist in argillaceous sediments in the Springsure Shelf area is not clear; this area was possibly close to a metamorphic provenance.

Figure 36

MEASURED SECTION IN THE PEAWADDY AND BANDANNA FORMATIONS (S27)

Measured west of Mt. Serocold in small tributary of Serocold Creek from SP 731/1 to SP 731/3 (Springsure, Run 3, Photo 5149)
(measured by A.G. Kirkegaard using pace and compass)



The Peawaddy Formation is about 500 feet thick in the type section (Fig.31). This thickness appears to be fairly constant across the Sheet area; for instance near Tanderra Homestead in the Springsure Shelf it is nearly 450 feet thick (Fig. 35).

The Peawaddy Formation contains the very fossiliferous lenticular Mantuan Productus Bed and some poorly fossiliferous lower horizons (see Fig. 35). The fossils collected from the formation are regarded as Upper Permian (see Appendix 1).

Bandanna Formation

The Bandanna Formation (Hill, 1957) was originally named the 'Bandanna Series' by Shell (SQD, 1952). The name was first published, without definition, by Maxwell (1954). It is named after Bandanna Homestead in the Eddystone Sheet area and the type area is stated by Hill (1957) to be the headwaters of Rewan Home Creek, three miles south of Rewan Station. The creek is not identified in the accompanying map to Hill(1957) and could not be identified by the authors on maps of the Department of Public Lands, Brisbane.

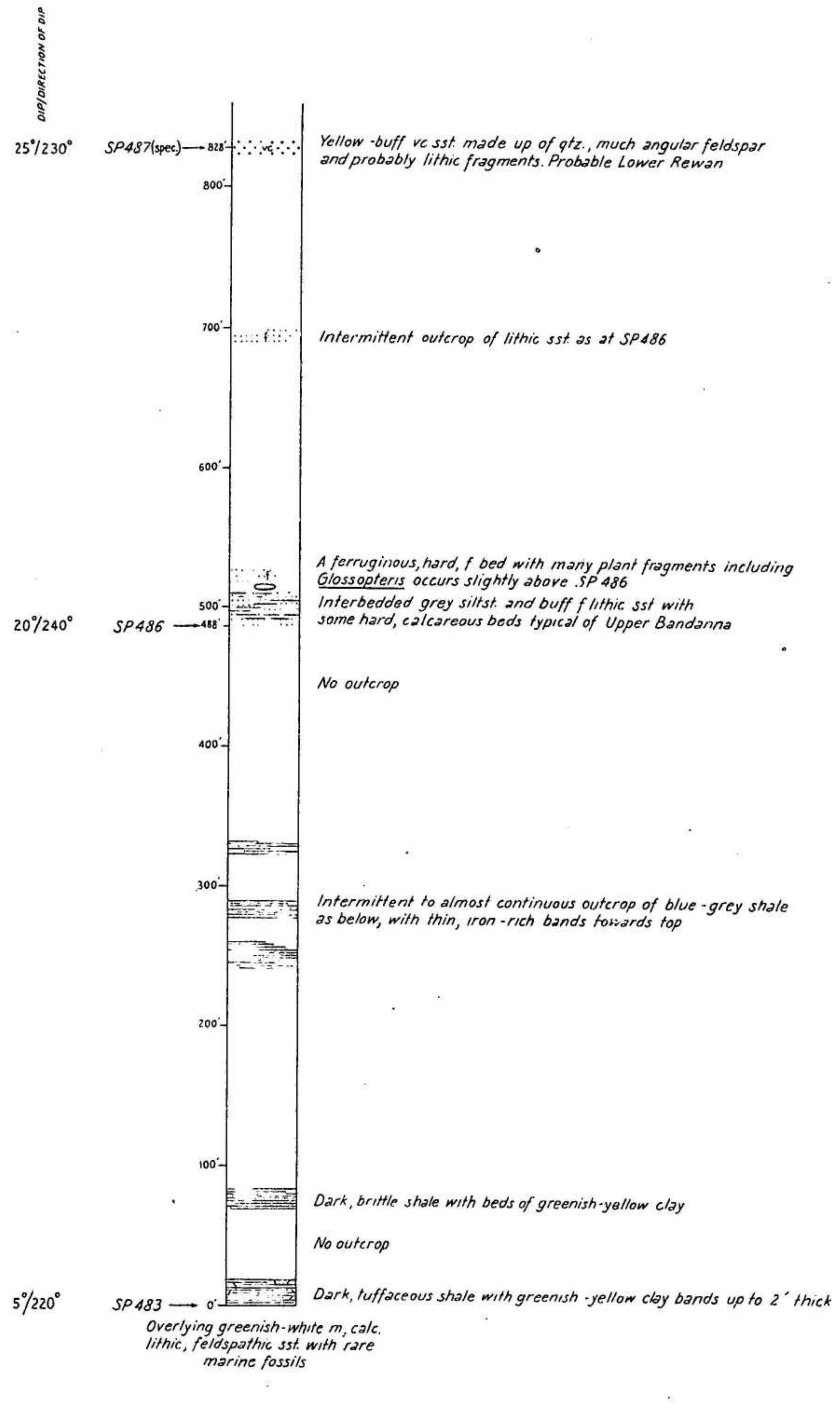
The formation crops out in the flanks of Reid's Dome, the Consuelo Anticline and the Springsure Anticline and across the Springsure Shelf in a belt extending west-north-west from near Wealwandangie Homestead. The unit forms mainly featureless country apart from the Reid's Dome area where some resistant beds form low strike ridges. The formation is dominantly soft argillaceous sediments which weather easily to form thick soil cover. The best exposures are in entrenched creeks. Across the Springsure Shelf the unit forms grassy black soil downs, with a few trees in some areas.

In the Reid's Dome - Springsure Anticline - Consuelo Anticline area, the formation is not readily distinguished in the air photos from the overlying and underlying formations, whereas in the Springsure Shelf area it is distinguished by its light tone and soft appearance with faint bedding trends.

Figure 37

GENERALISED SECTION OF BANDANNA FORMATION (S28)

On Carnarvon Gorge road, beginning 1⅙ mile west-north-west of junction with Bandanna road. (Eddystone, Run 1, Photo 5011), in Eddystone Sheet area
(Measured by J.M. Dickins and N.F. Exon, using dip and photo distance)



Bureau of Mineral Resources, Geology and Geophysics, March 1964 *To accompany Record No. 1964/27* *G 55/A3/5*

Figure 38: Silicified log in the Bandanna Formation about half a mile north of Buckland Plains Homestead. (Neg. No. G/6266)

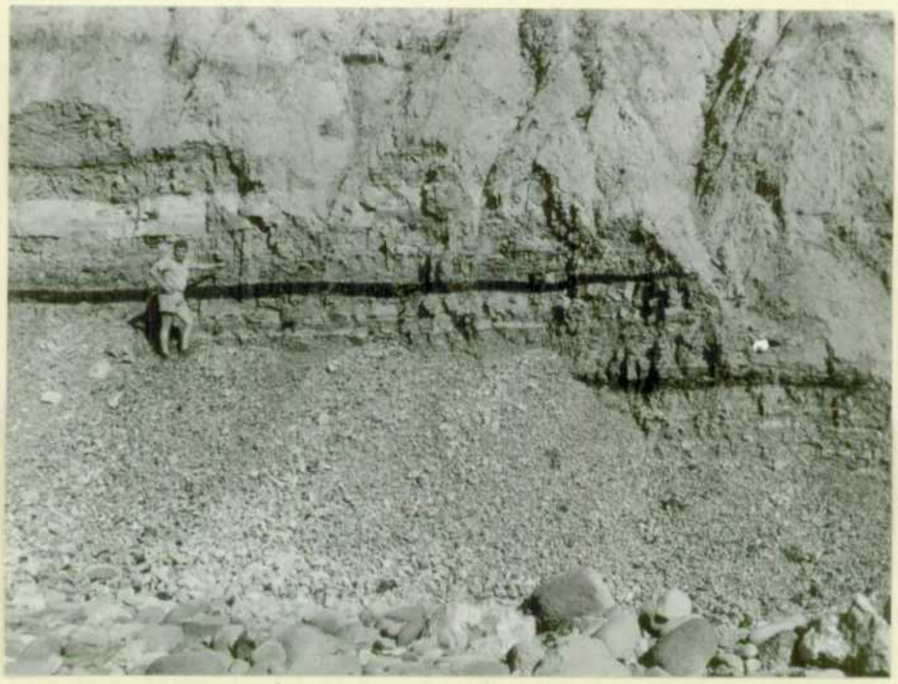


Figure 39: Thin coal seams in interbedded sandstone and siltstone in the Bandanna Formation, about four miles south of Kareela Homestead in Spring Creek. (Neg. No. G/6256)

The Bandanna Formation consists of lithologically distinct lower and upper parts which could not be mapped individually because of poor exposure. The lower part consists dominantly of blue-grey shale and mudstone containing characteristically, near the base, beds of white, yellow, greenish and red montmorillinitic clay. Shales adjacent to these clay beds are commonly tough and cherty, and contain a high percentage of volcanic ash and glassy shards. Some cherty light coloured bands are probably ashstone. Minor thin beds of lithic sandstone are also present.

The upper part of the formation is characterised by coal seams up to 15 feet thick (Fig. 39), and consists mainly of interbedded brown and green friable, fine to medium grained lithic sandstone and subgreywacke, calcareous sandstone tending to sandy limestone, and grey, carbonaceous sandy siltstone; some thin ferruginous (?sideritic) beds are also present. Beds of oil shale up to three feet thick have been recorded near Early Storms Homestead in the Eddystone Sheet area. A horizon containing numerous silicified logs occurs near the boundary between the lower and upper parts of the formation and forms a useful marker. The presence of the horizon is commonly detected by silicified logs as rubble at the surface; Fig. 38 shows one of several logs up to 40 feet long in a typical setting north of Buckland Plains Homestead. The fine-grained sediments are poorly bedded; sandstone beds are mainly thin to medium bedded, rarely cross bedded; some sandstone beds are contorted, lying between undisturbed sandstone. Figures 36 and 37 are measured and generalised sections of the formation.

In the western part of the Springsure Shelf the two-fold division of the Bandanna Formation is not as distinct as in the Denison Trough. The lower part consists of black clay, shale and mudstone with soft light-coloured clay beds. The upper part is also mainly fine-grained, but contains beds of brown, friable, fine to medium grained argillaceous lithic sandstone. These sandstone beds contain rounded concretions, lenses and thin interbeds of calcareous sandstone in which feldspar forms up to 30% of all grains. No coal outcrops were observed but thin seams occur near the top of the unit in stratigraphic hole BMR No.2 (see Stratigraphic Drilling).

The Bandanna Formation is apparently conformable on the Peawaddy Formation, though the sharp lithological change from sandstone at the top of the Peawaddy Formation to clay shale at the base of the Bandanna Formation may indicate a disconformity (see Fig. 37). The relationship between the Bandanna Formation and the Rewan Formation is apparently transitional in places in the Springsure Sheet area. Poor outcrop makes definition of the boundary difficult. However, the boundary lies between two distinctly different lithologies of the two formations, namely coal seams in the Bandanna Formation and reddish coloured sediments, commonly argillaceous, in the Rewan Formation. Between these different lithologies a sequence of grey, green, and khaki shale and green and grey lithic quartz sandstone occurs. Similar lithologies occur above the lowest reddish coloured sediment and below the highest coal seam. The thickness of this sequence varies widely: it is very thin near the junction of Sandy and Consuelo Creeks, where the Rewan Formation may be disconformable on the Bandanna Formation; it is much thicker further east where the two units are possibly transitional in places. In the Arcadia Anticline in the Taroom Sheet area, Woolley (1944) distinguished a slight unconformity at the base of a conglomeratic sandstone ('Malta Grit') which he regarded as the base of the Rewan Formation. Lenticular, pebbly, lithic quartz sandstone occurs at the southern end of Reid's Dome and is regarded as the equivalent of Woolley's 'Malta Grit'. During the present mapping the base of this pebbly sandstone was taken as the base of the Rewan Formation at the southern end of Reid's Dome. In Figure 40 a thin granular sandstone bed at the base of the measured section is probably an equivalent of the 'Malta Grit'. Elsewhere in the Springsure Sheet area the pebbly sandstone was not seen and the mapped boundary was placed at the lowest reddish coloured bed or the highest coal seam or dominantly carbonaceous bed. Evans (pers. comm.) has noted, during palynological investigations of material from exploratory wells, that there is a distinct lack of carbonaceous material in sediment between the highest coal seam of the Bandanna Formation and the lowest reddish coloured bed of the Rewan Formation when compared with the abundance of carbonaceous material in sediments interbedded with the coal seams. Woolley (1944) believed the base of the 'Malta Grit' to be unconformable on the Bandanna Formation. It seems that this supposition is wrong because reddish coloured lithologies occur below the 'Malta Grit' in A.A.O. No.7 (Arcadia) bore(Mines Administration

Pty.Ltd., 1957), and a probable unconformity was detected in Planet Warrinilla North No.1 bore at the lowest reddish coloured bed.

The presence of microplankton swarms in the basal part of the Bandanna Formation (Evans, 1964) suggests that marine conditions persisted during deposition of at least part of the lower part of the formation. There was also some contemporaneous volcanic activity as evidenced by tuffs; some soft clay beds are probably weathered, volcanic material. The lower part of the formation was probably deposited slowly in a gently subsiding basin. The fossil wood horizon probably represents a period of uplift. The upper part of the formation was deposited in a shallow fresh water basin with recurrent periods of subsidence. Swampy coal-forming conditions were present before periods of renewed subsidence. Glauconite in some sandstone possibly indicates marine incursions.

Shell (SQD, 1952) state that the thickness of the lower part of the Bandanna Formation is 300 to 400 feet; it is about 300 feet thick west of Mount Serocold (Fig. 36). Shell state that the upper part shows a marked variation in thickness, the extremes being 250 feet and 1100 feet. The generalised section (Fig. 37), south of Reid's Dome, shows a total thickness of 830 feet. Because of poor exposure it is difficult to estimate the thickness of the formation in the Springsure Shelf; it is probably about 500 feet thick.

The formation contains an abundant Glossopteris flora; plants found during the present survey are listed in Appendix 2. Other forms previously noted (Hill, 1957) include Cladophlebis cf roylei Arber, Glossopteris browniana Brongniart, G. jonesi Walkom, Phyllotheca sp. , P. australis Brongniart, P. deliquescens (Goppert), Sammaropsis sp., Schizoneura sp.nov., Sphenopteris lobifolia Morris.

The Bandanna Formation contains Upper Permian plants (Appendix 2). Palynological work (Evans, pers. comm., and unpublished notes on material from exploration oil wells not yet released for general information) has shown that the top coal in the Bandanna Formation coincides with the break between Permian and Triassic spores. The transition interval to the reddish coloured sediments, mainly mapped as Bandanna Formation in the Springsure Sheet area (see above) is therefore Triassic.

Correlation of Permian formations

A correlation of Permian formations between Reid's Dome and the Springsure Anticline in the Denison Trough and the western part of the Sheet area in the Springsure Shelf is shown diagrammatically in Enclosure 1. A correlation of the formations in eight exploratory oil wells drilled in the Springsure Sheet area and the adjoining Sheets of Baralaba, Taroom, and Eddystone is shown in Enclosure 11.

The probable lowest Permian unit in the area was encountered only in A.O.E. Reid's Dome No.1 and called by Webb (1956) the 'lower shales and mudstones'. The bore penetrated nearly 3000 feet of the unit before drilling ceased (Enclosure 11). The unit is overlain by the 'undivided freshwater beds' (Webb, 1956) with apparent unconformity in A.O.E. Reid's Dome No.1. The 'undivided freshwater beds' are absent in S.Q.D. Morella No.1, and A.F.O. Purbrook No.1, and possibly absent in A.F.O. Inderi No.1, and Planet Warrinilla North No.1 (Enclosure 11). They are nearly 5000 feet thick in A.O.E. Reid's Dome No.1. The Orion Formation, exposed only in the Springsure Anticline is regarded as equivalent to the top part of the 'undivided freshwater beds'. This correlation is based on freshwater characteristics of the Orion Formation (viz. rootlets, plant beds, and thin coaly bands), and the similar transitions of the 'undivided freshwater beds' to marine Cattle Creek Formation, and the Orion Formation to marine Stanleigh Formation. The Stanleigh Formation contains the same fauna as the Cattle Creek Formation (see Appendix 1). A thin lenticular unit of Lower Permian sandstone and siltstone, lying between the Joe Joe Formation and the Colinlea Sandstone in the Springsure Shelf is possibly equivalent to part of the Orion Formation. The Lower Permian sandstone and siltstone contains plant beds of Glossopteris similar to those in the Orion Formation and is unconformably overlain by the Colinlea Sandstone, which is probably no older than the Aldebaran Sandstone. The unconformity is therefore equivalent, at least, to the deposition of the Cattle Creek Formation in the Denison Trough.

The correlation of the Cattle Creek Formation with the interval from the base of the Stanleigh Formation to the top of the Sirius Formation (see Enclosure 1), is now thought to be less likely by the authors because of new information, regarding the Cattle Creek Formation-Aldebaran Sandstone interval in Reid's Dome, which has become available since the map was drawn; the new information more strongly supports an an alternative correlation. The alternative correlation is that the Cattle Creek Formation is equivalent to the Stanleigh Formation, and that the Aldebaran Sandstone in Reid's Dome as shown in Enclosure 1 between the Cattle Creek Formation and the Ingelara Formation, is equivalent to the interval from the base of the Staircase Sandstone to the top of the Aldebaran Sandstone in the Springsure Anticline, the Sirius Formation having completely or nearly wedged-out southwards between the Springsure Anticline and Reid's Dome.

There are two main reasons for believing this correlation to be the most likely.

(i) As already noted (see Aldebaran Sandstone) there is a distinct lithological difference between the lower 1200 feet of the Aldebaran Sandstone and the upper 600 feet, in Reid's Dome; the two parts are separated by a breccia-like conglomerate with large fragments of soft, dark siltstone and shale, and about 130 feet of fine-grained sandstone with worm burrows and intervals of no outcrop (Figs. 25 and 26). Bastian (pers. comm., see Introduction to Permian) who is studying the specimens collected from sections S16 and S17 (Figs. 25 and 26) confirms the difference. The upper 600 feet is dominantly quartzose and poor in feldspar, comparing closely with the whole of the Aldebaran Sandstone in the Springsure Anticline (see Aldebaran Sandstone); the lower 1200 feet is less quartzose and richer in feldspar, compares closely with the Staircase Sandstone in the Springsure Anticline (see Staircase Sandstone). The interval between 540 feet and 670 feet in Figure 25, i.e. between 1065 feet and 1195 feet from the base of the Aldebaran Sandstone as mapped (Figs. 25 and 26), consists of fine-grained sandstone beds riddled with worm tubes, silty intervals, and intervals of no outcrop. The interval is compared with the basal part of the Sirius Formation (Fig. 20). The soft siltstone and shale fragments of the breccia-like conglomerate were derived from a nearby source, possibly by erosion of the Sirius Formation. The dark siltstone and shale are typical lithologies of the Sirius Formation. Thus the base of the breccia-like conglomerate is probably a disconformity. It seems therefore that the Aldebaran Sandstone (of the Springsure Anticline) overlaps the Sirius Formation southwards; the Aldebaran Sandstone thins, and the Staircase Sandstone in turn, thickens, southwards.

Thin section examination of cuttings from Planet Warrinilla North No.1 well (Bastian, pers. comm.) reveals a similar threefold lithologic division in the 'Aldebaran Sandstone', as shown in Enclosure 11. The middle unit (between 4880 feet and 4930 feet) is probably equivalent to the middle interval in the measured section (i.e. between 540 feet and 670 feet in Figure 25).

(ii) From the type area, south to Aldebaran Creek the Staircase Sandstone thins a mere 40 feet (see Figs. 18 and 19). It is apparent in the air-photos that the Staircase Sandstone is not thinning south of Aldebaran Creek. In contrast, the Sirius Formation appears to thin southwards in the southern plunge of the Springsure Anticline; three miles west of Mount Kelman Homestead the Sirius Formation is estimated to be less than 200 feet thick, forming a very narrow corridor between cuestas of the Aldebaran and Staircase Sandstones.

A small culmination in the southern plunge of the Springsure Anticline was detected in the air-photos about two miles north of Sandy Creek. A slight angular discordance between beds exposed in the core of the culmination and the overlying sandstone is apparent in the air-photos. Unfortunately this was not investigated in the field but it is possible that the rocks exposed in the core of the culmination belong to the Staircase Sandstone and not the Aldebaran Sandstone.

In the initial stages of the mapping of the Springsure Anticline and Reid's Dome the authors accepted that Patterson (1956) and Webb (1956) had proved, on faunal evidence, the correlation shown in Enclosure 1. Similarly, Phillips (1954) adopted Patterson's and Webb's correlation, with only slight modification. By contrast, Dickins has found the faunal evidence to be inconclusive (see Appendix 1). Thus the lithological and structural evidence for the correlation outlined above is not contradicted by palaeontological data

The correlation is summarised below :-
(thicknesses in feet, shown in brackets).

	Reid's Dome	Springsure Anticline
	Ingelara Formation	Ingelara Formation
Aldebaran Sandstone (of Figs.25 and 26, and Enclosure 1)	upper part (670)	Aldebaran Sandstone (1040
	middle part (130)	Sirius Formation(350)
	lower part (1065)	Staircase Sandstone (740)
	Cattle Creek Formation (1625)	Stanleigh Formation (1100)

Detailed study of specimens from the Colinlea Sandstone (Figs. 12 and 13) has shown that there is a distinct lithological break near the top of the complete section of the Sandstone (Fig. 13, see Colinlea Sandstone). The lower part is distinctly similar to the Aldebaran Sandstone in the Springsure Anticline, and the upper part of the 'Aldebaran Sandstone' in Reid's Dome, whereas the upper part, containing feldspar, is very similar to the Catherine Sandstone.

In the type section (Fig. 12) the upper feldspathic part is apparently missing; it is probably present under Tertiary basalt to the east; the whole of the section compares closely with the lower part of the complete measured section (Fig. 13). Evans (1964) has found a similar spore assemblage in the Colinlea Sandstone from cuttings in stratigraphic hole B.M.R. No.6 to the assemblage from the top part of the 'Aldebaran Sandstone' in Reid's Dome.

The Peawaddy Formation, overlying the Colinlea Sandstone, contains only the Mantuan Productus bed fauna (Fauna IV, Dickins et al, in press) and no assemblages were found that could be related to the fauna of the Ingelara Formation (Fauna III, see Appendix 1). Thus, it seems most probable that the Colinlea Sandstone represents the interval Aldebaran Sandstone-Ingelara Formation-Catherine Sandstone. The Colinlea Sandstone thickens eastwards and possibly a representative of the Ingelara Formation is present in the east, being mostly obscured by Tertiary basalt.

The correlation is summarised as follows (thicknesses in brackets):

Denison Trough (Springsure Anticline)	Springsure Shelf
Peawaddy Formation (500)	Peawaddy Formation (440)
Catherine Sandstone (400)	Colinlea Sandstone (440–620+)
Ingelara Formation (670)	
Aldebaran Sandstone (1040)	

TRIASSIC

Rewan Formation

The term 'Rewan Series' was first used by Shell (SQD, 1952) and published as Rewan Formation by Isbell (1955); Rewan Formation is a synonym for 'Rewan Series'. The formation is named after Rewan Homestead; the type area is in the vicinity of the homestead and the type section is in a creek several miles north of the homestead (Fig. 40). The Rewan Formation is preserved over much of the southern half of the Bowen Basin. It crops out in large areas in the south-east quadrant of the Springsure Sheet area and in a narrow sinuous belt extending east-west across the central part of the western half of the Sheet area. In the north-east quadrant of the Sheet area the unit underlies much of the sheet of Tertiary basalt. The formation consists dominantly of soft rocks which weather readily, producing thick soil cover. Within the areas of outcrop shown in Enclosure 1 the best exposures are found along stream courses. The unit forms featureless country with varying densities of scrub and tree cover. In the air-photos the tone produced by the formation is not consistent, varying from light to very dark with changes in vegetation.

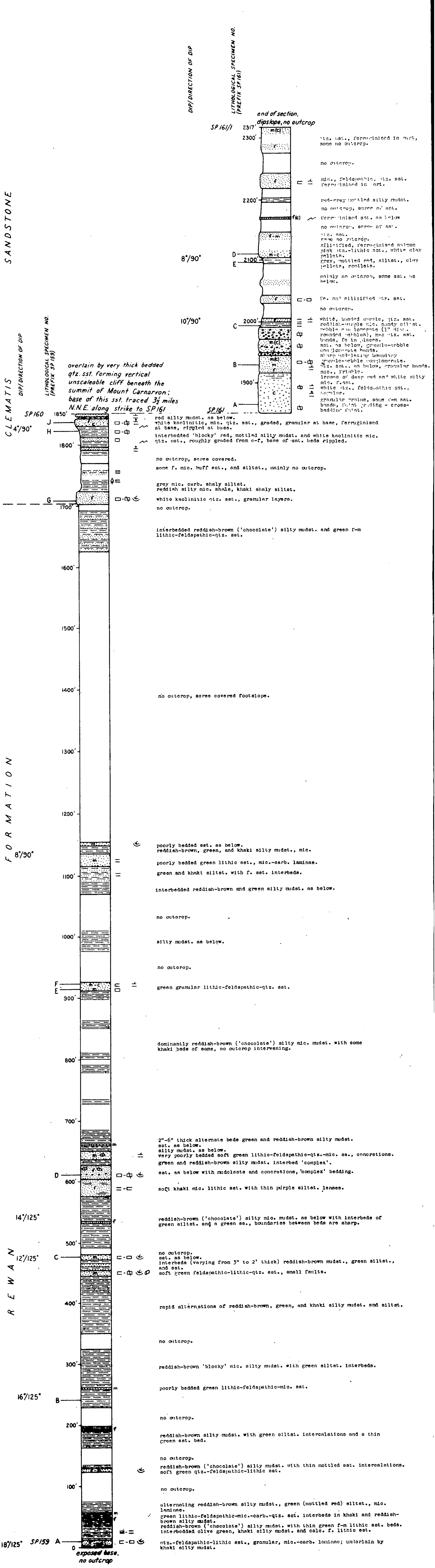
The Rewan Formation is characterised in the type area by massive beds of reddish-brown dense silty mudstone, which weather along complex networks of fractures; thin green layers are the only indication of bedding. The relationship of the green colouration to the red appears to be transitional and due to alteration rather than variations in initial composition. Green and khaki lithic quartz sandstone, in places coarse and granular, is an important lithology in the Rewan Formation. The sandstone is commonly festoon-bedded and in some places contains layers of green well-rounded mud clasts; it is strongly calcareous in places.

In the Cona Creek - upper Peawaddy Creek area the formation consists of thin multicoloured silty mudstone with poor shaly fissility, and, particularly near the bottom, thin khaki-green festoon-bedded lithic quartz sandstone beds with mud clasts. Much of the silty mudstone is the typical reddish-brown but, in contrast to the type area, it includes numerous green, grey, and khaki interbeds. The reddish-brown colouration is dominant higher up the sequence.

Figure 40

MEASURED SECTION IN THE REWAN FORMATION AND CLEMATIS SANDSTONE (S29)

Measured in a small creek from its junction with Consuelo Creek (SP 159) to its head at the base of Mount Carnarvon (SP 160) and in cuestas immediately east of Serocold Homestead between SP 161 & SP 161/1 (Springsure, Run 4, Photo 5231)
(Measured with Abney Level by R.G. Mollan)



In the western half of the Sheet area, the unit consists of fine-grained green and grown lithic quartz sandstone, commonly calcareous, and reddish-brown silty mudstone. Stratigraphic hole B.M.R. No.3 penetrated over 100 feet of the unit in this area (see Stratigraphic Drilling).

Shell (SQD, 1952) recognised two lithologic subdivisions, namely the 'Lower Rewan Group', characterised by lithic quartz sandstone and the 'Upper Rewan Group' dominantly reddish-brown silty mudstone. Shell maintained that the 'Lower Rewan Group' is extremely lenticular which 'suggests that the Lower Group is a facies of the Upper Rewan'. Shell's concept of the lower sandy part appears to be valid and important in defining the Rewan Formation and Bandanna Formation boundary (see Bandanna Formation).

The Rewan Formation is overlain by the Clematis Sandstone with no apparent angular discordance. In the Mount Carnarvon area there is a rapid change from green lithic quartz sandstone of the Rewan Formation to white quartz sandstone of the Clematis Sandstone (see Fig. 40). In Cona Creek several contacts were observed; interbedded reddish-brown, green, and khaki silty mudstone, containing at the top a white leached zone, one to two feet thick, is overlain by coarse, granular, thick bedded, cross-bedded quartz sandstone. The sharpness of the contacts and the presence of a leached zone at the top of the Rewan Formation suggests a depositional break possibly an erosional break accompanied by a probable change in provenance and environment of deposition. A leached zone at the top of the Rewan Formation was also seen in the western half of the Sheet area. South of Tanderra Homestead the Rewan Formation appears to be absent over a distance of about 15 miles (Enclosure 1). This is caused probably by non-deposition or erosion, and local overlap by the Clematis Sandstone along the extension of the Nogoa anticlinal axis. Movement on this axis during Rewan times is probably the reason for the overlap. The relationship of the Rewan Formation to the underlying Bandanna Formation is not clear (see Bandanna Formation).

The Rewan Formation is dominantly a red-bed sequence. The typical deep reddish-brown coloration is a result of specific oxidising conditions either in the provenance area or in the depositional environment. The red coloration is confined mainly to argillaceous rocks which also contain bright green bands and patches apparently altered from the red rock; they possibly represent local reducing environments.

The red beds which probably derive their colour from finely divided hematite, were possibly derived from an arid landscape and deposited rapidly in a subsiding shallow, probably non-marine basin; the presence of glauconite in some sandstone (Fehr, 1962) suggests occasional marine incursions. The lack of sand grains in the red beds suggests the fine material was winnowed from the provenance area, possibly by wind. Sandstone beds, with their dominant festoon bedding and mud clasts, were possibly deposited from streams which flowed during intermittent wet periods, following periods of desiccation. On the other hand the red beds were possibly derived from a hot humid region in which thick lateritic soils were being rapidly formed and continually removed by streams. The red beds possibly accumulated in small shallow basins which periodically dried up, allowing the beds to remain in an oxidized state. Sand was probably mainly confined to stream courses. Renewed subsidence altered the courses of streams and formed new basins. The high content of reworked vitric tuff in some sandstone (Fehr, 1962) indicates a volcanic provenance for some of the sand.

The Rewan Formation is 1600 feet thick in the type section (Fig. 40). It is probably about 1000 feet thick on the west side of Reid's Dome. In Cona Creek it is estimated to be about 400 feet thick but thins rapidly westwards and appears to be absent about 15 miles away, in the area south of Tanderra Homestead. Westwards from Tanderra Homestead the unit thickens to about 400 feet thick in the area south of Mantuan Downs Homestead.

No fossils were found in the formation during the present survey. Probable Triassic plants were found in the formation in the Duaringa Sheet area (Appendix 5, in Malone et al, 1963). Spores from the formation are Lower Triassic (Evans, pers. comm., and unpublished notes on material from exploration oil wells not yet released for general information). Palynological evidence relating to the Rewan/Bandanna boundary is discussed under the Bandanna Formation.

Clematis Sandstone

The 'Clematis Sandstone' was named and the name published by Jensen (1926); the name is derived from Clematis Creek which crosses the boundary between the Baralaba and Taroom Sheet areas. Clematis Sandstone is apparently synonymous with the 'Carnarvon Red Member' of Reid (1930), the 'Carnarvon Sandstone' of Reeves (1947), and the 'Carnarvon Series' of Shell (SQD, 1952). The type area of the formation is in the Baralaba Sheet area, in the headwaters of Clematis Creek. The type section is in cliffs bordering Clematis Creek (Olgers, et al, 1964).

The Clematis Sandstone crops out in the southern half of the Springsure Sheet area in the Rewan Syncline, in the west limb of Reid's Dome, in isolated areas between Reid's Dome and Tanderra Homestead, and in a continuous belt from Tanderra Homestead to the western boundary of the Sheet area. It crops out in the adjoining Baralaba, Tambo, and Eddystone Sheet areas, and in the Taroom and Duaringa Sheet areas. In the Reid's Dome - Rewan Syncline area it forms pinkish-red cliffs and cuestas. It forms benches beneath Tertiary basalt west and north-west of Reid's Dome. Westwards it forms low, poorly defined, escarpments and ridges. In the air-photos the formation has a dark tone due to dense timber cover; distinct white lines mark cliff forming beds, and in the Rewan Syncline area some beds can be traced for several miles.

The measured section (Fig. 40) shows the characteristics of the formation. The lower 150 feet consists of cliff-forming, thick, bedded, cross bedded, rarely graded bedded, fine to coarse, white quartz sandstone, in places kaolinitic, interbedded with massive, blocky, mottled red, silty mudstone, from which the red stain on the sandstone cliffs is derived. Several sandstone beds have hard ferruginous bases. Some laminated grey siltstone is also present. Lying above the lower 150 feet, is 150 feet of coarse, very thick bedded conglomeratic sandstone with conglomerate beds; this part of the section forms the prominent cliff at Mount Carnarvon. Above this is about 300 feet of quartz sandstone interbedded with brownish, often flaggy, micaceous, lithic and feldspathic fine sandstone, siltstone, and grey silty mudstone. The fine-grained blue grey sandstone and siltstone contain very well preserved plants (Appendix 2). Current ripple marks are common in sandstone throughout.

In the area between Reid's Dome and Tanderra Homestead the formation consists typically of white coarse thick-bedded and cross bedded sandstone and granule conglomerate. West of Tanderra Homestead, fine-grained buff sandstone is dominant.

The Clematis Sandstone appears to be structurally conformable on the Rewan Formation; disconformity between the two formations is present in places (see Rewan Formation). The Sandstone is conformably overlain by the Moolayember Formation with a transition from quartz sandstone to lithic sandstone. The highest quartz sandstone is regarded as the top of the Clematis Sandstone.

The Clematis Sandstone represents a marked change in provenance or environment from Rewan Formation. It is an extensive blanket sand which in the Baralaba Sheet area was derived mainly from the north-west (Olgers, et al., 1964). The abundance of cross-bedding and current ripple marks, and some scour structures suggests deposition by streams. Interbedded siltstone and mudstone with abundant plant debris were probably deposited in lagoonal areas, isolated from the main stream courses. Red beds in the lower part of the unit indicate a temporary recurrence of an environment similar to that in which the Rewan Formation was deposited.

The Clematis Sandstone is estimated to be about 800 feet thick in the west limb of the Rewan Syncline; 600 feet of this were measured (Fig. 40). In the west limb of Reid's Dome the formation is probably of the order of 500 feet thick. It appears to thin westwards from Reid's Dome; and in the western half of the Sheet it is probably only 200 feet thick.

Plants collected from the formation have a Triassic to Lower Jurassic range (Appendix 2). Spores indicate a Middle Triassic age for the formation (Evans, pers. comm.).

Moolayember Formation

The term 'Moolayember Shale' was published by Reeves (1947) and subsequently referred to as the Moolayember Formation (Phillips, in Hill and Denmead, 1960). Whitehouse (1955) nominated the Injune - Rolleston road exposures on the descent to Moolaymember Creek as the type section for the formation.

The formation crops out in the Rewan Syncline, in the west flank of Reid's Dome beneath cliffs of Tertiary basalt and Precipice Sandstone, and in a belt about ten miles wide, across the Springsure Shelf. The unit forms areas of low relief in contrast to the adjacent cliff-forming Clematis and Precipice Sandstones; some more resistant sandstone beds form low cuestas but bedding patterns generally cannot be discerned. The formation is, for the most part, sparsely timbered and has a light air-photo tone. Exposure is generally poor.

The formation consists of siltstone, sandy siltstone, and sandstone. Siltstone is dominant and is grey, greenish-brown, or buff in outcrop. Soft carbonaceous shale with coal bands and leaf beds are present. Thin beds of reddish-brown mudstone were observed in the Nogoa River near Cungelella Homestead. Stratigraphic drill hole B.M.R. No.4 penetrated the basal 200 feet of the formation; lithologies are mainly grey micaceous, carbonaceous siltstone and interlaminated fine-grained sandstone and siltstone. Sandstone is brown, friable and fine to medium grained; it consists mainly of lithic grains with some quartz and many fresh angular feldspar grains, with minor biotite, muscovite, and iron ore. The sandstone contains rounded calcareous concretions in places and beds of thin-bedded carbonaceous, micaceous calcareous sandstone, tending to sandy limestone, throughout. Whitehouse (1955) records oil shale from the top of the formation in the Nogoa River.

The beds are characteristically thin-bedded to laminate; in places they are ripple-marked, worm-tracked, and contain mud-clasts at the base. Cross-beds are rare.

The top of the Moolayember Formation consists of a weathered and leached zone up to ten feet thick. Shale at the top of this zone is pink and ash-grey; sandstone beds are purple and probably partly reconstituted. The leached zone transgresses bedding planes where the formation is dipping.

The Moolayember Formation conformably overlies the Clematis Sandstone. The change from cross-bedded quartz sandstone of the Clematis Sandstone to feldspathic-lithic sandstone of the Moolayember Formation is gradational; the boundary is taken at the highest cross-bedded quartz sandstone. The formation is unconformably overlain by the Precipice Sandstone. Complete overlap occurs in the west limb of Reid's Dome where the Precipice Sandstone overlies the Clematis Sandstone.

There is a marked, though gradual, change in conditions of deposition from the Clematis Sandstone to the Moolayember Formation. Slow deposition of reworked quartz sandstone gave way to more rapid deposition of laminate siltstone and sandstone which contains a large percentage of potash feldspar. The formation was deposited in a shallow freshwater basin. Mudclasts in the base of the sandstone beds indicate periods of emergence and desiccation of the mud.

The thickness varies because of erosion beneath the Precipice Sandstone. Hill (1957) records the maximum thickness in the Springsure Sheet area as 1400 feet in Consuelo Creek. In the west part of the Sheet area the thickness, from water bore information, is at least 1000 feet.

Plant fossils collected during the present mapping are listed in Appendix 2. Additional forms previously recorded (Hill, 1957) include Cladophlebis australis, Dicroidium feistmantili, D. lancifolia, D. acuta, and ?Phoenicopsis. On palynological evidence the formation is Triassic, and not older than Middle Triassic (Evans, in Mines Administration Pty.Ltd., 1962b)

JURASSIC

Precipice Sandstone

The name Precipice Sandstone was first used by Whitehouse (1953) for the lowest sandstone member of the Bundamba Group, replacing 'Bundamba Sandstone' (Reeves, 1947). The type area is in the sandstone cliffs in Precipice Creek, a tributary of the Dawson River, in the Taroom Sheet area. Phillips (in Hill and Denmead, 1960) applied the name 'Morella Sandstone' to the cliff-forming sandstone in the area south and west of Reid's Dome. This sandstone can be traced laterally into the type area of the Precipice Sandstone, and the use of 'Morella Sandstone' is discontinued.

The Precipice Sandstone crops out in cliffs below basalt tablelands west of Reid's Dome, and forms a sandy plateau extending across the south-west of the Sheet area. Near the western boundary of the Sheet it forms a white escarpment about 400 feet high, whereas eastwards only the lower part of the Sandstone forms cliffs, the higher parts of the Sandstone forming several terraces and mesas on the plateau. The air-photo tone varies; where the sandstone is exposed the tone is dark due to dense growth of small trees and bushes; where the sandstone is covered by a deep residual sand, vegetation is sparser and the tone is lighter.

The Precipice Sandstone consists dominantly of medium to coarse-grained strongly cross-bedded quartz sandstone, with bands and lenses of pebble conglomerate; scattered cobbles are present. The pebbles and cobbles are mainly milky quartz, but some consist of lithic sediments. Some beds of fine-grained, thin-bedded, occasionally festoon-bedded micaceous quartz sandstone are present. The sandstone is very friable and porous; matrix is generally absent, but traces of kaolinite are present in some sandstone. Sand grains are pressure welded, with quartz overgrowths in some specimens.

The Precipice Sandstone unconformably overlies the Moolayember Formation and the Clematis Sandstone west of Reid's Dome. In the south-western part of the Sheet area it disconformably overlies the Moolayember Formation. In the type area the Precipice Sandstone is conformably overlain by the Evergreen Formation (Jensen, et al., 1964). In the Springsure Sheet area it is the youngest Mesozoic unit exposed; it is overlain by Tertiary basalt. The Sandstone has a low regional dip to the south and is folded into several small domes, south and south-west of the headwaters of Meteor Creek.

The Precipice Sandstone is probably a blanket fluviatile sand. Sand was probably spread and reworked by rapidly flowing streams in a gently downwarped basin. Cross-bedding measurements indicate a derivation dominantly from the west and north-west.

The Sandstone is estimated to be about 500 feet thick in the western part of the Sheet area and about 200 feet thick immediately west of Reid's Dome.

No macrofossils have been found in the Precipice Sandstone; recent work on spores (P.R. Evans, pers. comm.) strongly suggests the unit is Lower Jurassic.

TERTIARY

Basalt

A dissected sheet of Tertiary basalt and other less basic flows covers much of the eastern half of the Springsure Sheet area. Several small outliers of basalt occur in the south-west quadrant of the Sheet area. In the area immediately north, west and east of Springsure, pyroclastics and sediments (see Tertiary sediments) are interbedded with the flows. The best outcrops are found along the edges of the sheet.

The flows consist of olivine basalt and less basic rocks, probably with the compositions of trachybasalt and mugearite. Olivine basalt forms hard, platy jointed flows whereas, in general, less basic rocks form scoriaceous, massive flows. Richards (1918a) recorded the presence of a nosean-bearing phonolite near Springsure. The pyroclastics in the vicinity of Springsure consist of massive, extremely scoriaceous agglomeratic tuff, commonly reddish-purple and probably trachytic in composition, and well bedded, off-white, fine rhyolitic agglomerate and tuff. Mount Pinnacle is an outlier of massive trachytic agglomerate, possibly a vent agglomerate, Immediately north of Springsure, the lavas and pyroclastics are capped by a flow of the Minerva Hills Volcanics.

The flows were extruded through fissures which are now represented by dykes; swarms of basaltic dykes, commonly trending north-south, and sills are exposed near the head of Orion Creek and several were observed near the southern end of Reid's Dome, all intruding Permian sediments. The dykes intruding the Orion and Stanleigh Formations near the head of Orion Creek have baked shales to a dark splintery rock and contorted the bedding; baked zones are commonly less than a foot wide. Several dykes were observed intruding the Tertiary flows, particularly in the Sandy Creek-Meteor Creek area, west of the Springsure Anticline.

Flows were also probably extruded from vents or narrow cylindrical pipes; these are now represented by basalt plugs which remain as conical hills in areas where most of the flows have been denuded. Examples of the basalt plugs occur about three and a half miles south of Shadeville Homestead, three miles south-east of Mount Catherine, and half a mile south-east of Rewan Homestead. Several isolated conical hills, circular in plan, in the south-west quadrant of the Sheet area were identified as basalt in the air-photo (shown as Tb in Enclosure 1) and are probably plugs in old feeder vents. At the head of Meteor Creek a cone of basalt was identified in the air-photos and is certainly an old vent. The Steeple appears to be a vent with an acidic, rather than a basaltic, plug.

The pyroclastics, and probably some lavas, in the area immediately west, north, and east of Springsure were probably extruded from some centres and fissures now occupied by the Minerva Hills Volcanics. At least three beds of rhyolitic fine agglomerate and tuff were identified in the volcanic pile in this area and it is suggested that they represent intrusions of acidic lava of the Minerva Hills Volcanics type, shattered and pulverised by renewed basaltic lava effusion and by explosive activity.

The basaltic sheet probably originally covered much of the Sheet area, apart from the north-west quadrant. The lavas flowed on to an uneven terrain; the base of the basalt Sheet is about 700 feet above sea level east of the Springsure Anticline, whereas west of Springsure the exposed base of the sheet is at levels over 1000 feet, and at Mount Serocold, in Reid's Dome, it lies about 2500 feet above sea level.

Lava was erupted immediately west of the Springsure Anticline and Reid's Dome which formed a range; lava breached the barrier formed by the range and flowed to the lower areas eastwards along stream courses; this is evidenced in narrow east-west tongues of basalt, preserved in valleys in the Permian rocks across the Springsure Anticline.

Gentle dips can be identified in the surface of the basalt sheet in some areas. In the vicinity of Springsure the flows dip away from the Dilly Pinnacle-St. Peter-Red Hill triangle and, north of the Great Dividing Range they dip gently northwards. The dips are probably depositional, rather than the result of diastrophism.

The volcanic pile, measured between Springsure and the top of Mount Boorambool is 900 feet thick; a similar thickness is probably present in, and northoof, the Great Dividing Range. Elsewhere the sheet is much thinner.

The basalt lavas are at least post-Lower Jurassic because they overlie the Precipice Sandstone. Preliminary dating of basalt samples from the Springsure area by the Potassium-Argon method at the Department of Geophysics, A.N.U., indicates an Oligocene to Miocene age (A.W. Webb, pers. comm.).

Minerva Hills Volcanics

The Minerva Hills Volcanics were named by Veevers, Mollan, Olgers, and Kirkegaard (in press) after Minerva Hills Homestead in the Emerald Sheet area, about a mile north of St. Peter. The Volcanics occur in the Minerva Hills, a group of sharp, rocky peaks, ridges, and mesas which lie immediately west of the Emerald-Springsure road about the boundary between the Emerald and Springsure Sheet areas.

The Minerva Hills Volcanics consist of a suite of alkaline acidic rocks, ranging in composition from quartz trachyte to comendite, a soda-rich rhyolite. The Volcanics are preserved mainly in the form of dykes, plugs, and domes; one dissected flow is present. The shallow intrusions form rocky peaks and ridges, of which the most prominent are St. Peter, Red Hill, and Dilly Pinnacle; most of the other shallow intrusions occur within the triangle formed by these three peaks. The dissected flow, which is possibly a series of flows, forms a rocky plateau, immediately south of the shallow intrusions, and extending southwards to Mount Zamia near Springsure. Several small outliers of the flow occur immediately west of the plateau.

The dykes, which form rocky ridges, vary greatly in length and width; the dimensions of individual dykes are usually difficult to assess because of complex auto-intrusion. Several dykes, radiating from a central plug about a mile south of Red Hill, are over half a mile long and about ten feet wide. More commonly dykes are shorter and wider than this. Dykes commonly hade slightly from the vertical and trend dominantly north-westerly. Joint sets, normal to dyke margins, are common. Autobrecciation is a common peripheral feature; some dykes are completely sheared and brecciated. Along the line between Dilly Pinnacle and St. Peter there is a complex of multiple dyke auto-intrusion with local centres marked by plugs (Fig. 41). Rows of knife-like ridges attest the multiple intrusion history.

Plugs are commonly discrete rocky bodies, roughly circular in plan; several are associated with multiple dyke complexes and their form is less distinct. St. Peter is the largest plug, roughly elliptical in plan, and about half a mile long and nearly 1000 feet high. It has shear rocky flanks and a flat summit. Numerous sets of joints are well exposed in the flanks and in places produce crude columnar jointing. Spacing within sets of joints varies from several inches to about five feet; the widely spaced joints are the more persistent and generally normal to the flanks; several sets of joints with about one foot spacing are roughly parallel to the flanks. Peripheral autobreccia is commonly found near the exposed base of the plug. Other plugs are smaller than St. Peter, ranging down in size to about a hundred yards wide at a needle like plug a mile south-east of St. Peter. They show similar jointing and shearing features to St. Peter. Flow banding is common in some plugs; it is dominantly vertical and parallel to the flanks of plugs. The differentiation between plugs and domes is based on morphology; domes are broader in plan with gentler flanks than plugs. The differences in morphology are probably related to genetic differences; domes are emplaced as domal masses of lava over vents, with some lateral displacement of lava from the vent, whereas plugs represent exhumed vent plugs.

Red Hill is a dome with a marked depression in the centre. It is roughly circular in plan, and about half a mile across. The dome shows similar joint patterns and peripheral autobreccia to the plugs. The depression was probably caused by a retraction of the lava over the vent.

Several volcanic bodies immediately north of the plug forming Dilly Pinnacle, and in the area about two miles south-east of St. Peter cannot be classified definitely as plugs, domes, or dykes, because of their irregular form, which is probably related to recent erosion.

The flow or series of flows which form the plateau immediately south of the intrusions has an uneven rocky surface. Major joint patterns are visible in the air-photos. Hummocks, protruding from the surface are possibly domes or plugs. The flow rests on basaltic flows and forms a hard capping between 50 and 200 feet thick at the exposed edge.

In hand specimen the Minerva Hills Volcanics are light grey to off-white, fine-grained, commonly porphyritic rocks; flow-banding is a common feature. The rocks range in composition from quartz trachyte with less than 10% modal quartz to comendite, a soda-rich rhyolite. Mineralogically the rocks consist of porphyritic alkali feldspar (dominantly anorthoclase and some sanidine), quartz, and minor quantities of sodic pyroxene, sodic amphibole, and magnetite. Porphyritic green pitchstone is common in margins of intrusions. Much of the Volcanics has been hydrothermally altered. Detailed descriptions of rocks from the Volcanics in the Emerald Sheet area are given in Veevers, Mollan, Olgers, and Kirkegaard (in press).

Figure 41: Oblique aerial view of a rift with numerous dykes and plugs of quartz trachyte and rhyolite of the Minerva Hills Volcanics. St. Peter in centre background, looking north-west.
(Neg. No. G/6255)

Petrogenetically the Minerva Hills Volcanics are related to the Tertiary basaltic lavas, and pyroclastics. The Volcanics are separated from the basaltic lavas and pyroclastics because they are strongly acidic and their mode of occurrence is in distinct contrast to the basaltic lavas, and pyroclastics. By comparison with the Peak Range Volcanics in the Clermont Sheet area (Veevers, Randal, Mollan and Paten, in press) it seems certain that much comendite in the Minerva Hills Volcanics is peralkaline. The origin of peralkaline oversaturated magma from a basaltic parent is not clear; some processes of physical and chemical differentiation are involved. The theory of cupola formation above a parent magma chamber is supported by the localised distribution of the Minerva Hills Volcanics.

The Minerva Hills Volcanics were emplaced, probably sub-aerially, along fissures and vents. The intrusion of the acidic magma appears to have been directed from depth along north-west trending basement rifts (Fig. 41). Some plugs and domes are probably endogenous; the peralkaline oversaturated magma was highly viscous. The intrusions have updomed and diapirically pierced Lower Permian Orion and Stanleigh Formations and the Staircase Sandstone. No alteration of the intruded rocks was evident at contacts with the volcanics.

The Minerva Hills Volcanics have a complex petrogenetic and spatial relationship to the Tertiary basaltic lavas, and pyroclastics (see basalt).

The Volcanics have extruded through Permian rocks and their youthful morphology suggests they are much younger than Permian. Sanidine phenocrysts from a quartz trachyte intrusion at Crystal Hill in the Emerald Sheet area, were dated as Oligocene to Miocene by the Potassium-Argon method at the Department of Geophysics, A.N.U. (A.W. Webb, pers. comm.); the radioactive dating work on Tertiary volcanics is at a preliminary stage.

Sediments

Tertiary sediments form small outliers along the eastern margin of the Sheet area, and inliers in the north-east corner of the Sheet. Tertiary sediments form extensive sheets to the east and north-east in the Baralaba and Duaringa Sheet areas. Most of the outcrops in the Springsure Sheet area were identified in the air-photos. The outliers rest mainly on Tertiary basalt and the inliers are overlain by, and interbedded with Tertiary basalt. Several beds were found interbedded in Tertiary basalt mesas about five miles west of Springsure and about a mile west of Mount Zamia; the outcrops are too small to be shown in Enclosure 1.

The sediments consist of sandstone, pebbly conglomerate, and poorly exposed clays. The outcrop about five miles west of Springsure in cuttings along the Central Western Highway consists of soft massive light clay, possibly diatomaceous; at the contact with an overlying basalt flow or sill it is baked to a black brittle rock. About a mile west of Mount Zamia a fairly hard cross-bedded pebbly sandstone is interbedded with flows. In the areas of outcrop of Tertiary sediments in the north-east corner of the Sheet area the sediments have been deeply weathered and form unconsolidated gravel, sand, and clay. The sediments in this area are clearly overlain by, and interbedded with, Tertiary basalt; logs of water bores (Table 2) also show this relationship.

The sediments are essentially flat lying. The coarse sediments are probably fluviatile deposits. Clays were probably deposited in lakes which may have been formed by the damming of streams by lava flows.

The sediments vary in thickness; their total composite thickness is difficult to estimate because of interbedded lavas. They are regarded as Tertiary because of their association with Tertiary lavas (see basalt).

Laterite

Three mesas of laterite about 200 feet high are present in the north-west corner of the Sheet area. In profile the laterite has an upper red zone and a lower white zone with 'billy' boulders at the base. The laterite is probably developed in sediments of the Joe Joe Formation.

A small outcrop of Tertiary sediments, immediately east of the Rewan Syncline has a thin lateritic capping.

CAINOZOIC

Collapsed basalt sheets

Collapsed basalt sheets occur extensively in the area between Freitag Creek and Tanderra Homestead. The unit forms rugged, densely timbered foothills on the northern side of the tablelands of Tertiary basalt. The collapsed basalt sheets form prominent knife-edge ridges, and hummocky terrain. They form a distinct mottled dark tone in the air-photos; ridges form distinct trend lines.

The collapsed basalt sheets apparently occur only over the soft rocks of the Bandanna and Rewan Formations; basalt sheets have not collapsed where they overlie the Clematis Sandstone, Moolayember Formation, and Precipice Sandstone. The collapse of the basalt sheet is due either to the undermining of the soft units or to inadequate support. In small tributaries of Cona Creek, about a mile south of Goathland Homestead, brecciated basalt was observed at creek level in trenches in the Bandanna Formation, whereas, farther south, basalt lies on Clematis Sandstone, several hundred feet above the creeks.

Alluvium

Alluvium is not widespread in the Sheet area. It is confined mainly to narrow belts along most of the rivers and major creeks. Locally thick and wide belts of alluvium occur along the Nogoa River, and Vandyke, Freitag, Orion, Meteor, Consuelo, and Carnarvon Creeks.

Miscellaneous deposits

In Enclosure 1 various superficial deposits are grouped under the symbol Cz. Rounded pebble and cobble gravels with scattered boulders cover areas in the Nogoa and Telemon Anticlines. The fragments are strongly silicified. Much of the gravel is probably derived from conglomerate of the Joe Joe Formation. Cobble and boulder gravels, consisting of basalt and 'billy' (fine-grained siliceous rock), are thick in areas bordering the tablelands of Tertiary basalt. The gravels commonly occur as scree. Zones of fine grained siliceous rock were observed in several places at the top of the Clematis Sandstone and the Colinlea Sandstone where the units are in contact with basalt. 'Billy' boulders are probably derived from these siliceous cappings.

Residual sandy soil covers large areas of the Precipice and Colinlea Sandstones. Residual heavy-textured dark soil covers much Tertiary basalt, and much of the Bandanna, Rewan and Moolayember Formations. Thin soil cover is not mapped in Enclosure 1.

GRANITE INTRUSION

A very poorly exposed granite stock intrudes the Dunstable and Telemon Formations in the Telemon Anticline. It is roughly elliptical in plan with a north-south elongation; it is two and a half miles long and a mile wide. The stock forms gently undulating country with an even cover of timber. Deep weathering has produced a coarse sandy soil. The stock has a light tone in the air-photos, not readily distinguished from the Dunstable Formation but forming a sharp contrast to the dark tone of the Telemon Formation.

The few exposures of the stock indicate that it is a heterogeneous granite body, the mafic content, mainly biotite and hornblende, varying from place to place. Several basic xenoliths, deeply altered by the granite, could be distinguished; assimilation of basic xenoliths may explain why the granite is heterogeneous.

It is almost certain that the stock intrudes the Dunstable and Telemon Formations. Immediately west of the stock the Telemon Formation is extremely contorted and silicified; some quartz veins intrude the formation. No contacts with the granite were observed.

The granite is probably post-Upper Devonian; it is probably associated with the main folding phase of the Drummond Basin, which is of probable Middle Carboniferous age.

STRUCTURE

Folding

The Springsure Sheet area covers parts of the Drummond, Bowen, and Great Artesian Basins (see Introduction to Permian). It includes two tectonic units of the Bowen Basin, namely the Denison Trough in the east and the Springsure Shelf in the west(see Fig. 2a).

The rocks in the Drummond Basin have been folded into broad north to north-north-east trending anticlines, of which the Nogoa and Telemon Anticlines are the major features. The Dunstable Formation is exposed in the cores of the Nogoa and Telemon Anticlines and pre-Devonian metamorphics in the core of the Telemon Anticline.

The Nogoa Anticline plunges northwards; the southerly extent of the anticline is ill-defined because of overlapping Colinlea Sandstone, but outcrop of Dunstable Formation several miles north of Hillview Homestead confirms a southerly continuation of the fold. The west limb of the anticline is well-defined; a small flexure reduces dips down the limb (Enclosure 8). The east limb of the fold is poorly defined and complicated by a small south plunging anticline and intervening syncline which parallels the Nogoa axis. This small anticline is, in turn, complicated by a sharp synclinal flexure in the east limb.

The Telemon Anticline is an asymmetrical dome, elongated north-south, with a steeper west limb; the domal form is well expressed by ridges and cuestas of the Mount Hall Conglomerate and Raymond Sandstone. The Medway Anticline, closed in the Ducabrook Formation, is the only other anticline within the Springsure Sheet area in which rocks of the Drummond Basin are exposed. Between the anticlines are broad synclines, such as the asymmetrical Mistake Syncline between the Nogoa and Telemon Anticlines. The Joe Joe Formation has been gently folded on the fold axes of the Drummond Basin sequence.

Folds in the Denison Trough part of the Bowen Basin are dominated by a major north-trending anticline which extends the length of the Sheet area and continues north and south into the Emerald and Eddystone Sheet areas. Previous definitions of folds along this major axis are not clear, and a variety of names have been used for the folds by previous workers. The following nomenclature is preferred for the two major culminations within the Sheet area: Springsure Anticline for the very large northern culmination, which extends into the Emerald Sheet area and is obscured in the vicinity of Springsure; and Reid's Dome for the large culmination at the southern end of the axis. A small unnamed dome immediately east of Mount Inglis Homestead separates the two larger culminations.

The Orion Formation which crops out in the southern and northern plunges, is the lowest exposed unit in the Springsure Anticline. The eastern limb and the southern plunge are well expressed in the cuestas and ridges of the Aldebaran Sandstone. The structure is asymmetric, with a steeper west limb. The culmination, obscured by Tertiary basalt, is probably three to four miles east of Springsure; similarly much of the western limb is obscured for several miles north and south of Springsure. The fold is complicated and poorly defined about ten miles north of Springsure because of poor exposure and local doming about intrusions of the Minerva Hills Volcanics; mapping suggests the anticline is plunging northwards in this area. Phillips (1959) suggests that the anticline in this area is not a continuation of the Springsure Anticline but is a separate anticline; he locates the axis of the Springsure Anticline further to the east and continues it northwards to join up with the axis of the Fernlees Anticline in the Emerald Sheet area. Patterson (1956) on the other hand, apparently is of the opinion that the Springsure Anticline bifurcates into two anticlines northwards, one the Fernlees Anticline and the other the Springsure Anticline proper which is coincident with the Springsure Anticline as mapped during the present survey.

Patterson does not continue the axis of the Fernlees Anticline south into the Springsure Sheet area; further mapping in the area about the northern boundary of the Sheet area will probably confirm Patterson's interpretation of the structure.

Reid's Dome is an asymmetric elongate dome with a steeper west limb, well expressed by Aldebaran Sandstone cuestas. The Cattle Creek Formation is the lowest exposed unit in the Dome. The culmination is about one mile north of A.O.E. Reid's Dome No.2 bore, and is accurately located by outcrops of the _Eurydesma_ bed in the Cattle Creek Formation (see fossil localities SP 460, SP 720, SP 732, and SP 733 in Enclosures 1 and 9). A small domal flexure between the northerly plunge of Reid's Dome and the southerly plunge of the Springsure Anticline has the Aldebaran Sandstone as its lowest exposed unit and culminates about a mile east of Mount Inglis Homestead; the dome plunges more steeply southwards.

The Consuelo Anticline has an elongate asymmetric domal form with a steeper west limb. It is well expressed by the lowest exposed unit, the Aldebaran Sandstone; A.O.E. No.3 Consuelo bore was drilled close to the culmination. A slight reversal in the southerly plunge occurs immediately north of Peawaddy Creek.

The northern part of the Rewan Syncline lies between the Springsure and Consuelo Anticlines. A basin along the axis in this area is well expressed by a small outlier of Clematis Sandstone. Southwards the syncline broadens to form another much larger, fairly symmetrical structural basin, again well expressed by cliffs of Clematis Sandstone; the Moolayember Formation is preserved in the centre of this basin.

North of the Consuelo Anticline, where Permian and Triassic rocks are obscured by Tertiary basalt, several domes and anticlines have been detected by seismic methods (Enclosure 4). The largest of these is the anticline on which A.F.O. Inderi No.1 bore was sited. The folds have sinuous axes and, apparently, lower amplitudes than the exposed folds.

In the Springsure Shelf part of the Bowen Basin folding is extremely gentle. The Permian-Triassic rocks dip dominantly to the south-west in the Shelf; east of the Nogoa Anticline, the Colinlea Sandstone dips dominantly eastwards. Two anticlines are mapped, both being the southerly continuation of folds in the beds of the Drummond Basin. The Fairview Anticline in the west is a gentle, south plunging structure with a steeper east limb in which dips are up to ten degrees. The anticline is a continuation of the Medway Anticline. A broad south plunging anticline in the Colinlea Sandstone near Hillview Homestead is clearly an extension of the Nogoa Anticline. The Wealwandangie Syncline is a very broad, poorly defined south plunging structure, apparently complementary to the Springsure Anticline and to an anticline in Permian rocks to the west. The Colinlea Sandstone is infolded with the Ducabrook Formation in a southerly plunging syncline about five miles east of Nandowrie Needle. The Triassic rocks in the Springsure Shelf are extremely gently folded; some reflection of the Nogoa Anticline is seen in a southerly bowing of the Clematis Sandstone outcrop along the line of the axis.

The Precipice Sandstone of the Great Artesian Basin has a very shallow regional dip to the south. At the heads of Dooloogarah and Marlong Creeks in the southern part of the Sheet area there are several small anticlines, trending north-east and north-west. They are possibly the result of updoming by Tertiary intrusions which did not reach the surface; several volcanic vents and plugs are at the surface in this area and can be recognised in the air-photos.

Faulting

The identification of faults in the Sheet area is based mainly on air-photo interpretation; exposure of shear zones and fault planes is rare.

The rocks of the Drummond Basin are the most intensely faulted. In the Nogoa Anticline the Dunstable Formation is intensely faulted and commonly has a faulted contact with the Telemon Formation; faults are aligned north-east, north-west and north. They appear to be normal, or slightly overthrust longitudinal and transverse faults resulting from the folding. A fault along the north part of the axis probably has a large vertical displacement, down to the east, because along it the Ducabrook Formation appears to be in contact with the Telemon Formation. Transverse normal faulting in the west limb and axial part of the Telemon Anticline is common. The faults are short and throws are, at most, a few hundred feet; they are aligned dominantly west-north-west.

Faulting in the Consuelo Anticline and Reid's Dome appears to be slight. The extremely straight lineament formed by the scarp edge of the Clematis Sandstone in the west limb of the Rewan Syncline does not appear to be a fault; however a local steepening of dip along the scarp edge immediately north of Serocold Homestead probably indicates local faulting (see Enclosure 9).

In the Springsure Anticline several longitudinal faults have been identified, apparently with vertical displacements of several hundred feet. Immediately east of Dalmally Homestead two north-trending faults, probably slightly overthrust to the west, have cut out section at the surface in the west limb of the anticline. The northerly extensions of the faults are obscured by Tertiary basalt. In the east limb of the Springsure Anticline two strike faults in the Aldebaran Sandstone have produced local steep dips on their east side. The faults were probably caused by release of tension in the competent Sandstone during folding. The arcuate northern extension of the southern one of these two faults has a vertical displacement of several hundred feet down on the east, and probably considerable lateral displacement, bringing the Staircase Sandstone, Sirius Formation, and Aldebaran Sandstone in contact with the Stanleigh Formation. Small transverse faults are also present in this area. Near the head of Orion Creek and near Mount Catherine small faults are commonly associated with probable Tertiary basalt dykes (see Figs. 14, 15, 16 and 24).

North of Dilly Pinnacle, a fault, down to the west, cuts acutely across the nose of the Springsure Anticline and displaces the Orion and Stanleigh Formations. The fault which was originally named the Minerva Fault by Patterson (1956), apparently continues northwards into the Emerald Sheet. It possibly influences the apparent bifurcation of the Springsure Anticline in this area (see Folding).

Faults in obscured Permian rocks east of the Springsure Anticline were detected by seismic work (Enclosure 4).

Faulting in the Springsure Shelf appears to be slight. Strong lineaments formed by the scarp edges of the Colinlea Sandstone north and east of the Nogoa Anticline, notably between Glenlee and Vandyke Homesteads, are possibly the result of shallow block faults. Near the scarps the Colinlea Sandstone dips at up to ten degrees away from the scarps. This dip rapidly diminishes away from the scarps. The sheet of Colinlea Sandstone was possibly faulted by slight movements along old faults which had previously affected the Drummond Basin beds.

Strong north-west lineaments associated with intrusions of the Minerva Hills Volcanics are probably faults at depth (Fig. 41).

SKETCH OF GEOLOGICAL HISTORY

A downwarp in probable pre-Devonian metamorphosed sediments and plutonic rocks initiated the formation of the Drummond Basin, probably in early Devonian times; the inlier of metamorphics in the Telemon Anticline marks a ridge in the basin floor. Andesitic and basaltic lavas, erupted probably from centres probably east of the Nogoa Anticline, and accumulated in the basin, partly under water. Lavas plus sediments, deposited between eruptive phases constitute the Dunstable Formation. Deposition was probably interrupted by slight movements, particularly uplift of the Nogoa Anticline. Marine conditions prevailed for at least part of the time; the formation includes lenses of coralline limestone, deposited along the edges of a geanticlinal ridge now represented by the Nogoa Anticline. The end of deposition of the Dunstable Formation was marked by slight epeirogenic uplift producing local erosional unconformities at the base of the overlying Upper Devonian Telemon Formation. Volcanic activity during deposition of the Telemon Formation was limited to outbursts of tuff and ash which were distributed throughout the basin, and deposited in a shallow non-marine environment. Epeirogenic uplift at the end of the Upper Devonian was followed by the fluviatile deposition of the Lower Carboniferous Mount Hall Conglomerate and Raymond Sandstone in a more slowly subsiding basin. The rate of subsidence increased during the deposition of the Lower Carboniferous Ducabrook Formation under conditions similar to those during deposition of the Telemon Formation.

A period of folding followed the deposition of the Ducabrook Formation; the folding of the Telemon Anticline was probably partly controlled by a basement ridge; the Nogoa Anticline was already established and was merely emphasised during this diastrophism. Competent beds and formations, particularly volcanics in the Dunstable Formation, the Raymond Sandstone and the Mount Hall Conglomerate, fractured during the folding. Granite intrusion in the Telemon Anticline probably accompanied the folding phase. The glacigene Carboniferous-Permian Joe Joe Formation was deposited after the folding; its area of deposition was controlled to some degree by the topographic features formed by the folds in the Devonian-Carboniferous rocks. Slight growth of folds in the Devonian-Carboniferous continued during, and immediately after, deposition of the Joe Joe Formation.

The Denison Trough was probably initiated in late Carboniferous or early Permian times. Subsidence probably started close to the present western margin of the trough with faults separating the Springsure Shelf from the trough. The rapidly subsiding area received thick freshwater sediments in the Lower Permian (the 'lower shales and mudstones' of A.O.E. Reid's Dome No.1). This downwarp was bounded on the east by the Comet Platform (Derrington and Morgan, in Hill and Denmead, 1960) which did not receive the freshwater sediments (see log of A.F.O. Purbrook No.1 bore, Enclosure 11). The deposition of the 'lower shales and mudstones' was accompanied by volcanic activity, which produced the volcanics encountered in S.Q.D. Morella No.1 well (Enclosure 11). A slight diastrophism possibly followed the deposition of the 'lower shales and mudstones' and volcanics. Rapid subsidence of the trough continued during the deposition of the 'undivided freshwater beds' and the trough probably enlarged eastwards at this time. A slight epeirogenic subsidence of the Springsure Shelf probably occurred during the deposition of the 'undivided freshwater beds', with deposition of similar freshwater beds.

In Cattle Creek times the Denison Trough was more extensive, and open to the sea for the first time. The trough remained a distinct downwarp along the western margin of the Bowen Basin until the end of the Lower Permian when the trough was filled with sediment and uplift probably commenced, and the trough was no longer distinct. Deposition during the Lower Permian continued in alternating marine, fluviatile-deltaic, and restricted basin conditions; environmental changes were mainly the result of epeirogenic movements. Several short periods of local erosion are evident.

Deposition commenced in the Upper Permian in a broad marine basin covering the Springsure Shelf and the Denison Trough, and extending farther east than the trough. The Upper Permian transgression followed a period of uplift in the Denison Trough which was no longer a distinct downwarp. Volcanic activity commenced in the Upper Permian with outbursts of tuff. Erratic boulders whose origin is not clear were deposited at intervals during the Permian.

During the deposition of the Aldebaran Sandstone and Catherine Sandstone, fluviatile sand and conglomerate was being deposited in the Springsure Shelf forming the Colinlea Sandstone. Much slower subsidence of the shelf probably restricted the rate of deposition compared with the trough. A break in deposition occurred in the shelf while the Ingelara Formation was being deposited in the trough.

A major orogeny, probably in the late Triassic, folded the Permian-Triassic rocks of the Denison Trough. The western margin of the long Springsure Anticline-Reid's Dome fold probably marks the western hinge-line of the Denison Trough. The fold was probably formed by compression and uplift of the basement; a force from the east is indicated by the asymmetry of the fold, which has a steeper west limb, and faults thrust to the west. During the orogeny, gentle folding and faulting occurred in the Springsure Shelf; the folds and faults in the Devonian-Carboniferous rocks were rejuvenated. Movement along the Nogoa Anticline probably occurred also during deposition of Permian-Triassic rocks in the Springsure Shelf. The apparent absence of the Rewan Formation along the line of the Nogoa Anticline and the thinning of the Colinlea Sandstone across the axis support this contention.

Following the late Triassic orogeny the southern part of the Sheet area was gently downwarped, forming part of the Great Artesian Basin. In the early Jurassic, the fluviatile Precipice Sandstone was deposited in the Great Artesian basin.

In the Tertiary, intense volcanic activity was possibly associated with renewed movement along the hinge-line of the Denison Trough. During intermittent quiescent periods sediments were deposited in lakes.

ECONOMIC GEOLOGY

Oil Prospects

An outline of geological work, geophysical surveys and exploratory drilling for oil and gas is outlined in "Previous Investigations". Significant quantities of petroliferous gas, were discovered in some of the A.F.O. Rolleston wells, A.F.O. Inderi No. 1 well and Planet Warrinilla No.1 well, and several oil shows and fluorescence were noted in other exploratory wells in the Springsure Sheet area and adjacent areas to the east and south. These results give promise of finding commercial quantities of gas, and possibly oil, in the Sheet area, particularly in the Bowen Basin sequence.

The beds of the Drummond Basin have not been tested for oil in the Springsure Sheet area. Porous beds occur in the Raymond Sandstone and Mount Hall Conglomerate; unfortunately the Raymond Sandstone appears to be mostly a well compacted sandstone; porosity could be expected to vary. The Mount Hall Conglomerate similarly has little pore space despite low matrix content (see Appendix I in Veevers, Mollan, Olgers, and Kirkegaard, 1962). Both these units, and particularly the Mount Hall Conglomerate, are extremely lenticular and probably contain potential stratigraphic traps. Conglomerate in the base of the Telemon Formation, and interbedded with volcanics in the Dunstable Formation is possibly porous but the porosity has not been investigated. Conglomerate in the Dunstable Formation wedges-out and probably forms potential oil traps. Marine deposition is indicated by lenses of coralline limestone in the Dunstable Formation. Dark shale beds in the Devonian to Carboniferous sequence are potential oil source beds. The Nogoa and Telemon Anticlines are not good structural traps; the Telemon Anticline is intruded by granite and both anticlines are deeply faulted. Southwards, better culminations are probably present on the extension of the Nogoa axis beneath Permian rocks. The Ducabrook Formation is the oldest exposed unit in the Medway Anticline and forms an effective cap over the structure; the culmination lies in the Emerald Sheet area.

The Catherine and Aldebaran Sandstones, and a lithic sand near the top of the Peawaddy Formation have yielded significant amounts of gas in the wells mentioned above. It is not known what controls porosity changes in these sands. The lenticularity of the Catherine and Aldebaran Sandstones suggests the possibility of stratigraphic traps. The Staircase Sandstone has gas and oil potential for similar reasons.

Possible source beds in the Permian sequence are the Cattle Creek, Stanleigh, Sirius, Ingelara and Peawaddy Formations, and the lower part of the Bandanna Formation; dark shale is also contained in the freshwater beds of the 'lower shales and mudstones', the Orion Formation, and upper part of the Bandanna Formation. The upper part of the Bandanna Formation contains oil shale associated with coal seams in the Eddystone Sheet area, a few miles south of Ingelara Homestead. The oil shale has yielded 30 gallons of crude oil per ton (Hill, 1957).

The most prominent structural traps in the Springsure Sheet area have been tested. The Springsure Anticline is not a promising structural trap because it is breached down to the Orion Formation; the culmination is obscured by Tertiary basalt. It is also faulted and intruded by Tertiary dykes and plugs; the Permian rocks are only slightly altered, within narrow zones adjacent to the Tertiary intrusions.

A dome between Reid's Dome and the Springsure Anticline, with the Aldebaran Sandstone exposed in the core, has a small closure; the dome has not been drilled. Seismic surveys outlined several anticlines, east of the Springsure Anticline (Enclosure 4). One anticline was drilled (A.F.O. Inderi No.1 well) and produced 800,000 cu.ft. of gas per day.

In the Springsure Shelf the Lower Permian Colinlea Sandstone and the Triassic Clematis Sandstone are porous. It is possible that oil has migrated from the Denison Trough into these sands. However, structural traps in the form of closed anticlines are not present at the surface; the gentle folds open northwards and plunge south with the regional dip. Reversals of the regional dip may be present southwards under the Precipice Sandstone and could have trapped oil migrating up-dip; the Moolayember Formation would act as a suitable impervious cap to any oil in the Clematis Sandstone, and similarly the Bandanna and Peawaddy Formations would entrap oil in the Colinlea Sandstone. The Colinlea Sandstone thins across the Nogoa axis; southwards, thinning over the axis may have produced wedge-out traps.

The Precipice Sandstone is the reservoir for the oil at the Moonie oilfield in the Surat Basin and is the target of much exploratory drilling in the Roma area at present. In the Springsure Sheet area it appears to be porous but no porosity determinations have been made. It dips regionally southwards and is folded into small anticlines near the head of Marlong Creek; the Sandstone is not capped, except partly by Tertiary basalt, and cannot be considered as a potential reservoir within the Sheet area. The Springsure Shelf area is an intake area for the aquifers of the Colinlea, Clematis, and Precipice Sandstones; water flowing southward down-dip along the porous zones may create favorable hydrodynamic conditions for oil entrapment and obviate the need for northern structural closures.

Water

Table 2 sets out water bore information obtained during the field season from landholders in the Sheet area. The water from the bores is used mainly for stock. The best aquifers are the Colinlea, Clematis, and Precipice Sandstones in the western half of the Sheet area. In the east of the Sheet area most water is obtained from Tertiary basalt; water for Springsure is derived from the basalt. Several bores have struck good water supplies in Permian Sandstone, particularly the Aldebaran Sandstone. Good water is locally obtained from bores in alluvium. Several landholders in the north-west quadrant of the Sheet area are deriving good water supplies from Devonian-Carboniferous rocks of the Drummond Basin. Details of these bores were not obtained.

The Nogoa River and Meteor, Peawaddy, Consuelo, Rocky, and Carnarvon Creeks flow perennially. Vandyke and Cona Creeks flow throughout most years but cease flowing during prolonged dry spells; the water in the two creeks is hard. Most of the creeks are fed from Springs at the base of the Tertiary basalt sheet; the water in Meteor, Peawaddy, Consuelo, Rocky, and Carnarvon Creeks is particularly soft and clear. Creeks south of the Great Dividing Range, are dry for long periods. Waterholes in most of the large creeks in the Sheet area rarely dry up.

Coal

No coal has been mined in the Springsure Sheet area. Coal seams occur in the 'undivided freshwater beds' (A.O.E. No.1 (Reid's Dome), Enclosure 11), the Aldebaran Sandstone (Reid, 1930), and the upper part of the Bandanna Formation (Fig. 39). Several outcrops of coal were found in the Bandanna Formation during the present survey (see Enclosure 1); seams range from a few inches to about three feet thick. Several water bores, and stratigraphic hole B.M.R. No.6 have penetrated coal in the Bandanna Formation. Reid (1930) reports that several coal seams were penetrated by water bores in the Aldebaran Sandstone;

TABLE 2.

SELECTED WATER BORES, SPRINGSURE SHEET AREA.
(Position of bores shown in Enclosure I)

Name	Date	Depth (feet)	Water Struck (feet)	Water level (feet)	Supply (g.p.h.)	Strata
Albinia Downs Homestead	Drilling commenced March 1954.	149	72 - 73 480 g.p.h. 84 - 100 100 - 149 1200 g.p.h.		approx.1500 ; operating	0 - 16 soil 16 - 30 broken rock clay 30 - 35 honey comb 35 - 42 broken honey-comb 42 - 50 patches hard rock 50 - 72 hard blue rock 72 - 82 clay 82 - 84 blue rock 84 -100 blue honey-comb 100 -149 hard grey metal to clay bottom.
Aldebaran	Drilling commenced June 1943	122	at 65 soak at 95 300 g.p.h. at 108 good supply	60 below	450 measured	0 - 3 black soil 3 - 20 rotten rock 20 -105 blue rock 105 -120 honey-comb rock (blue) 120 -122 blue rock
Bonnyboys		103		63 below surface	1000 estimated; operating	
Boomerang	drilling commenced April 1950 : completed 1950	80	40 - 45 some 67 - 73 some 78 - 80 - 960 g.p.h.	65 below surface	960 measured; operating	0 - 40 brown sandy loam 40 - 45 slush and water 45 - 67 brown sandy clay 67 - 73 slush and water 73 - 78 yellow clay 78 - 80 coarse sand and water.
Bottle Tree Plain	Drilling commenced May 1961 : and finished 1961	400	70 - 98 soak 121- 123 soak 180- 188 - 340 g.p.h.		340 measured; operating	0 - 6 black soil 6 - 7½ broken grey rock 7½- 70 clay and gravel varying colours. 70 - 98 dark puggy clay w.shale patches 98 -121 grey clay 121 -123 hard grey rock, sedimentary 123 -128 white slippery rock 128 -170 dark grey clay and shale 170 -180 dark brown clay and shale patches 180 -188 hard grey sed.rock. 188 -198 clay and shale 198 -400 clay,shale and slippery back
Bullock Paddock		104		48 below surface	1200 estimated; operating	
Coynes			81 - 87 soak 97 -113 some 218 -226 - 480 g.p.h.		480 measured; operating	0 - 37 clay (soak) 37 - 50 boulders & clay 50 -57½ sandy clay 57½-63 sandstone 63 -81 clay 81 - 87 sandstone 87 - 93 clay 93 - 97 sandstone 97-105 clay 105 -113 sandstone 113 -210 clay 210 -215 slippery back 215 -226 pervious white rock 226 -242 clay
Dalmally No.1	Drilling commenced Oct.'49.	100	86 - 100			0 - 4 black soil 4 -16 red brown clay 16 - 61 broken blue rock 61 - 64 hard blue rock 64 - 86 hard grey metal 86 -100 blue honey-comb.
Four Mile Yards		193			1000 operating	
Freitag No.2	Drilling commenced Feb.1962	200	92 - 122 some 167 - 179 some 185 - 191- 540 g.p.h.		540 approx.	0 - 25 basaltic alluvium 25 - 76 dark clay 76 - 79 red sandstone 79 - 84 white sandstone 84 - 92 yellow sandstone 92-122 white sandstone 122 -146 yellow sandstone 146 -167 white sandstone 167 -179 yellow sandstone 179 -185 white sandstone 185 -191 yellow sandstone 191 -195 white sandstone 195 -200 yellow sandstone

Name	Date	Depth (feet)	Water Struck (feet)	Water level (feet)	Supply (g.p.h.)	Strata
Gibbs No.2	drilling commenced 1933; ceased 1933	295	at 150 - 250 g.p.h.		250 estimated	0 - 188 yellow sst.& clay; 188 - 194 hard grey sandstone; 194 - 220 rotten sst. and sandy blue clay; 220 - 230 coal; 230 - 236 largely white sandy clay; 236 - 244 silty sandstone and blue sandy clay; 244 - 295 blue sandy clay
Heifer Paddock No.2		200			1000; operating	
Ingelara Homest.		50		48 below surface	500	
Kurrajong		95	at 58 - 600 g.p.h.		600 measured	0 - 80 alluvium; at 80' sand and gravel, 80 - 95 sandy shale.
Lower Canopus	drilling comm. 1943.	105	100 - 105 1000 g.p.h.		1000 ;operating	
Lower Springs		107	90 - 107 1000 g.p.h.		1000	approx.0 - 90 alluvium; 90 - 107 basalt.
MacQueens	drilling commenced April 1963	125	115 - 118		450 estimated	0 - 49 hard clay and weathered basalt. 49 - 93 basalt; 93 -100 clay and soapstone; 100 - 115 basalt; 115 - 118 water seam; 118 - 125 basalt
Mantuan Downs Bores:						
No.1 House (Reg.No.9783)	commenced 27/6/36 completed 12/7/36	251		12	900	
No.2 Avenue (Reg.No.9784)	1934	330		285	900	0 - 230 soil,sand,blue shale; 230 - 236 sandstone; 236 - 310 blue shale; 310 -313 sandstone; 313 - 330 blue shale; 330 - 380 sandsrone
No.3 Double Tank (Reg.No.9785)	commenced 17/4/34 completed 22/9/34	428	308 - 313	298	660 abandoned	0 - 32 red, brown, grey sandy clay; 32 - 186 dark, buff and grey shale; 186 - 188 hard patch of rock.; 188 - 222 pipe clay and soft sand rock; 222 - 308 shale, small coal seam at 300'; 308 - 313 sandstone, small water supply; 313 - 380 shale; 380 - 418 sandstones of various kinds. 418 - 428 sandstone, water.
No.4 (Reg.No.9786)	commenced 24/9/34 completed 24/10/34	290			700	
No.5 Bay of Biscay (Reg.No.9787)	commenced 1/10/34 completed 1/11/34	366			900	
No.6 (Reg.No.9788)	commenced 15/10/34 completed 3/11/34	254		40	800	
No.7 Engine Well (Reg.No.9789)	comm. 5/11/34 completed 29/11/34 deepened 243- 500' on 24/5/39	500				
No.8 Maori Gully (Reg.No.9790)		243		90	960	0 - 110 seams of stone; 110- 180 black pug and sandstone; 180 - 203 sandstone; 203 - 243 sandstone - 5 ft. pipe clay.
No.9 Johnny's (Reg.No.8496)	commenced Aug.1935 completed Jan.1936	831		148	1200 at 800 ft.	

Name	Date	Depth (feet)	Water Struck (feet)	Water Level (feet)	Supply (g.p.h.)	Strata
Mantuan Downs Bores (Cont.)						
No.10 Letter Box (Reg.No.8497)	commenced 5/2/35 completed 8/10/35	930		190	600	0 - 280 sandstone & rock 280 - 290 crumbly black shale 290 - 304 sandy shale, patches of sandstone 304 - 410 bad seams, white rock patches of grey shale 410 - 415 pipe clay 415 - 790 grey shale 790 - 860 sandy pipe clay 860 - 930 fine sandstone
No.12 Hobblers (Reg.No.3498)	commenced 25/3/38 completed 4/8/38	550		60	960	0 - 45 hard clay and rock 45 - 66 grey and white crumbling shale 66 - 102 blue sandstone, hard blue rock. 102 - 262 layers hard green rock; brown shale & sst. 262 - 284 white sandstone 284 - 480 shale of various colours, caves badly. 480 - 550 not logged, bad cavings.
No.14, Box Creek (Reg.No.8499)	completed 10/2/39	335		artesian	3800 (g.p.day)	
No.15 Bletsoe	completed 1939	596	306,553	266	900	0-26 yellow sandy clay 26-42 yellow clay 42-98 blue shale 98-192 grey sh.& slate 192-200 grey & blue shale and slate 200-216 grey sandstone 216-227 brown shale 227-233 br.shale & sst. 233-239 sandstone 239-245 blue shale & sst. 245-256 sandstone 256-263 sst.& blue shale 263-298 grey sandstone 298-318 green sandstone 318-333 green sandstone 333-337 brown & grey sst. 337-340 clay 340-341 black shale 341-354 grey shale 354-360 brown shale 360-381 grey shale 381-388 blue clay 388-405 sandstone 405-424 red & grey rock 424-441 grey sandstone 441-447 grey slate 447-463 sandstone 463-480 red and grey rock 480-482 pug 482-501 sandstone 501 502 black shale 502-537 sandstone 537-542 chocolate shale 542-574 sandstone water at 553 ft.pebbles. 574-583 grey clay (driller's log and total depth differ.)
No.16. Spring Tank (Reg.No.9793)	commenced 14/6/39 completed 16/8/39	400		192	unlimited supply	
New Five Mile	Drilling commenced March '58.	180	103 - 109 146 - 161		1000 estimated	0-30 clay 30 -52 shale 52 -62 clay ' slipperyback 62 -71 white sandstone 71 -74 clay 74 -80 white sandstone 80 - 94 clay 94 -103 white sandstone 103-109 coal 109-140 white sandstone 140-146 clay 146-161 coal 161-180 puggy brown clay
New Slip		187	95 - 136 some	68	480 measured	0-5 soil, 5- 15 broken rock 15 -33 clay 33 -50 soft rock 50 -81 hard rock 81 - 90 soft rock 90 - 95 hard rock 95 -136 hard rock 136 -187 shale. (grey)
No.1 (Rat Hill)	Drilling commenced June 1933	270	at 115 soak at 150 some at 200 some		nil	
One Mile	Drilling commenced 1944	123			1000 estimated	approx.0 - 40 alluvium. 40 - 123 basalt.
Orion Park Homestead		98	75 - 76 fair 85 - 87 good 95 - 98 probable		800	0 - 5 black soil 5 - 10 eroded basalt 10 - 36 sandy clay and soft sandstone 36 -43 yellow clay 43 - 47 eroded basalt 47- 75 hard basalt 75 - 76 hard honey comb 76 - 85 hard basalt 85 - 87 honey comb 87 - 95 hard basalt 95 - 98 soapstone

Table 7. [illegible]

Name	Date	Depth (feet)	Water Struck (feet)	Water level (feet)	Supply (g.p.h.)	Strata	
Paten's	. Drilling comm. Feb. 1933 Completed 1935	300	at 120 some at 165 - 350 (1935)		nil now 350 in 1935	0 - 36 basalt (in well) 36 - 90 yellow clay 90 -108 sandstone 108 -120 clay 120 -129 sandstone 129 -133 coal 133 -150 blue clay 150 -152 coal 231 total depth in 1933;	152- 166 blue clay 166- 205 sandstone 205- 225 coal 225- 231 clay 231- 244 clay 244 -255 coal 255 -265 clay 265 -300 sandstone extended in 1938
Rocky	) Drilling commenced 1951 and finished 1951	95	at 40 soak 91-95 main supply		720 measured at 70' operating	0 -40 brown sandy clay 40 -70 silt 70 -86 brown sandy clay	86 - 91 black mud 91 - 95 coarse mud
Sandy Creek		400 (deepened from 96)				0 -12 loam 12 -30 clay 30 -32 gravel 32 -78½ slippery back clay 78½-80¼ shells in hard rock	80¼ -88½ dark clay 88½ -93 shells in hard rock 93 - 96 clay 96 - about 250' clay 250 - about 400' shales
Shed		90			1000 estimated	0 - 90 basalt?	
Shelley's		183			450 originally nil now	0 - 5 soil 5 -21 solid 21 -71 soft 71 -130 hard	130 -141 water bearing 141 -152 slippery back with hard brown pebble band just below 152 -183 red clay
Stoney No.2	Drilling commenced Feb. 1947, completed 1947	182	at 127 small 144 -146 500 g.p.h.		500 estimated	0 - 45 soil 45 - 52 gravel and sand 52 - 91 clay	91 - 95 yellow sandstone 95 -144 green clay 144 -146 medium green sand 146 -182 green clay
Top eight mile	Drilling comm.Nov. 1926	244	at 86 soak, at 98 increase 180-229 good supply 220-244 better supply	38	520 measured; operating	0 -28 earth 28 -38 brown rock 38 -64 brown clay 64-106 slate,shale. 106-108 white clay	108- 114 hard rock 114- 130 shale 130 -180 shale 180 -220 hard rock 220 -224 hard and soft rocks.
Wash Pool	3 Drilling comm. 1951 finished 1951	210	59 - 60 soak 81 - 85 main water	60	400 estimated	0- 50 sandy clay 50 - 60 small boulders 60 - 63 sandy clay 63 - 65 black mud	65 - 80 soapstone 80 - 81 blue shale 81 - 85 soapstone 85 -210 black shale
Wealwandangie Home Site		96½				0 - 23 sandy loam 23 - 80 dark grey clay 80 -84¾ blue shale	84¾ -89¼ grey clay 89¼ -94-2/3 grey shale 94-2/3 - 96½ light grey shale

outcrops of two seams, four inches thick, occur in the Sandstone in Rocky Creek. Coal seams in the upper part of the Bandanna Formation are commonly shallow dipping and near the surface and are the only seams with possible commercial value.

Other Minerals

Opal: Saint-Smith (1922) records opal occurrences in amygdaloidal basalt and rhyolitic tuff, $\frac{3}{4}$ mile west-south-west of Springsure, and in amygdaloidal basalt 8 miles south of Springsure. Precious opal has been reported, but is apparently rare. Several fragments of poor quality precious opal were found in a rhyolitic tuff bed during the present survey, about a mile north-west of Springsure.

Alunogen: Encrustations of alunogen (aluminium sulphate), about $\frac{1}{3}$ inch thick, and up to several inches thick in places, occur on vertical faces of small buttes of Colinlea Sandstone in an area about three miles south-east of Vandyke Homestead. The occurrences of the mineral are fully described by Richards (1918b). Small amounts have been used commercially, but it does not appear to be a deposit large enough for profitable mining.

Phosphate: Sandstone in the Cattle Creek Formation contains accessory amounts of apatite (Fehr, 1962). An analysis of a sandstone specimen yielded 12% P_2O_5. Concretions with fish scales in the Ducabrook Formation and coquinitic lenses of the Mantuan *Productus* bed and the '*Eurydesma* limestone' (Cattle Creek and Stanleigh Formations) are possible uninvestigated sources of phosphate.

Clay: One sample of greasy clay from the lower part of the Bandanna Formation has been shown to be pure clay of the montmorillonite type. Numerous green, yellow, grey, and red, soft, greasy clay beds are present; individual beds are generally less than two feet thick.

STRATIGRAPHIC DRILLING

Fifteen shallow holes were drilled for stratigraphic information in the Springsure Sheet area from October 3rd to October 8th, 1963. The cores and cuttings obtained from the drilling have not yet been studied in thin section, but detailed logging of the cores and cuttings provided useful lithological information. Several bores in the western half of the Sheet, and B.M.R. No.12 in the eastern half helped to elucidate some mapping problems. Several samples of cuttings yielded spores which provided useful correlative data (Evans, 1964). Details of the drilling are recorded in Malone (1963). The cores and cuttings are stored in the core and cuttings laboratory of the Bureau of Mineral Resources, Canberra.

Detailed lithological logs of the holes are listed below (the positions of the bores are shown in Enclosure 1):

B.M.R. No.1

Location — 5 miles north-west of Tanderra Hs. Pt. 778 Photo 5114, Run 1, Springsure 1:85,000 photos.

Stratigraphic Description — Lower part of Peawaddy Formation.

Log (feet)

0 - 5	Soil.
5 - 40	No cuttings. Weathered fine-medium grained feldspathic-lithic-quartz sandstone with some carbonaceous grey siltstone interbeds.
40 - 45	Fine-grained, buff, friable sandstone. Most grains are of quartz, some feldspar and lithic grains, also mica flakes. Grains are .15 mm., ranging to .3 mm., and angular to subangular; coal grains are present. Bands and lenses of gypsum.
45 - 50	Sandstone as above, fresher, light grey colour.
50 - 55	Fine-grained, grey gypsiferous, carbonaceous sandstone. Finer than above, and has more feldspar grains and coal fragments.
55 - 60	Grey fine-grained carbonaceous micaceous feldspathic-lithic-quartz sandstone, with some bands of sandy siltstone.
60 - 67	Grey fine-grained micaceous feldspathic-lithic-quartz sandstone with coal fragments up to .5 mm.
67 - 73	Very fine-grained grey carbonaceous micaceous feldspathic-lithic-quartz sandstone with thin beds and laminae of darker grey carbonaceous sandy siltstone.
73 - 80	Fine-grained grey carbonaceous micaceous feldspathic-lithic-quartz sandstone; some green grains- ?glauconite. Coal fragments and carbonaceous laminae.
80 - 87	Fine-grained sandstone, light and dark bands darker bands finer and more carbonaceous; some dark grey carbonaceous sandy siltstone.
87 - 93	Fine-grained, light-grey, carbonaceous, micaceous feldspathic-lithic-quartz sandstone.
93 -100	Very fine-grained sandstone, tending to sandy siltstone, some dark grey carbonaceous siltstone.

100 - 110 Cored. Recovered 8 ft. Dark grey mudstone, micaceous, carbonaceous, poorly sorted, with scattered sand grains and irregular laminae of light green-grey fine sandstone to sandy mudstone. Some plant detritus.

110 - 120 Dark grey micaceous silty shale and shale, some laminae of fine-grained sandstone.

120 - 130 Light grey carbonaceous sandy siltstone, darker grey silty shale.

130 - 140 Dark grey carbonaceous micaceous siltstone and silty shale.

Water flow 140'. Slight, probably less than 100 galls. per hour.

B.M.R. No.2

Location 4 miles south of Mantuan Downs Hs.
Pt. 779, Photo 5054, Run 4, Springsure North
1:85,000 photos.

Stratigraphic Description Spudded in Rewan Formation, and entered Bandanna Formation in first 40 feet.

Log (feet)

0 - 5 Soil.

5 -20 No cuttings. Weathered thinly bedded and colour banded siltstone, yellow, brown, red, grey and green, and friable yellow lithic sandstone.

20 -30 Very weathered material, buff siltstone and shale, some fine-grained sandstone.

30 -40 Weathered brown shale, including clay shale, some carbonaceous material; fresher material is grey.

40 -50 Carbonaceous dark grey shale and lighter grey silty shale. Thin coal seams.

50 -60 Mainly dark grey shale, light grey siltstone, some laminae of fine-grained sandstone in the shale.

60 -70 Light-grey sandstone, grains .3 mm., subangular to subrounded; quartz grains commonest, numerous feldspar and lithic grains.

70 -80 Sandstone as above, some silty shale and shale; dark brown waxy carbonaceous material.

80 -90 Fine-grained, micaceous, lithic-feldspathic-quartz sandstone; some dark brown waxy material.

90 -100 Dark grey carbonaceous siltstone, some black carbonaceous shale and silty shale; some fine-grained sandstone.

100 -110 Fine-grained micaceous lithic-quartz sandstone some sandy siltstone, rare black shale.

110 - 120 Mainly dark grey carbonaceous silty shale, some siltstone.

120 - 130 Dark grey carbonaceous shale and silty shale, some laminae of fine-grained sandstone.

130 - 140 Black shale.

140 - 147 Black shale.

147 - 155 Black shale, some lighter-coloured clay.

155 - 162 Black clay shale, pyritic silty shale, some fine-grained sandstone.

162 - 170 Black shale, some lighter-coloured clay.

170 - 180 Cored. Recovered 7'6".

170 - 176 Dark grey and black micaceous, carbonaceous sandy mudstone with laminae of light-grey micaceous, ?pyritic sandy siltstone. Hard in places. Some bands of dark green sandy claystone.

176-176'6" Cherty vitric tuff with ?shards.

176'6"-177'6" Dark green sandy claystone with carbonaceous mudstone laminae.

B.M.R. No.3

Location 12 miles west of Mantuan Downs Hs.
Pt.780, Photo 5052, Run 4, Springsure North
1:85,000 photos.

Stratigraphic Description 0'- 90' Clematis Sandstone; 90' -205' Rewan Formation.

Log (feet)

0 - 10 Sandy soil.

10 - 20 No cuttings. Weathered fine-grained quartz sandstone.

20 - 30 Brown, weathered fine-grained micaceous quartz sandstone.

30 - 40 Brown, fine-grained micaceous quartz sandstone and silty sandstone; laminae of carbonaceous siltstone.

40 - 50 Fresher, buff, fine-grained micaceous (biotite) quartz sandstone; grains .2 mm., sub-rounded to sub-angular.

50 - 60 Light-coloured fine-grained micaceous (muscovite and biotite) quartz sandstone.

60 - 70 Dark grey micaceous siltstone and silty shale.

70 - 80 Fine to coarse grained white micaceous quartz sandstone; some pink sandy siltstone.

80 - 90 Medium to coarse-grained white pebbly quartz sandstone.

90 - 100 Green fine-grained silty micaceous feldspathic-lithic-quartz sandstone; some reddish brown mudstone.

100 - 110 Green fine-grained micaceous (biotite) feldspathic-lithic-quartz sandstone; some tough purple and red ferruginous sandstone; dark greenish-grey siltstone and silty mudstone.

110 - 120 Green fine-grained micaceous feldspathic-lithic-quartz sandstone; some medium-grained sandstone; some dark reddish-brown mudstone, tending to claystone.

120 - 130 Green fine-grained lithic-quartz sandstone; dark reddish-brown mudstone.

130 - 140 Mainly dark reddish-brown mudstone; some fine-grained green lithic-quartz sandstone.

140 - 150 Dark reddish-brown mudstone, light-green siltstone, some fine-grained green silty lithic-quartz sandstone.

150 - 160 Light green siltstone, some mottled red and green mudstone.

160 - 167 Light green micaceous fine-grained feldspathic-lithic-quartz sandstone.

167 - 175 Sandstone as above; greenish-grey claystone, some tending to mudstone; reddish-brown mudstone and claystone.

175 - 182 Light greenish-grey micaceous siltstone; minor reddish-brown mudstone.

182 - 190 Greenish-grey micaceous siltstone, dark reddish-brown claystone.

190 - 197 Dark reddish-brown mudstone some with light-green mottling.

197 - 205 Grey-green siltstone and mudstone.

B.M.R. No.4

Location: 16 miles west of Mantuan Downs Hs. Pt. 781, Photo 5052, Run 4, Springsure North 1:85,000 photos.

Stratigraphic Description: Basal part of Moolayember Formation. Probably bottomed in transition from Moolayember Formation to Clematis Sandstone.

Log (feet)

0 - 4 Soil.

4 - 20 Weathered brown lithic sandstone and siltstone with very hard calcareous lithic sandstone bands or nodules.

20 - 22 Tough light-grey calcareous lithic-quartz sandstone.

22 - 30	Weathered brown friable fine-grained micaceous (biotite) feldspathic-quartz-sandstone; grains .2 - .3 mm. subangular to subrounded.
30 - 40	Weathered brown micaceous siltstone, grains of quartz and feldspar.
40 - 50	Fresher micaceous carbonaceous siltstone; some shale and silty shale.
50 - 60	Grey micaceous, carbonaceous siltstone and sandy siltstone tending to a fine grained sandstone pyritic in part.
60 - 70	Grey shale and clay shale with fragments of carbonised plants; brown friable carbonaceous fine-grained lithic-feldspathic-quartz sandstone.
70 - 72	Tough, light-grey calcareous, micaceous lithic-feldspathic-quartz sandstone.
72 - 80	Light grey carbonaceous micaceous siltstone.
80 - 90	Fine-grained light-grey micaceous quartz sandstone, some feldspar and lithic grains; grey carbonaceous siltstone and shale.
90 -100	Grey shale and siltstone.
100 -110	Light-grey fine-grained carbonaceous, micaceous, lithic-feldspathic-quartz sandstone; some dark shale.
110 -120	Light-grey micaceous, carbonaceous siltstone tending to fine-grained lithic-quartz-sandstone; some black shale.
120 -130	Grey carbonaceous shale and silty shale; some light-grey siltstone tending to a fine-grained sandstone with carbonaceous bands.
130 -140	Interlaminate fine-grained silty sandstone and carbonaceous siltstone.
140 -150	Black carbonaceous shale; thinly interbedded to interlaminate fine-grained sandstone and carbonaceous siltstone.
150 -160	Dark grey shale and silty shale; some fine-grained light-coloured micaceous sandstone.
160 -167	Light grey siltstone with plant fragments.
167 -175	Interlaminate light coloured fine-grained sandstone and grey carbonaceous siltstone; fine grained micaceous sandstone.
175 -182	Grey shale with carbonised plant fragments, grey siltstone.
182 -190	Interlaminate fine-grained light-coloured sandstone and grey carbonaceous siltstone.
190 -197	Interlaminate fine-grained light-coloured sandstone and grey carbonaceous siltstone; fine-grained sandstone with carbonaceous silty laminae.

197 -205 Interlaminate fine-grained sandstone and carbonaceous siltstone.

205 -215 Cored. Recovered 9'.

205 -206'6" Irregularly interlaminated light grey micaceous fine sandstone and dark grey micaceous, carbonaceous mudstone.

206'6"-214 Light grey-green fine quartz-lithic sandstone with laminae and thin beds of dark grey carbonaceous and very micaceous sandy mudstones.

B.M.R. No.5

Location 2 miles north of Mantuan Downs Hs.
Pt. 782, Photo 5022, Run 3, Springsure 1:85,000 photos.

Stratigraphic Description

0 - 90 Bandanna Formation
90 -205 Peawaddy Formation.
135 -140 Mantuan *Productus* Bed.

Log (feet)

0 - 4	Dark clayey soil.
4 - 20	Weathered shale.
20 - 30	Brown weathered shale, some fresher grey shale.
30 - 40	Black carbonaceous shale and clay shale.
40 - 50	Black carbonaceous shale.
50 - 60	Dark grey carbonaceous shale.
60 - 70	Black carbonaceous shale; light greenish-grey clay.
70 - 80	Black shale and clay as above.
80 - 90	Black carbonaceous shale.
90 -100	Light-coloured, friable, medium-grained sandstone, mostly quartz grains, some lithic and feldspar grains; grains are subrounded, ranging from .1 - 1 mm.
100 -110	Grey, micaceous, carbonaceous, fine to fine-medium grained feldspathic-lithic-quartz sandstone.
110 -120	Grey, fine-grained, micaceous, carbonaceous lithic-feldspathic-quartz sandstone; minor dark grey carbonaceous siltstone.
120 -130	Grey fine-grained carbonaceous lithic-feldspathic-quartz sandstone; minor dark grey carbonaceous sandy siltstone.
130 -140	Light-grey fine-grained lithic-quartz sandstone; shell fragments.

140 - 150 Cored. Recovered 10ft. Fine-medium grained, light-grey and green, feldspathic-lithic-quartz sandstone, carbonaceous and micaceous with beds and laminae of dark grey mudstone. Some small quartz granules and pebbles. Some carbonized plant remains, warm tubes and churned up laminae due to scavenger action.

150 - 160 Grey fine-grained micaceous, carbonaceous lithic-quartz sandstone.

160 - 167 Grey fine-grained micaceous, carbonaceous, feldspathic-lithic-quartz sandstone, partly pyritic.

167 - 175 Dark grey carbonaceous sandy siltstone tending to silty sandstone and fine-grained sandstone; shell fragments.

175 - 182 Dark grey carbonaceous sandy siltstone.

182 - 190 Very fine-grained carbonaceous feldspathic-lithic-quartz sandstone; dark grey siltstone with sandy laminae.

190 - 197 Dark grey carbonaceous siltstone, some shale, with laminae of fine-grained sandstone.

197 - 205 Dark grey carbonaceous siltstone and silty shale; some fine-grained carbonaceous silty sandstone.

<u>B.M.R. No.6</u>

<u>Location</u> 11 miles north-west of Mantuan Downs Hs. Pt. 783, Photo 5026, Run 2, Springsure North 1:85,000 photos.

<u>Stratigraphic Description</u>

Upper part of Colinlea Sandstone.

<u>Log</u> (feet)

0 - 4 Sandy soil.

4 - 10 Boulder gravel

10 - 20 Weathered quartz sandstone.

20 - 30 Weathered brown and fresher buff quartz sandstone with some silty matrix; mostly angular grains of clear quartz about .2 mm., muscovite flakes, some weathered feldspar.

30 - 40 Medium-grained quartz sandstone, some finer matrix; grains of angular clear quartz .5 mm. some larger; also some fine-grained quartz sandstone.

40 - 50 Light coloured medium-grained quartz sandstone; subangular quartz grains .4 - .5 mm., some up to 1 mm.: white matrix.

50 - 60 Fine and fine-medium micaceous quartz sandstone, white matrix.

60 - 70	Fine-grained light-coloured quartz sandstone; some white matrix.
70 - 80	Fine-medium grained quartz sandstone, some lithic grains; some grey siltstone.
80 - 90	Fine-medium grained quartz sandstone, some matrix.
90 -100	Fine-grained quartz sandstone.
100 -120	Fine-grained quartz sandstone, pebbly sandstone,
125 -132	Grey carbonaceous siltstone; pebbles.
140 -150	Grey siltstone; pebbles.

B.M.R. No.7

Location: 12½ miles north-west of Mantuan Downs Hs. Pt.784, Photo 5026, Run 2, Springsure North 1:85,000 photos.

Stratigraphic Description: Basal part of Colinlea Sandstone and entered Joe Joe Formation.

Log (feet)

0 - 16	Black soil
16 - 60	Mainly black and brown clay with some sandy pebbly gravel at about 57'.
60 - 70	No cuttings. Fine friable quartz sandstone.
70 - 80	Dark greenish-grey shale, some weathered brown shale; thin beds and laminae of siltstone.
80 - 90	White to light grey siltstone, grey shale; interlaminate siltstone and shale.
90 -100	Light-grey quartz siltstone tending to very fine grained sandstone.
100 -110	Core. Recovered 8'.
	Greenish-grey fine-grained lithic-quartz sandstone, argillaceous in part, with dark carbonaceous laminae in places.
	Water flow at 100'. Moderate flow possibly up to 200 galls. per hour.

B.M.R. No.8

Location: 5 miles south of Joe Joe Hs. pt. 785, Photo 5026, Run 2, Springsure North 1:85,000 photos.

Stratigraphic Description: Upper part of Joe Joe Formation.

Log (feet)

0 - 10	Soil
10 - 20	Brown, weathered, fine to fine-medium grained micaceous quartz-lithic sandstone.
20 - 30	Weathered sandstone, buff siltstone; pebbles.
30 - 40	Buff siltstone with shale laminae, thinly interbedded to interlaminate buff siltstone and dark green clay shale.
40 - 50	Thinly interbedded and interlaminate fine buff siltstone and dark greenish-grey clay shale.
50 - 60	Buff quartz siltstone; dark grey shale.
60 - 70	Dark grey shale.
70 - 80	Dark grey shale, laminae of fine-grained lighter coloured siltstone and finer silty shale.
80 - 90	Dark grey shale, laminae and thin beds of light coloured siltstone.
90 -100	Mainly light grey siltstone, some dark grey carbonaceous shale with laminae of lighter coloured siltstone; lighter grey clay shale; some black coaly shale and coal.
100- 110	Fine-grained light coloured micaceous quartz-lithic-sandstone; minor dark grey carbonaceous shale.
110 -120	Light grey siltstone tending to fine-grained sandstone; some dark grey carbonaceous siltstone; minor black coaly shale.
120 -130	Light grey siltstone tending to a very fine-grained sandstone; thin coal bands and laminae.
130 -140	Light grey siltstone, some containing plant fragments; minor black coal shale.
140 -150	Cored. 8' recovered. Dark greenish-grey very fine-grained quartz-lithic sandstone to sandy mudstone, laminated in places. Some ?cherty matrix produces a mottled appearance in places. Dark carbonaces laminae near the top.

B.M.R. No.9

Location 4 miles east of Joe Joe Hs.
Pt. 786, Photo 5109, Run 1, Springsure North
1:85,000 photos.

Stratigraphic Description In conglomeratic lower part of the Joe Joe Formation.

Log (feet)

0 - 1	Soil
1 - 10	Light brown quartz siltstone tending to very fine-grained sandstone, minor greenish-grey shale.

10 - 20	Fine-grained buff silty sandstone and siltstone with laminae of grey shale and siltstone; grey sandy siltstone, scattered hard boulders.
20 - 30	Buff to light-brown siltstone and sandy siltstone interlaminate buff siltstone and dark grey shale.
30 - 40	Buff to light-grey siltstone, some sandy siltstone; minor darker grey shale; some large, hard boulders, ?erratics.
40 - 50	Fine-grained light brown lithic-quartz sandstone, some sandy siltstone; minor light grey siltstone.
50 - 60	Brown sandstone, mostly quartz, some feldspar and lithic grains; grains .2 - .5 mm., subrounded to rounded; brown finer-grained silty sandstone; scattered ?erratic boulders.
60 - 70	Fine-grained brown lithic-quartz sandstone; buff quartz siltstone, some finer grey siltstone.
70 - 80	Brown fine-grained lithic-quartz sandstone; light grey sandy siltstone.
80 - 90	Brown fine-medium grained lithic-quartz sandstone with a silty matrix; light grey quartz siltstone.
90 -100	Grey quartz siltstone.
100 -110	Grey sandy siltstone with dand grains up to .3 mm.; fine-grained silty sandstone.
110 -120	Very fine-grained grey sandstone and silty sandstone; poorly sorted fine-grained lithic-quartz sandstone.
120- 130	Light grey siltstone and fine sandy siltstone; poorly sorted silty sandstone, mostly quartz grains ranging from silt-size to .5 mm., most about .2 mm.
130 -140	Fine to fine-medium grained lithic-quartz sandstone, some feldspar grains, some silty matrix; grains up to .5 mm., mostly subangular.
140 -150	Grey fine-grained lithic-quartz sandstone, pebbles of quartz and lithic material, conglomerate band 147'-149'.
150 -160	Very fine-grained grey quartz sandstone, grains about .05 mm., slightly larger; some coarser sandstone (grains .1 - .2 mm.); grey siltstone and interlaminate light grey siltstone and dark grey shale.
160 -167	Very fine-grained light grey sandstone and siltstone; some laminae of dark grey shale.

167 -175 Fine-grained grey lithic-quartz sandstone; some quartz siltstone.

175 -182 Mostly buff siltstone, some fine-grained sandstone laminae of dark grey shale.

182 -190 Grey fine-grained quartz-feldspathic-lithic sandstone; light-coloured siltstone and sandy siltstone.

190 -197 Grey friable fine-grained poorly sorted lithic-quartz sandstone; grains are subrounded, range from silt sized to .5 mm.

197 -205 Sandstone similar to that above but finer and more uniform grain size.

B.M.R. No.10

Location 3/4 mile west of echo Hills Hs. Pt.787, Photo 5111, Run 1, Springsure North 1:85,000 photos.

Stratigraphic Description Upper part of Ducabrook Formation.

Log (feet)

0 - 10 Brown friable, fine-grained, lithic-quartz sandstone; subrounded grains .1 - .2 mm.

10 - 20 Slightly weathered grey carbonaceous siltstone.

30 - 40 Fine grained brown friable lithic-quartz sandstone; some grey shale; reddish brown mudstone.

B.M.R. No.11

Location 3/4 mile west of Echo Hills Hs. Pt. 788, Photo 5111, Run 1, Springsure North 1:85,000 photos.

Stratigraphic Description Upper part of Ducabrook Formation.

Log (feet)

0 - 2 Soil

2- 15 Weathered lithic sandstone and mudstone; no cuttings.

15 -20 Weathered buff and fresher light grey siltstone and sandy siltstone.

20 -30 Buff siltstone, some sandy siltstone tending to fine-grained sandstone; minor reddish-brown mudstone.

30 -40 Brown fine-grained micaceous sandstone, mostly quartz, some feldspar and lithic grains; subangular to subrounded grains, .2 -.3 mm.; buff siltstone tending to very fine-grained sandstone minor reddish brown mudstone.

40 -50 Fine-medium grained, brown, friable, micaceous, lithic-quartz sandstone; greenish-grey fine mudstone or claystone; pink siltstone.

50 -60 Pink, rather tough fine sandy siltstone, probably tuffaceous, dominant; tough greenish-grey? tuffaceous mudstone; fine-grained, friable, pink lithic-quartz sandstone, colour due to pink ? tuffaceous matrix.

60 -70 Tough, pink, ?tuffaceous, fine-grained sandstone and siltstone; some pink tuff; minor tough greenish-grey siltstone.

70 -80 Bright pink tuffaceous siltstone or ?tuff; tough dark grey and greenish-grey siltstone; some lighter grey very fine-grained sandstone.

80 -90 Tough grey siltstone.

90 -100 Fine-grained (grains .1 - .2 mm.) grey lithic-quartz sandstone; some drab reddish-brown siltstone.

100 - 110	Tough dark reddish-brown siltstone; some grey siltstone.
110 - 120	Brown, friable, fine-grained lithic-quartz sandstone (dominant); grey micaceous sandy siltstone; minor reddish-brown siltstone.
120 - 130	Brown friable, fine-medium grained felds-pathic-lithic-quartz sandstone.
130 - 140	Sandstone as above; tougher finer-grained feldspathic-lithic-quartz sandstone; some siltstone.

B.M.R. No.12

Location 2 miles north of Wealwandangie Hs.
Pt. 788, Photo 5011, Run 3, Springsure North 1:85,000 Photos.

Stratigraphic Description. Lower part of Bandanna Formation.

Log (feet)

0 - 17	Black soil.
17 - 25	Weathered basalt and clay.
25 - 32	White and buff siltstone, mauve claystone.
32 - 40	White sandstone, quartz, feldspar and lithic grains; high percentage of white matrix, probably tuffaceous; pink claystone; pebble of basic volcanic rock.
40 - 50	Mudstone and sandy mudstone, fine-grained sandstone.
50 - 55	Buff, sandy, carbonaceous, micaceous, clay-stone and clay shale; some carbonaceous siltstone and very fine-grained sandstone; feldspar and quartz grains in both sandstone and claystone.
55 - 60	Buff, fine-medium grained micaceous lithic-quartz sandstone, subrounded grains .3 mm.
60 - 70	Brown, micaceous, friable, quartz-lithic sandstone.
70 - 80	Brown fine-grained lithic-quartz sandstone and silty sandstone.

Water flow at 75'. Moderate flow, possibly up to 200 galls. per hour.

B.M.R. No.13

Location Rocky Creek Road, 10 miles south-west of Consuelo Hs.
Pt. 789, Photo 5145, Run 3, Springsure 1:85,000 photos.

Stratigraphic Description. Hole spudded immediately below Mantuan Productus Bed ; upper part of Peawaddy Formation.

<u>Log</u> (feet)

0 - 1	Black soil.
1 - 10	Weathered brown fine-grained argillaceous feldspathic-quartz sandstone, grey when fresher.
10 - 20	Weathered brown siltstone and micaceous sandy siltstone.
20 - 30	Weathered brown fine-grained quartz sandstone (grains .1 mm.); some weathered shale and sandy shale.
30 - 40	Dark grey carbonaceous sandy siltstone (dominant) and fine-grained carbonaceous feldspathic-quartz sandstone with white ? kaolinitic matrix; sandstone and siltstone are also thinly interbedded.
40 - 50	Fine-grained light-coloured feldspathic-quartz sandstone, white matrix, carbonaceous laminae; minor dark grey carbonaceous silty sandstone and sandy siltstone.
50 - 60	Fine-grained, light-grey, feldspathic-quartz sandstone; dark grey and black carbonaceous siltstone and shale; some interlaminate sandstone and siltstone.
60 - 70	Fine-grained, light-grey, carbonaceous, quartz sandstone some very carbonaceous laminae which are also very micaceous; interlaminate fine-grained sandstone and siltstone; some dark grey carbonaceous siltstone and shale.
70 - 80	Light-grey carbonaceous quartz sandstone with white ?kaolinitic matrix; dark grey carbonaceous siltstone and shale with plant fragments.
80 - 90	Light-grey, friable, fine-grained, micaceous, quartz sandstone, white matrix, some grains of feldspar and lithic material; subangular to subrounded grains up to .5 mm.; sandstone carbonaceous, some samples containing up to 30% coal fragments; minor black shale.
90 -100	Sandstone as above but not as extremely carbonaceous; some dark grey carbonaceous siltstone.
100 -110	Light grey friable, fine-medium grained carbonaceous, lithic-feldspathic-quartz sandstone; poor sorting grains ranging from .1 - .5 mm.
110 - 120	Fine-grained quartz sandstone, micaceous, rare feldspar and lithic grains, some white matrix; some dark grey carbonaceous sandy siltstone with sandy laminae.
120 - 130	Some fine-grained carbonaceous sandstone as above; mainly dark grey carbonaceous sandy siltstone and siltstone.

130 - 140 Fine sandstone as above; dark grey carbonaceous siltstone.

140 - 150 Dark grey carbonaceous sandy siltstone; some fine-grained feldspathic-lithic-quartz sandstone.

150 - 160 Fine-grained micaceous, carbonaceous, feldspathic-lithic-quartz sandstone with some white matrix; some dark-grey carbonaceous sandy siltstone and black shale.

160 - 170 Fine-grained sandstone as above; dark grey and black siltstone, sandy siltstone and shale.

170 - 180 Dark grey carbonaceous siltstone and sandy siltstone; some fine-grained argillaceous lithic-quartz sandstone.

180 - 190 Dark grey carbonaceous siltstone and sandy siltstone with sandstone laminae, some fine-grained feldspathic-lithic-quartz sandstone.

190 - 200 Fine-grained carbonaceous lithic-quartz sandstone with white matrix; dark grey carbonaceous siltstone.

200 - 210 Fine-grained friable lithic-quartz sandstone with white matrix; black carbonaceous siltstone and shale.

210 - 220 Sandstone and siltstone as above.

220 - 230 Sandstone and siltstone as above.

230 - 240 Fine-grained lithic-quartz sandstone with white matrix; black carbonaceous silty shale and shale; interlaminate sandstone and shale.

240 - 250 Cored. Recovered 9'

240 - 243 Light-grey, fine-grained feldspathic-lithic-quartz sandstone with much carbonaceous debris and dark mudstone and ?cherty siltstone zone.

243 - 250 Irregularly interlaminated dark grey mudstone and light grey fine lithic sandstone, dark laminae very micaceous and carbonaceous and containing plant debris. Some light grey sandstone lenses to 3" thick. Some laminae of cherty siltstone with pockets of ?pyrite in places.

B.M.R. No.14

Location Rocky Creek Road, 1 mile west of B.M.R. 13.
Pt. 790, Photo 5145, Run 3, Springsure 1:85,000 photos.

Stratigraphic Description.
Lower part of Peawaddy Formation; hole bottomed just above Catherine Sandstone.

Log (feet)

1 - 10	Black soil and clay.
10 - 20	Weathered brown siltstone; sandy clay.
20 - 30	Weathered brown micaceous carbon aceous shale and sandy shale.
30 - 40	Brown eathered carbonaceous shale and silty shale, grey when fresher; some brown fine-grained lithic-feldspathic-quartz sandstone.
40 - 50	Light grey fine-grained carbonaceous lithic-feldspathic-quartz sandstone with some white matrix; brown and grey shale.
50 - 60	Light grey feldspathic-lithic-quartz sandstone coal fragments, occasionally very carbonaceous with carbonaceous laminae.
60 - 70	Micaceous, carbonaceous, fine-grained sandstone; subrounded grains .2. - .3 mm.
70 - 80	Sandstone as above; dark grey carbonaceous shale and siltstone with coal; laminae .3 mm. thick.
80 - 90	Dark grey carbonaceous sandy siltstone (sand grains of feldspar and quartz) and siltstone; some fine-grained light-grey feldspathic - lithic-quartz sandstone.
90 -100	Dark grey carbonaceous siltstone and sandy siltstone; interlaminate siltstone and fine-grained sandstone, some fine-grained felds-pathic-lithic-quartz sandstone.
100 -110	Dark grey carbonaceous siltstone and sandy siltstone, some shale; laminae and small lenses of fine-grained sandstone.
110 -120	Fine-grained carbonaceous lithic-feldspathic - quartz sandstone; dark grey carbonaceous siltstone.
120 -130	Dark grey micaceous, carbonaceous siltstone and sandy siltstone, some shale; sandy laminae siltstone; fine-grained sandstone.
130 -140	Black shale and sandy shale; dark grey siltstone; bands and laminae of fine-grained sandstone.
140 -150	Tough black carbonaceous shale; some sandy shale.
150 -160	Black carbonaceous shale, some sandy shale with sand grains up to 1 mm.; some grey siltstone.
160 -170	Black carbonaceous shale and silty shale; some pyritic siltstone
170 -180	Light grey fine-grained micaceous carbonaceous quartz sandstone, some lithic grains; some dark grey pyritic sandy siltstone and black sandy shale.

180 -190	Very fine-grained grey micaceous, carbonaceous silty sandstone.
190 -200	Fine-grained light grey quartz-lithic-sandstone and grey carbonaceous silty sandstone tending to sandy siltstone.
200 -210	Very fine-grained light grey slightly carbonaceous feldspathic-lithic-quartz sandstone; some darker grey carbonaceous sandy siltstone.
210 -220	Grey carbonaceous very fine-grained silty sandstone; some dark grey siltstone.
220 -230	Cored. Recovered 9'. Fine grained greenish-grey micaceous lithic-quartz sandstone with patches and irregular laminae of dark grey sandy carbonaceous mudstone.

B.M.R. No.15

Location Rocky Creek Road, 3/4 mile west of B.M.R. 14.
pt. 791, Photo 5145, Run 3, Springsure 1:85,000 photos.

Stratigraphic Description.
Top part of Ingelara Formation, spudded near base of Catherine Sandstone.

Log (feet)

0 -10	Soil, sand and clay.
10 -20	Not logged.
20 - 30	Weathered brown micaceous, carbonaceous sandy siltstone and fine-grained sandstone.
30 - 40	Weathered brown micaceous carbonaceous sandy siltstone and siltstone grey when fresher.
40 - 50	Dark grey carbonaceous sandy siltstone and siltstone, sand grains of quartz and feldspar; silty shale .
50 - 60	Dark grey micaceous carbonaceous siltstone and sandy siltstone, some tending to fine-grained silty sandstone.
60 - 70	As above.
70 - 80	Dark grey carbonaceous siltstone and sandy siltstone; irregular small lenses and laminae of fine-grained sandstone; some tends to a fine-grained light-grey, carbonaceous sandstone with irregular darker grey silty bands.
80 - 90	Dark grey, micaceous, carbonaceous siltstone with irregular patches of lighter coloured fine-grained sandstone; some black shale.
90 -100	Dark grey carbonaceous siltstone with irregular streaks and laminae of fine-grained sandstone; small sandy lenses; some tends to a fine-grained silty sandstone.

100 -110	Dark grey micaceous, carbonaceous siltstone and fine sandy siltstone, irregular patches and poorly defined laminae of fine-grained sandstone; some black shale.
110 -120	Dark grey micaceous, carbonaceous siltstone and sandy siltstone; laminae and small lenses of fine-grained sandstone.
120 -130	Mainly dark grey carbonaceous siltstone, some black shale, irregular streaks of fine-grained sandstone; irregular interlaminations and interlensing of fine sandstone and silty shale.
130 -140	Dark grey, micaceous,carbonaceous siltstone.
140 -150	Dark grey carbonaceous siltstone and sandy siltstone; streaks of fine-grained sandstone.
150 -160	Black micaceous, carbonaceous siltstone.
160 -170	Dark grey carbonaceous siltstone and silty shale.
170 -180	Dark grey carbonaceous siltstone.
180 -190	Dark grey carbonaceous siltstone; some black shale; small lenses of fine-grained sandstone.
190 -200	Grey micaceous, carbonaceous siltstone and sandy siltstone, tending to very fine-grained sandstone; small lenses of black shale.
200 -210	Grey micaceous, carbonaceous, siltstone and sandy siltstone; lenses of black shale.
210 -220	Dark grey carbonaceous micaceous siltstone and black silty shale.
220 -230	Grey carbonaceous, micaceous siltstone and sandy siltstone, tending to very fine-grained sandstone; some black shale containing sand grains up to .5 mm.
230 -240	Grey carbonaceous sandy siltstone and siltstone.
240 -250	Cored. Recovered 9'.
	Mainly dark grey micaceous sandy mudstone, grading to very fine sandstone, carbonaceous in part and containing laminae and pods of carbonaceous mudstone with carbonised plant remains and coal debris.

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APPENDIX I

PERMIAN MARINE MACROFOSSILS FROM THE SPRINGSURE SHEET AREA

by

J. M. Dickins

SUMMARY

Examination and listing of fossils from 42 localities has substantially increased the number of species known from the Springsure area. The faunal subdivision into Faunas I, II, III and IV in ascending stratigraphical order, first recognized in the marine Permian rocks of the northern part of the basin, is extended to this area.

Marine sedimentation commenced at about the same time in Springsure as in the northeastern and southeastern areas of the basin. Indication of oldest age is shown in the lowest part of the Stanleigh Formation where Fauna I is possibly represented. The fauna in the basal marine beds near the old Dilly Siding and in the Cattle Creek Formation (including in subsurface) does not appear to be older and therefore the underlying fresh-water deposits with Glossopteris occupy a stratigraphical position beneath the marine beds, similar to the bulk of the Lower Bowen Volcanics to the east.

The fauna of the rest of the Stanleigh Formation, of all or the upper part of the marine beds at Dilly, and of the Sirius and Cattle Creek Formations appear to represent Fauna II. The Ingelara Formation and Catherine Sandstone (as used in this report) apparently contain a Fauna III and the overlying Peawaddy Formation with the Mantuan Productus Bed at the top contains Fauna IV. On this basis the marine formations below the Aldebaran Sandstone can be regarded as representing Unit A of the Middle Bowen Beds of Dickins, Malone & Jensen (in press). The lowermost part of these, however, was possibly laid down at the same time as the top part of the Lower Bowen Volcanics to the east. The stratigraphical interval from the Aldebaran Sandstone to the Catherine Sandstone is equivalent to Unit B of the Middle Bowen Beds and the Peawaddy Formation and the lower part of the Bandanna Formation (from which no marine macrofossils are known at the surface) is equivalent to Unit C of the Middle Bowen Beds.

The faunas of the Ingelara Formation and Catherine Sandstone have similarities with Faunas IIIB and IIIC (Fauna III has been subdivided into IIIA, IIIB and IIIC in the northern

part of the basin) but differences, which seems to be largely ecological, obscure an understanding of exact relationships. Faunas of this age seem absent from the Monto and Mundubbera areas where an hiatus occurs in the sequence. The Mantuan Productus Bed seems to be equivalent to part of the interval from the Big Strophalosia Zone to the Streptorhynchus pelicanensis Bed of the northern part of the basin and the upper Barfield Formation to lower Flat Top Formation of the southeastern part. The evidence is slightly in favour of correlation with the higher parts of these intervals rather than the lower parts.

The marine sedimentation extends from the Lower Permian (Upper Sakmarian or Lower Artinskian) probably to Lower Upper Permian (Kazanian).

INTRODUCTION

The Springsure area has been the centre of considerable geological interest partly because of its closeness to the Roma area where gas accumulation has been known for many years, partly because of the prominent anticlines, which expose Palaeozoic and, to a lesser extent, Mesozoic rocks, and because of the detailed work, including drilling, which Shell (Queensland) Development Pty Ltd have done in this area. In addition considerable geophysical work and drilling has been done while this survey was being carried out (see main report).

The rich invertebrate faunas found in some parts of the Permian sequence have also caused considerable interest. In recent years Fletcher (1945a & b) and Dickins (1961) have described pelecypods, Campbell (1953, 1959, 1960, 1961 and in press) has described the fauna from the Ingelara Formation and spiriferoids and terebratuloids, Maxwell (1954) Strophalosia, Dorothy Hill (1957, and in unpublished reports of Shell and other companies) has identified marine investebrate faunas and J.F. Dear in unpublished reports, has identified fossils from oil wells. Some of the fossils are illustrated in the Permian Index Fossils of Queensland (Hill & Woods, 1964).

There has been a tendency to think of the Bowen Basin largely in terms of the Springsure area but the Bowen Basin Regional Survey has shown that both the sediments and the fauna have certain features which are not characteristic for other parts of the basin. Although the faunas are rich they are confined to a number of discrete horizons separated by barren rocks so that most of the sequence is unfossiliferous. This applies particularly to the interval above the top of the Cattle Creek Formation and its equivalents. In this interval, in other parts of the basin, marine fossils are found at numerous horizons throughout the sequence and the Springsure faunas seem best understood in this context.

The faunal subdivision of Dickins (in press; 1962) into Faunas I, II, III and IV in this stratigraphical order, first based on analysis of faunas collected in the Mt. Coolon and Clermont Sheet areas, and later applied to other parts of the basin, is also used for the Springsure area. It gives a guide to a threefold subdivision of the marine rocks corresponding to the threefold subdivision used in other parts of the basin (Units A,B and C of the Middle Bowen Beds of Dickins, Malone & Jensen, in press).

The age of the marine sedimentation is considered in detail elsewhere (Dickins, MS). It is regarded as ranging from Lower Permian (Upper Sakmarian or Lower Artinskian) probably into Lower Upper Permian (Kazanian).

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The collections were made during two field seasons. Those with the prefix Z were made during 1962 and those with the prefix Sp in 1963. Three of the samples are from adjacent sheets - Sp 133 from the southern parts of the Emerald Sheet and Z 66 and 68 from northern part of the Eddystone Sheet. The KOE numbers refer to collections made by Kimberley Oil Exploration Syndicate. Some of these numbers have appeared in published reports.

The identifications are standardized with those used in other reports on the Bowen Basin. In the main, the names correspond to those used in the Permian Index Fossils of Queensland (Hill & Woods, 1964).

IDENTIFICATIONS

Stanleigh Formation

Stanleigh Area

Z15 (probably same horizon as KOE 5). In Orion Creek 3.4 miles at 123° from "Spring Hill".

Pelecypods

Schizodus sp. (different from S. sp. nov. A from M 412a of Mackay Sheet area)

Z16 (slightly higher stratigraphically than KOE 5). In Orion Creek, 3.4 miles at 126° from "Spring Hill".

Pelecypods

Glyptoleda cf. buarabae Campbell 1951 (in Dickins 1962, regarded as a new species. Probably referable, however, to G. buarabae)

Glyptoleda cf. reidi Fletcher 1945

Chaenomya sp. (juvenile)

Notomya sp. ind.

Atomodesma sp.

Gastropods

Indeterminate pleurotomarian

Straight Nautiloid

Brachiopods

Ingelarella profunda Campbell 1961

Glossopteris leaf

Z 21A. In Orion Creek about 100 yards east of Z21 which is in Orion Creek, 3.3 miles at 132° from "Spring Hill".

Pelecypods

Glyptoleda cf. reidi Fletcher 1945

Brachiopods

Strophalosia sp. ind.

Sp6 (KOE 6)*. 1.8 miles at 106° from "Spring Hill.

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* KOE 5 and KOE 6 are from the Stanleigh Formation and not from the Staircase Sandstone as suggested in Dickins (1961). The Stanleigh Formation was shown on maps, current at that time, as Dilly Beds.

Pelecypods

Megadesmus cf. nobilissimus (de Koninck) 1877

Astartila? cf. gryphoides (de Koninck) 1877

Chaenomya sp.

Modiolus sp.

Pseudomyalina sp. (not as definitely referable to P. mingenewensis as specimens from Homevale)

Aviculopecten sp. (large with relatively simple ribbing).

Stutchburia cf. *randsi* (Etheridge Jnr.) 1892. (same species as in Fauna II and possibly Fauna I).

Cypricardinia? cf. *gregaria* (Laseron) 1910

Oriocrassatella queenslandica Dickins 1961

Gastropods

Warthia sp.

Brachiopods

Notospirifer cf. *extensus* Campbell 1961

Sp 408/2. 1.2 miles at 329° from "Stanleigh".

Pelecypods

Megadesmus cf. *nobilissimus* (de Koninck) 1877.

"*Megadesmus*" cf. *antiquatus* (Sowerby) 1838. (similar to species identified as *Notomya* cf. *antiquata* in Fauna I of St. Lawrence Sheet area)

Chaenomya sp. (similar to *Chaenomya* sp. in Faunas I and 2 of northern part of Bowen Basin).

Eurydesma hobartense (Johnston) 1887

Aviculopecten sp. (large with relatively simple ribbing)

Oriocrassatella queenslandica Dickins 1961

Old Dilly Siding Area

Z 75. 6.5 miles at 17° from Springsure.

Pelecypods

Merismopteria sp.

Modiolus sp. (comparable with species found elsewhere in Fauna II)

Deltopecten limaeformis (Morris) 1845.

Brachiopods

Ingelarella profunda Campbell 1961.

Sp. 132. On Emerald Road 6.7 miles from Springsure.

Pelecypods

Eurydesma hobartense (Johnston) 1887

Aviculopecten sp. (large species with ribbing of moderate complexity).

Brachiopods

Terrakea pollex Hill 1950

Terrakea sp. (similar to species in Faunas II and IIIA in northern part of basin)

Strophalosia preovalis Maxwell 1954

Ingelarella ovata Campbell 1961

Notospirifer extensus Campbell 1961

Sp. 133 (KOE3). Emerald Sheet area, approx. 4 miles at 85° from Minerva Siding.

Pelecypods

Astartila? cf. *gryphoides* (de Koninck) 1877

Modiolus sp. (species found in Fauna II)

Aviculopecten sp. (large specimens, character of ribbing not clear).

Stutchburia sp. ind.

Gastropods

Warthia sp.

Ptychomphalina sp.

Brachiopods

Terrakea or Cancrinella sp.

Strophalosia preovalis Maxwell 1954

Ingelarella plana Campbell 1960*

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* Campbell (1961, p.188) suggested that I. ingelarensis might be present at this locality. The additional material indicates, however, that the specimens are more satisfactorily referred to I. plana. The Strophalosia appears referable to S. preovalis sensu lato.

Notospirifer extensus Campbell 1961.

Terebratuloids. (described by Campbell, in press)

Sp 451. On Emerald Road, 6.9 miles from Springsure.

Pelecypods

Eurydesma hobartense (Johnston) 1887 (1 specimen is partly decorticated which gives it the appearance of approaching E. cordatum in shape.)

Brachiopods

Terrakea sp. (as at Sp 132)

Strophalosia sp?

Ingelarella plana Campbell 1960

Notospirifer extensus Campbell 1961 (lacks plates in brachial valve)

Sirius Formation

Z5 (KOE 7). In Staircase Creek immediately south of the Springsure-Rolleston road (immediately south of old road crossing of creek).

Brachiopods

Terrakea sp.

Strophalosia preovalis Maxwell 1954.

Neospirifer (Grantonia) cf. hobartensis (Brown) 1953.

Neospirifer sp.A

Trigonotreta sp.A

Ingelarella plana Campbell 1960

Ingelarella cf. plica Campbell 1960

Ingelarella cf. ovata Campbell 1961

Z 5a. 300 yards south along strike from Z 5, small hill to east of Staircase Creek.

Brachiopods

Neospirifer sp? (very large internal impressions)

Ingelarella plana Campbell 1960.

Ingelarella plica Campbell 1960.

Notospirifer cf. extensus Campbell 1961.

Z 5b. In Staircase Creek about ¼ mile along strike south of Z 5.

Brachiopods

Cancrinella sp.

Cancrinella farleyensis (Etheridge & Dun) 1909.

Anidanthus springsurensis (Booker) 1932.

Strophalosia preovalis Maxwell 1954.

Neospirifer sp.A.

Ingelarella cf. plana Campbell 1960 (similar to I. plana but adminicula in brachial valve longer than normal)

Pseudosyrinx sp. ind.

Cattle Creek Formation

"Eurydesma Limestone"

Sp 720. 0.3 miles at 320° from AOE No.2 Well.

Pelecypods

Eurydesma hobartense (Johnston) 1887

Deltopecten limaeformis (Morris) 1845 (in one large specimen the ribbing simulates that of D. illawarensis in broadness. In the younger part, however, the ribs are too numerous for D. illawarensis and are like those of D. limaeformis)

Aviculopecten sp. ind.

Brachiopods

Anidanthus springsurensis (Booker) 1932.

Strophalosia preovalis var. warwicki Maxwell 1954.

(probably also S. preovalis var. pristina and S. jukesi of Maxwell, 1954.

Taeniothaerus subquadratus var. acanthophorus Fletcher 1945. and T. subquadratus (Morris) 1845 s.s.

Neospirifer (Grantonia) cf. hobartensis (Brown) 1953.

Neospirifer sp.A.

Ingelarella plana Campbell 1960.

Plekonella sp.

Streptorhynchus sp.

Bryozoans

Fenestellid, branching and forms encrusting shells

Sp. 732. 0.3 miles at 55° from A.O.E. No.2 Well.

Pelecypods

Eurydesma hobartense (Johnston) 1887.

Deltopecten limaeformis (Morris) 1845.

Aviculopecten sp.

Brachiopods

Anidanthus springsurensis (Booker) 1932.

Strophalosia cf. preovalis or jukesi of Maxwell 1954 (probably also contains S. preovalis var. warwicki Maxwell 1954).

Taeniothaerus subquadratus (Morris) 1845.

Taeniothaerus subquadratus var. acanthophorus Fletcher 1945.

Neospirifer (Grantonia) cf. hobartensis (Brown) 1953?

Neospirifer sp. A.

Ingelarella plana Campbell 1960.

Notospirifer extensus Campbell 1961 (brachial valves not very satisfactory but pedicle valves identical with N. extensus)

Plekonella sp.

Streptorhynchus sp. nov. (differs from S. pelicanensis in coarser ribbing).

Bryozoans

Fenestellid, branching and encrusting shells.

Sp. 733. In Little Gorge Creek 1.8 miles south of A.O.E. No.1 Well

Brachiopods

Strophalosia sp. ind.

Neospirifer sp. A.

Notospirifer sp. ind.

Other fragments

Single Corals

Cattle Creek Formation

Above "Eurydesma Limestone"

Z46. In Cattle Creek, 2.6 miles at 170° from A.O.E. No.2 Well

Pelecypods

Myonia sp. ind.

Cypricardinia? sp. ind.

Gastropods

Warthia sp. (or cephalopod)

Bembexia sp. ind.

Brachiopods

Cancrinella farleyensis (Etheridge & Dun) 1909.

Strophalosia preovalis Maxwell 1954.

Lissochonetes sp.

Neospirifer (Grantonia) cf. hobartensis (Brown) 1953.

Neospirifer sp. A.

Ingelarella cf. plana Campbell 1960.

Notospirifer cf. hillae Campbell 1961.

- *Cancellospirifer*? sp.
- *Pseudosyrinx* sp. nov.

Bryozoans

- Branching and fenestellid forms

Crinoid stems

Single Corals

Float Close to Z 46

Brachiopods

- *Taeniothaerus* cf. *subquadratus* (Morris) 1845
- *Neospirifer* sp. A.
- *Ingelarella* cf. *plana* Campbell 1960

Sp. 209 C. In Cattle Creek, 2.4 miles at 183° from A.O.E. No. 2 Well.

Brachiopods

- *Neospirifer* sp. A.

Conulariid

Sp 460. 1.2 miles at 320° from A.O.E. No.2 Well.

Pelecypods

- *Modiolus* sp. (as in Fauna II elsewhere)

Brachiopods

- *Cancrinella farleyensis* (Etheridge & Dun) 1909
- *Anidanthus springsurensis* (Booker) 1932.
- *Strophalosia* cf. *preovalis* Maxwell 1954
- *Neospirifer* sp. A.
- *Ingelarella* cf. *profunda* Campbell 1961.
- *Ingelarella plana* Campbell 1960
- *Ingelarella plica* Campbell 1960
- *Notospirifer* cf. *extensus* Campbell 1961 (or possibly a young *N. hillae*)
- Rhychonellid gen.et sp. (lacks lateral plication)

Sp 747. 6 miles 186° from A.O.E. No. 2 Well.

Brachiopods

- *Neospirifer (Grantonia)* cf. *hobartensis* (Brown) 1953?
- *Ingelarella* cf. *plana* Campbell 1960.

Sp 748. 5.4 miles at 183° from A.O.E. No. 2 Well.

Pelecypods

- *Deltopecten limaeformis* (Morris) 1845

Gastropods

- Indeterminate spired form

Brachiopods

- *Strophalosia jukesi* of Maxwell 1954 (probably *S. preovalis* also present).
- *Neospirifer* sp. A.
- *Trigonotreta* or *Pseudosyrinx* sp.
- *Ingelarella* cf. *plana* Campbell 1960.

Notospirifer hillae Campbell 1961
Plekonella sp.
Bryozoans
Fenestellids and stenoporoids

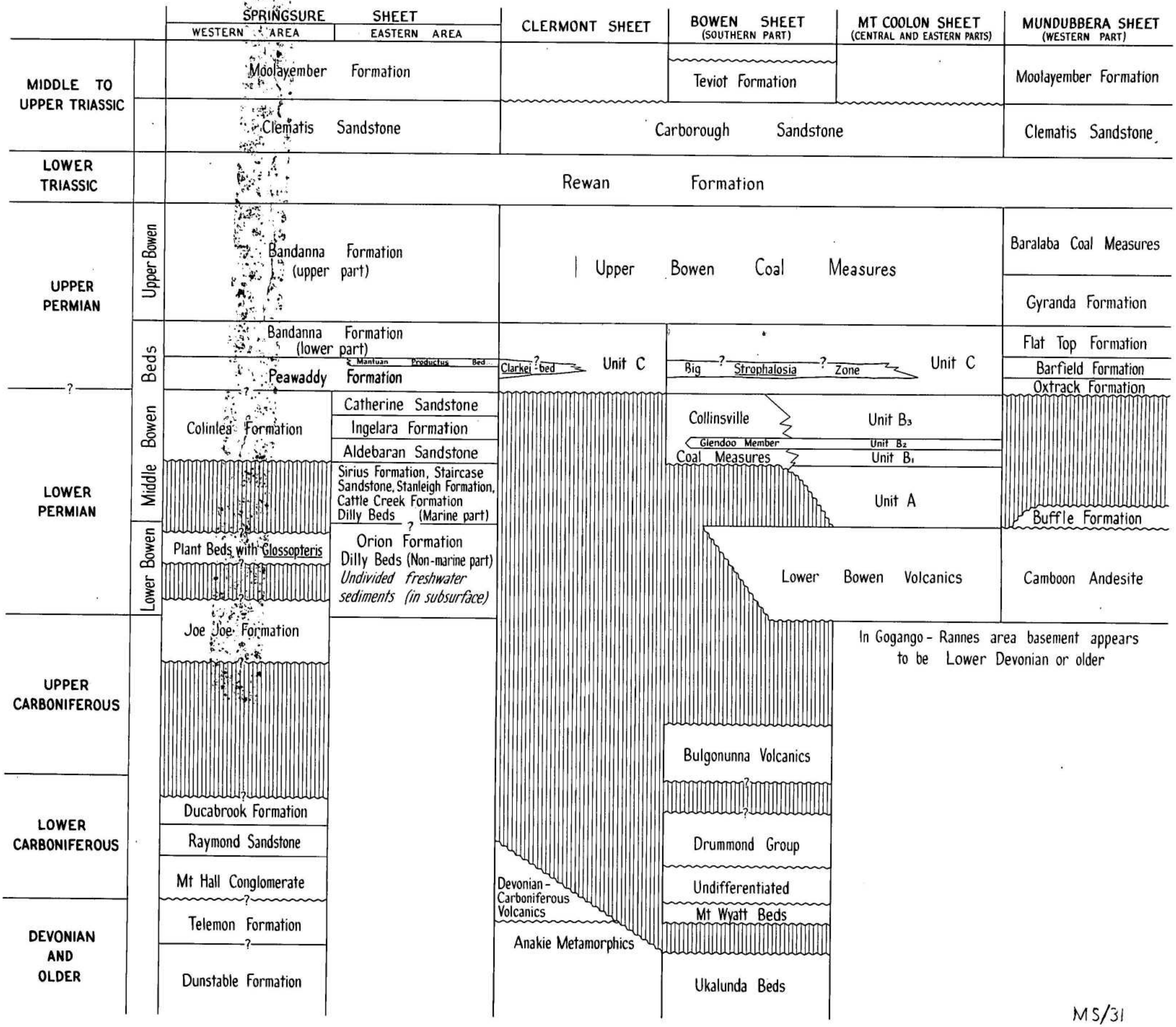
Relationships

The collections identified from the Stanleigh (including the Dilly Beds), the Sirius and Cattle Creek Formations show a uniformity throughout. Faunally the evidence for the oldest age is shown by the samples Sp 6 and Sp 408/2 from the basal Stanleigh which contain "Megadesmus" cf. antiquatus and Aviculopecten with relatively simple ribbing. These indicate that possibly Fauna I is represented. Whether Fauna I or/only II is represented near Dilly isn't clear, but Keeneia sp (identified in the collections of the Queensland Geological Survey) suggests that in part it is not younger than basal Fauna II. The rest of the faunas seem referable to Fauna II.

The faunas from the Dilly area, the part of Stanleigh above the base and the "Eurydesma Limestone" of Reid's Dome all seem close to each other and to the faunas found near Homevale, Mackay Sheet area, and at stratigraphically equivalent positions in the northern part of the basin. It is also close to the fauna of the Buffle Formation of the Mundubbera and Monto Sheet areas (including the Cracow area). These beds contain, in particular, Eurydesma hobartense, Deltopecten limaeformis, Cancrinella farleyensis, Terrakea pollex, varieties of Strophalosia preovalis, Anidanthus springsurensis, Taeniothaerus spp. Neospirifer (Grantonia) cf. hobartensis, and Ingelarella profunda. Differences such as the rarity of Notospirifer hillae in the Springsure area and the common occurrence of N. extensus seem to be largely ecological. When all the species represented are taken into account there seems little basis for regarding these horizons as younger than Fauna II or even younger than the fauna at Homevale. It follows, therefore, for example, that the range of Glyptoleda must be extended down into Fauna II.

In the Springsure area, Ingelarella plana has been recorded previously only from the Sirius Formation and the upper part of the Cattle Creek Formation so that its occurrence at Dilly and in the "Eurydesma Limestone" of Reid's Dome, extends its range. As a result of re-examination of material from the St. Lawrence Sheet area it appears that I. plana occurs at SL 59, 1 mile east of Marylands Homestead, with a fauna very similar to that from the beds at Homevale.

The fauna from the Sirius Formation and from the part of


SPRINGSURE SHEET
WESTERN AREA
EASTERN AREA
CLERMONT SHEET
BOWEN SHEET (SOUTHERN PART)
MT COOLON SHEET (CENTRAL AND EASTERN PARTS)
MUNDUBBERA SHEET (WESTERN PART)
MIDDLE TO UPPER TRIASSIC
LOWER TRIASSIC
UPPER PERMIAN
LOWER PERMIAN
UPPER CARBONIFEROUS
LOWER CARBONIFEROUS
DEVONIAN AND OLDER
Upper Bowen
Middle Bowen Beds
Lower Bowen
Moolayember Formation
Teviot Formation
Moolayember Formation
Clematis Sandstone
Carborough Sandstone
Clematis Sandstone
Rewan Formation
Bandanna Formation (upper part)
Upper Bowen Coal Measures
Baralaba Coal Measures
Gyranda Formation
Bandanna Formation (lower part)
Mantuan Productus Bed
Peawaddy Formation
Clarkei bed
Unit C
Big Strophalosia Zone
Unit C
Flat Top Formation
Barfield Formation
Oxtrack Formation
Colinlea Formation
Catherine Sandstone
Ingelara Formation
Aldebaran Sandstone
Sirius Formation, Staircase Sandstone, Stanleigh Formation, Cattle Creek Formation Dilly Beds (Marine part)
Collinsville Coal Measures
Unit B3
Glendoo Member
Unit B2
Unit B1
Unit A
Buffle Formation
Plant Beds with Glossopteris
Orion Formation
Dilly Beds (Non-marine part)
Undivided freshwater sediments (in subsurface)
Lower Bowen Volcanics
Camboon Andesite
Joe Joe Formation
In Gogango - Rannes area basement appears to be Lower Devonian or older
Bulgonunna Volcanics
Ducabrook Formation
Raymond Sandstone
Drummond Group
Mt Hall Conglomerate
Undifferentiated
Devonian - Carboniferous Volcanics
Mt Wyatt Beds
Telemon Formation
Anakie Metamorphics
Dunstable Formation
Ukalunda Beds
MS/31

the Cattle Creek Formation above the "*Eurydesma* Limestone" seems to differ from that found lower, importantly, only in containing *Ingelarella plica*. Not a great deal of weight, however, can be placed stratigraphically on a single species.

On the basis of the occurrence of typical Fauna II species in the Sirius Formation such as *Cancrinella farleyensis*, *Anidanthus springsurensis*, *Strophalosia preovalis* and *Neospirifer* (*Grantonia*) cf. *hobartensis* and their absence in Fauna III A immediately below the "Wall Sandstone" in the northern part of the basin and the intermingling of forms referable to *I. plica*, *I. ingelarensis*, *I. ovata*, *I. profunda* and *I. plana* in Fauna III A, it appears that the Sirius Formation is slightly older than base of the "Wall Sandstone" i.e. of Unit B of Dickins, Malone and Jensen (in press).

In the main report evidence is considered which may suggest that the Sirius Formation is not equivalent to the upper part of the Cattle Creek Formation, as has been fairly generally held, but to a finer grained interval above the base of what has been mapped as Aldebaran Sandstone on Reid's Dome. At present, the palaeontological work does not afford much information on this problem.

The correlations of the Permian sequence in the Springsure area with that in other parts of the basin and the relationship with the underlying and overlying formations is shown in the accompanying table.

From these data and from the occurrence of *Glossopteris* in both, it seems that the fresh-water beds underlying the marine beds of the Springsure area can, in a general way, be correlated with the main part of the Lower Bowen Volcanics to the east.

Ingelara Formation

Z 66. Eddystone Sheet area, in Dry Creek 5 miles at 263° from "Ingelara".

Pelecypods

Anthraconeilo sp.

Glyptoleda reidi Fletcher 1945.

Glyptoleda glomerata Fletcher 1945

Glyptoleda buarabae Campbell 1951

Chaenomya sp. (most like species in Fauna III A, but distinct from those in Peawaddy and Barfield Formations - elongated and distinctly produced in front of umbo, sulcate)

Volsellina? cf. *mytiliformis* (Etheridge Jnr.) 1892.

Gastropods

Warthia sp.

Platyteichum costatum Campbell 1953.

Brachiopods

Cancrinella magniplica Campbell 1953

Strophalosia sp. (flatter than S. ovalis or S. brittoni var. gattoni. Possibly a small S. clarkei but may represent a new species).

Strophalosia cf. typica (Booker) 1929 (no sulcus, poorly developed adductor muscle platform).

Ingelarella angulata Campbell 1959

Ingelarella ingelarensis Campbell 1960.

Pseudosyrinx? sp.

Streptorhynchus sp. ind.

This sample is from the main nodular fossiliferous horizon which is apparently the lower sandy part of the Ingelara referred to by Campbell (1953, p.3).

J.F. Dear has kindly lent me three specimens of Strophalosia from his locality D91, in Dry Creek, "from a boulder approximately 20 yards below the main outcrop of the lower (nodular) horizon of the Ingelara Shale". Two of the specimens F 6133, are brachial valves and the third, F 6132, is an incomplete pedicle valve which has a well developed adductor muscle platform and is possibly referrable to S. ovalis or S. brittoni var. gattoni

Sp 115. In Sandy Creek, 7.2 miles at 277° from "Springwood".

Pelecypods

Parallelodon sp.nov. (posterior carina tends to be rounded and radiating ribs are of a similar order over whole of the shell)

Pachymyonia cf. P. sp.nov. from Fauna III A

Pyramus sp?

Modiolus? sp. ind.

Streblopteria? sp.

Plagiostoma? sp.

Elimata sp. nov.

Stutchburia costata (Morris) 1845

Conocardium sp.

Gastropods

Peruvispira sp. (angular whorl cross-section, lowest lira set back from periphery)

Brachiopods

Cancrinella cf. magniplica Campbell 1953

Terrakea sp. (rather broad and umbo blunt - lacks distinct thickening of T. solida, same as in Catherine Sandstone)

Lissochonetes sp.

Neospirifer sp. A

Ingelarella mantuanensis Campbell 19..

Notospirifer sp. c. (plicae more distinct than in N. extensus, pedicle valve not swept back from umbo as in N. minutus, closely related to N. cf. extensus in Glendoo Member and from Fauna IIIC in Homevale area)

Plekonella acuta Campbell 1953

Other rhynchonellids

Terebratuloids

Large Single Corals

The matrix contains pebbles up to 1" across.

Sp 750/2. 2.7 miles at 322° from "Ingelara"

Pelecypods

Glyptoleda glomerata Fletcher 1945

Streblopteria sp.

Gastropods

Platyteichum costatum Campbell 1953

Brachiopods

Ingelarella sp. ind.

Wood fragments

Catherine Sandstone

Sp 383/3. 4.4 miles at 344° from "Croydon Hills".

Pelecypods

Parallelodon sp. ind.

Volsellina? cf. mytiliformis (Etheridge Jnr.) 1892.

Atomodesma exaratum Beyrich 1864 (one specimen may have two anterior grooves or this may be caused by crushing)

Plagiostoma? sp.

Conocardium sp.

Gastropods

Walnichollsia? sp. (carinate at all growth stages)

Brachiopods

Neospirifer sp. A

Ingelarella mantuanensis Campbell 1960

Notospirifer sp. C

Spiriferellina? sp.

Terebratuloids

Crinoid Ossicles

Sp 384/1. 1.1 miles at 256° from "Croydon Hills".

Brachiopods

Terrakea sp. (as in Ingelara and other Catherine localities)

Neospirifer sp. ind.

Plekonella cf. acuta Campbell 1953.

Sp 385/1. 1.2 miles at 299° from "Croydon Hills".

Brachiopods

Terrakea sp (as at other Catherine localities)

Sp 385/4. 0.9 miles at 290° from "Croydon Hills".

Pelecypods

Streblopteria sp.

Brachiopods

Terrakea sp.(as in other Catherine localities, rather geniculate, with occasionally umbonal thickening, sulcate)

Notospirifer sp. C

Sp 750/3. 2.8 miles at 335° from "Ingelara".

Terebratuloid Brachiopods

Relationships

The fauna from the Catherine Sandstone is from its lower part and, because of their similarity, the faunas of the Ingelara Formation and Catherine Sandstone are considered together. As indicated in the main report, the upper limit of the Ingelara Formation in Dry Creek, southern Reid's Dome, is open to doubt but, because of original definitions, the name Ingelara should be retained for the predominantly fine-grained interval between the Aldebaran and Catherine Sandstones i.e. Sp 115 is a definite reference for the fauna of the Ingelara. Sp 750/2 is found in the Ingelara Formation immediately below Sp 750/3 in the Catherine Sandstone, and forms a lithological and faunal link with Z 66, in indicating that it too is to be referred to the Ingelara. South of Sp 750/3 and Sp 750/2 the Catherine Sandstone wedges out and the Peawaddy rests directly on the Ingelara Formation. As shown in the next section, the fauna of the Peawaddy Formation appears to be distinctly younger than that of the Ingelara or Catherine.

Although the Ingelara and Catherine contain species which continue into Fauna IV, it seems more satisfactory to refer the faunas of these two formations to Fauna III. Parallelodon sp.nov.B, Myonia carinata, Platyteichum coniforme, Terrakea solida, Strophalosia ovalis, Neospirifer sp.B, Trigonotreta sp.B, Notospirifer minutus and Licharewia sp.nov. as well as other species characteristic of Fauna IV, are absent from these formations. On the other hand they contain different species of Parallelodon, Myonia (or Pachymyonia), Chaenomya, Terrakea, Strophalosia and Notospirifer which suggest affinity with Fauna III. The fauna appears to be closest to IIIB (Glendoo and Glendoo

Member equivalent) or IIIC, although it could possibly be intermediate between IIIC and IV. This evidence therefore, suggests the Ingelara Formation and Catherine Sandstone, as well as the Aldebaran Sandstone, are to be related to Unit B of the northern part of the basin which is characterised lithologically by containing quartz sandstones.

Peawaddy Formation

With two exceptions, Sp 169 and Sp 729, which are found in a lower stratigraphical position, all the samples are from the Mantuan *Productus* Bed.

Z68. Eddystone Sheet area, in Dry Creek, 4.6 miles at 243° from "Ingelara".

Pelecypods

Quadratonucula sp.nov.

Gastropods

Warthia sp.ind.

Z 72. In Sandy Creek 2.4 miles at 277° from Mt. Carnarvon

Pelecypods

Parallelodon sp.nov.B

Myonia cf. carinata (Morris) 1845.

Volsellina? *mytiliformis* (Etheridge Jnr.) 1892.

Aviculopecten sp.

Brachiopods

Terrakea *solida* (Etheridge & Dun) 1909

Strophalosia *ovalis* Maxwell 1954 (some specimens similar to *S.* *brittoni* var. *gattoni*)

Neospirifer sp.B

Ingelarella cf. *mantuanensis* Campbell 1960.

Fenestellid Bryozoans

Crinoid Cup

Z 73. Small quarry on road into Reid's Dome, 2.2 miles at 312° from "Ten Mile Hut".

Brachiopods

Terrakea sp. ind.

Strophalosia *clarkei* Etheridge Snr. 1872

Strophalosia *ovalis* Maxwell 1954

Bryozoans

Fenestellid and branching forms, and forms encrusting *Strophalosia* shells.

Sp 169. 3.3 miles at 58° from "Tanderra" (previously "Nardoo")

Pelecypods

Chaenomya sp. (small but of Fauna IV type)

Indet. shell fragments

Gastropods

Warthia sp.

Sp 378/1. 2.3 miles at 45° from "Kareela".

Pelecypods

Myonia sp. ind.

Brachiopods

Terrakea solida (Etheridge & Dun) 1909

Strophalosia ovalis Maxwell 1952 (some coarse spines on ears otherwise fine) Quartz pebble ½" across in matrix

Sp 391. Small quarry immediately north of road, 4.6 miles at 242° from "Wealwandangie".

Pelecypods

Phestia sp. (species referred to the genus Nuculana in previous reports are now assigned to Phestia - see Dickins, 1963).

Myonia carinata (Morris) 1845

Gastropods

Indet. pleurotomariid

Brachiopods

Terrakea solida (Etheridge & Dun) 1909 (wide variety, identified in Queensland Index Fossils as T. cf. brachythaera)

Strophalosia clarkei Etheridge Snr. 1872

Strophalosia clarkei var. minima Maxwell 1954

Strophalosia ovalis Maxwell 1954.

Ingelarella mantuanensis Campbell 1960

Terabratuloids

Fenestellid and Branching Bryozoans

Crinoid Ossicles

Single Corals

(The three species of Strophalosia identified seem to have a similar spine pattern - numerous fine spines over the body of the shell and coarser spines on the ears).

Sp 440/1. In Peawaddy Creek, 4 miles at 284° from "Consuelo".

Brachiopods

Terrakea solida (Etheridge & Dun) 1909

Strophalosia sp. ind.

Neospirifer sp.A.

Neospirifer sp.B.

Notospirifer minutus Campbell 1960

Terebratuloids

Branching Bryozoans

Sp 435. 1.2 miles at 302° from "Consuelo".

Pelecypods

Aviculopecten tenuicollis (Dana) 1847

Aviculopecten sp. ind.

Gastropods
  Indet. pleurotomariid
Brachiopods
  Terrakea solida (Etheridge & Dun) 1909
  Strophalosia clarkei Etheridge Snr. 1872 (predominates in numbers amongst Strophalosia)*

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* The taxonomic relationship of Strophalosia clarkei, S. clarkei var. minima, S. ovalis and S. brittoni var. gattoni has presented considerable difficulties. During the Bowen Basin Survey some thousands of specimens belonging to these species have been available for examination. Intergradation is found of important characters such as the depth and width of the valves and development of the umbo, dental callosities and ventral adductor muscle platform. In mature specimens, however, the ventral adductor muscle platform is generally moderately well developed and the overall spine pattern appears to be similar. In these circumstances, it might be better to regard these groups as varieties or subspecies, rather than referring them to three separate species. In numbers, S. clarkei var. minima predominates in the south-east part of the basin. S. clarkei in the northern part and S. ovalis in the south-west, suggesting that geographical subspecies may be represented. The distribution pattern, however, is a complex one as, for example, at Sp 435, in the south-west, S. clarkei predominates.

  Strophalosia cf. ovalis Maxwell 1954
  Neospirifer sp. A
  Notospirifer minutus Campbell 1960.
  Plekonella sp.
Single Corals

Sp 647. 2.2 miles at 12° from "Buckland Plains".
Brachiopods
  Terrakea solida (Etheridge & Dun) 1909
  Strophalosia ovalis Maxwell 1954
Branching Bryozoans
Single Corals

Sp 648/1. 1.2 miles at 200° from "Tanderra" (previously "Nardoo").
Brachiopods
  Ingelarella mantuanensis Campbell 1960

Sp 649. 2.0 miles at 188° from "Tanderra" (previously "Nardoo").
Some of the nodular material is very similar in appearance to that in Geological Survey of Queensland from Boat Mountain, Wealwandangie.

Pelecypods

Nuculopsis (Nuculopsis) sp.

Anthraconeilo sp.

Phestia sp.

Glyptoleda glomerata Fletcher 1945

Myonia carinata (Morris) 1845

Chaenomya? cf. carinata Etheridge Jnr. 1892

Chaenomya sp. (apparently Fauna IV type)

Pyramus? sp. (transverse oval form, in a general way similar to form in CL 12/1 of Clermont area)

Palaeosolen? sp.

Aviculopecten sp. ind.

Stutchburia costata (Morris) 1845

Astartidae gen. et sp.nov.B. (as in Fauna IV)

Conocardium sp.

Gastropods

Warthia sp.

Mourlonia (Mourlonopsis) cf. strzeleckiana (Morris) 1845 (has relatively long slit)

Mourlonia (Walnichollsia) cf. subcancellata (Morris) 1845. (as at MC 423 of Mt. Coolon Sheet area - early whorls carinate, later rounded).

Pleurotomariidae gen. et sp. (distinct ridge at periphery, whorl outline rectangular, distinct nodes on upper whorl surface).

Brachiopods

Terrakea solida (Etheridge & Dun) 1909

Strophalosia ovalis Maxwell 1954

Neospirifer sp.A.

Ingelarella mantuanesis Campbell 1960 (some approach I. ingelarensis in depth of sulcus)

Notospirifer minutus Campbell 1960

Licharewia sp. nov. (as in Fauna IV elsewhere)

Plekonella sp.

Terebratuloids

Single Corals

The matrix contains greenish cherty fragments up to ¾" across

Sp 719. 1.4 miles at 312° from Mt. Serocold.

Brachiopods

Terrakea solida (Etheridge & Dun) 1909 (specimens match those from Lonesome Creek road quarry of Monto Sheet area).

Strophalosia sp.ind.

Ingelarella mantuanensis Campbell 1960

Notospirifer minutus Campbell 1960

Terebratuloids

Fenestellid Bryozoans

Sp 729. 2.1 miles at 43° from "Tanderra" (previously "Nardoo")

Pelecypods

Glyptoleda sp. ind.

Astartila? sp. (juvenile specimen but similar to species in Fauna IV)

Gastropods

Warthia sp.

Mourlonia (Mourlonopsis) cf. strzeleckiana (Morris) 1845.

Brachiopods

Ingelarella sp. (one specimen of I. pelicanensis type as in Lonesome Creek Road quarry).

Scaphopods

Sp 731/2. 1.2 miles at 300° from Mt. Serocold.

Pelecypods

Myonia carinata (Morris) 1845

Myonia sp.ind.

Aviculopecten sp.ind.

Heteropecten sp.ind.

Brachiopods

Terrakea solida (Etheridge & Dun) 1909

Strophalosia cf. ovalis Maxwell 1954.

Neospirifer sp. A

Ingelarella mantuanensis Campbell 1960

Notospirifer minutus Campbell 1960

Relationships

The fauna from the lower part of the Peawaddy Formation (Sp 169 and Sp 729) is rather poor but Astartila? sp. and Ingelarella sp. afford slim evidence that Fauna IV is represented. In the subsurface, the Peawaddy Formation can be traced to Glentulloch No.1 Well, where Terrakea solida and Strophalosia ovalis have been recorded from Core 11 (2510-2530') at the base of the Peawaddy Formation (Dear, 1962). This is evidence for correlating the base of the Peawaddy Formation with the Oxtrack Formation of the Monto and Mundubbera areas and for considering that it is not older than the base of Unit C in the northern part of the Bowen Basin. In correlations of this nature, evidence based on one or two species whose ranges are poorly known, has been found to be unreliable. This is especially so when identification is based on small morphological differences whose taxonomic and stratigraphical significance is obscure. In this case, however, the identifications seem clear cut and a great deal of information is available on the ranges of T. solida and S. ovalis. The fauna of the Oxtrack Formation and its correlation with the Springsure sequence is considered further in Dickins (1964).

The Mantuan Productus Bed contains many species which are characteristic of Fauna IV and which do not occur lower down in Fauna III. In a general way, it is apparently equivalent to the upper Barfield and lower Flat Top Formation of the southeastern part of the basin. Whether it is equivalent to the Big Strophalosia Zone and the clarkei-bed of the northern part or to the Streptorhynchus pelicanensis Bed and the pelecypod bed, is a more difficult problem because, with a few exceptions the characteristic species of the Mantuan Productus Bed are found at both levels. The occurrence of N. minutus,*

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* Even here the evidence is not clear cut as N. minutus appears to occur in the Ingelarella isbelli horizon near Homevale, in the basal part of Unit C, and considerably below the Big Strophalosia Zone. This however, is additional positive evidence that the base of Unit C is younger than the Ingelara Formation.

Evidence for correlating the clarkei-bed of the Clermont Sheet area with the Big Strophalosia Zone of the Bowen area is considered in Dickins (in press) and for correlating the Crocker Formation of the Duaringa area with the pelecypod bed of the Clermont area and the Streptorhynchus pelicanensis of the Bowen area in Dickins (1963).

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lithological similarities, and the faunas from Glentulloch No.1 Core 9 (2215-2225') and from the Crocker Formation (Dickins, 1963) slightly favour a conclusion that the Mantuan Productus Bed is equivalent to the Streptorhynchus pelicanensis Bed and the pelecypod bed. It is probably equivalent, therefore, to the lower part of the Flat Top Formation rather than the upper Barfield (the fauna in Glentulloch No.1, Core 9, includes N. minutus as well as Terrakea solida, Dear, 1962). If this is correct the equivalent of the Big Strophalosia Zone = clarkei-bed is to be looked for lower in the Peawaddy Formation i.e. in the top part of the Catherine Sandstone of some previous authors. This would require a slight modification of conclusions made by Dickins, Malone & Jensen (in press) but would confirm the identification of the Big Strophalosia Zone by Dickins et al. in the Cooroorah, Morella and Arcadia Wells.

The Catherine Sandstone of Campbell (1960, 1961, after Hill, 1957) contained the Catherine Sandstone as restricted in the main report and all the Peawaddy Formation below the Mantuan

Productus Bed. When this is taken into account, the correlations of the Springsure sequence made here, correspond closely with Campbell's conclusions, except that the Ingelarella isbelli horizon of the Homevale area of the Mackay Sheet (found at the base of Unit C) is regarded as slightly younger than shown by Campbell (1961, p.167). If the lower part of the Big Strophalosia Zone were equivalent to the Ingelara Formation and the upper part to the Mantuan Productus Bed (Maxwell, 1954, p.535), the Big Strophalosia Zone would contain an hiatus representing the Catherine Sandstone and most of the Peawaddy Formation. Field examinations do not show any hiatus and lithological, bedding and faunal relationships throughout show that such a break is unlikely. Faunal evidence discussed earlier in this report, indicates the Big Strophalosia Zone is entirely younger than the Ingelara Formation.

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APPENDIX 2

1963 Plant Fossil Collections from Springsure, Queensland.

by

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SUMMARY

Plant fossils were collected at 37 localities in the Springsure region of Queensland in 1963. It was possible to determine the age of all but six of the fossil horizons on plant evidence.

The Joe Joe Formation, regarded by Shell as Permian was shown to be Carboniferous. The Mount Hall Conglomerate and the Ducabrook Formation contain Carboniferous Lepidodendron floras.

The Orion Shale contains Permian plants, and there is some evidence that it is of Lower Permian age. The Staircase Sandstone contains Lower Permian plants, and the Aldebaran Sandstone, Sirius Formation and Stanleigh Formation have floras of general Permian type without any forms diagnostic of Upper or Lower Permian. The Colinlea Sandstone has a Lower Permian assemblage of plants.

The Bandanna Formation contains two species of Glossopteris regarded as indicative of Upper Permian age. Plants from six localities in Bandanna Formation confirm an Upper Permian age for this formation.

The Clematis Sandstone and the Moolayember Formation both contain plant assemblages which could be of Triassic or Jurassic age.

INTRODUCTION

Plant fossils were collected from 37 localities in the Springsure area of Queensland in 1963 by R.G. Mollan and party. At many of the localities the plants are well preserved and the specimens are of considerable interest.

The localities have been arranged in stratigraphical order in the descriptions which follow. In some cases, field determination of formations has proved incorrect.

Field locality numbers are shown in Enclosure 1.

Plant Fossil Localities, plants identified, and age determinations of fossil horizons

1. Locality SP 79: $2\frac{1}{2}$ miles N.N.E. of Telemon Homestead. Springsure North, Run 1, Photo 5117, Pt. SP 79.

(Unit -"Middle Devonian Dunstable Fm.")

Specimens F 22337

Many indeterminate impressions of small stems are present. One lepidodendroid (decorticated) example shows features possibly of Protolepidodendron.

Age : ?Devonian.

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2. Locality SP 89/1: 4 miles West of Euneeke Homestead. Springsure North, Run 2, Photo 5018, Pt.SP 89/1.

(Unit -"Mount Hall Conglomerate")

Specimens F 22339

Stems of Lepidodendron veltheimianum Stbg. show many decortication forms as well as surface impressions.

Age: Carboniferous. Probably Lower Carboniferous. Unit therefore Mount Hall Conglomerate.

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3. Locality SP 80: 4 miles N.N.E. of Telemon Homestead. Springsure North, Run 1, Photo 5117, Pt.Sp 80.

(Unit - "?Telemon Formation").

Specimens F 22338

These specimens contain many lepidodendroid stems, mostly decorticated, showing features of Lepidodendron. Lenticular leaf trace scars are arranged in ascending spirals. Many of the impressions are of very young stems. There is a surface impression of a young stem, and a near-surface impression of a slightly older stem which shows that leaf base scars had rounded tops, pointed bases and a median groove similar to that seen in Lepidodendron scutatum Lx. In the absence of a surface impression of a mature stem it is not possible to determine the species. The stems are of the same general type as L. veltheimianum Stbg.

Age: Carboniferous, probably Lower Carboniferous. The unit is therefore not Telemon Formation

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4. Locality SP 56: Mistake Creek, about 10 miles N.W. of Telemon Homestead.

Springsure North, Run 1, Photo 5115, Pt. SP 56.

(Unit - "?Telemon Formation")

Specimens F22402

Decorticated, lepidodendroid stem impressions with widely spaced, lenticular leaf trace scars in an ascending spiral arrangement, are referred to Lepidodendron sp. No species determination can be made in the absence of surface impressions. Such decortication forms occur in Upper Devonian as well as in Lower Carboniferous species, but not in Leptophloeum australe which occurs in such profusion in Telemon Formation.

Age: Carboniferous, or Upper Devonian?
Unit probably not Telemon Formation.

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5. Locality SP 606: In Joe Joe Creek, immediately north of Joe Joe Homestead, in N.W. corner of Springsure Sheet.

Springsure North, Run 1, Photo 5109, Pt. SP 606

(Unit - "Joe Joe Formation. Shell's tentative Permian age not confirmed.")

Specimens F 22321
F 22322
F 22323
F 22330

The specimens from this locality contain well preserved fern fronds of characteristic Carboniferous appearance, showing a range of forms from examples with separate pinnules of "Rhacopteris meridionalis Feist." type, through intermediate forms to large, foliose pinnae not divided into distinct pinnules, of Cardiopteris polymorpha Goepp. type. It is clear from a study of all the specimens that all the pinna types seen in the collection are referable to one species. If the only specimen collected had been F 22321, this specimen would have been determined as Rhacopteris meridionalis Feist. Specimens in the collection of the Australian Museum, Sydney, referred to the species differ in no significant way from the frond in F 22321. The presence of a range of intermediate types, referable either to Rhacopteris or Cardiopteris, and of examples undeniably of "Cardiopteris polymorpha Goepp." (F 22322) confirms that one species is involved.

Diversity of pinnule form is a well known phenomenon in Carboniferous ferns of this sort. Seward ("Fossil Plants II") in discussing the problems of nomenclature arising from this diversity states that the name Ultopteris was suggested for ferns bearing Rhacopteris and Cardiopteris pinnae on the same plant.

There is no valid separation in form from the genus Neuropteridium and it has been decided by general consent to use the name Cardiopteris for Carboniferous examples and Neuropteridium for Mesozoic examples.

The name Cardiopteris polymorpha Goepp. is satisfactory for the specimens under discussion as it is descriptive of the diversity of form.

It seems likely, from the evidence in this collection, that Rhacopteris meridionalis Feist.may not be a valid species at all. In fact, some other species of Rhacopteris described from fragmentary specimens are possibly only diverse forms of Cardiopteris polymorpha Goepp.

In Eastern Australia the Carboniferous rocks are distinguished as Lepidodendron and Rhacopteris types. These overlap stratigraphically, the former being dominant in Lower Carboniferous and the latter beginning in the upper part of Lower Carboniferous and attaining full development in the Upper Kuttung beds and their equivalents.

Rhacopteris and Cardiopteris are recorded from many horizons in Australia including a Lower Carboniferous horizon at Stroud, N.S.W.; Glacial stage of Kuttung Series, N.S.W.; Upper Kuttung, N.S.W.; Upper Carboniferous passage beds into Lower Bowen at St. Helens in the Mackay-Proserpine region of Queensland; Silver Valley Series in Queensland; etc.

It is thus impossible to differentiate between Upper and Lower Carboniferous on the presence of Rhacopteris.

Age : Carboniferous.

(Shell's tentative Permian age is incorrect. There is no instance of Rhacopteris from Permian beds.)

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6. Locality SP 608: 5 miles west of Joe Joe Homestead. Springsure North, Run 1, Photo 5107, Pt. SP 608.

(Unit - "Joe Joe Formation").

Specimens F 22325

Indeterminate plant remains

Age: Indeterminate.

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7. Locality SP 609: 5 miles west of Joe Joe Homestead. Springsure North, Run 1, Photo 5107, Pt. SP 609.

(Unit -"Joe Joe Formation")

Specimens F 22326

Equisetalean stems.

Age: Indeterminate.

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8. Locality SP 311: 7½ miles west of Echo Hills Homestead.
Springsure North, Run 2, Photo 5024, Pt. SP 311.

(Unit-"Joe Joe Formation").

Specimens F 22327

Fragments of pinnules and rachis of *Cardiopteris polymorpha* Goepp. and Equisetalean stems occur in these specimens.

Age: Carboniferous.

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9. Locality SP 301: 6½ miles south of Echo Hills Homestead.
Springsure North, Run 2, Photo 5024, Pt. SP 301.

(Unit - "Below the Colinlea Sandstone which is regarded as Permian. Probably upper part of the Joe Joe Formation.")

Specimens F 22328 and F 22329

In Specimen F 22328 a small frond of *Cardiopteris polymorpha* Goepp. is present on one side, and a large frond with *Rhacopteris meridionalis* type pinnules on the reverse. In specimen F 22329, all the pinnules are of the latter type. In the light of evidence of the identity of the two forms at Locality 606, all fronds are referred to *Cardiopteris polymorpha*.

Age: Carboniferous

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10. Locality SP 352/2: 1¼ miles N.W. of Tresswell Homestead.
Springsure North, Run 2, Photo 5020, Pt. SP 352/2.

(Unit-"Ducabrook Formation")

Specimens F 22331

Equisetalean stems

Age: Indeterminate.

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11. Locality SP 354/1A: 1½ miles N.W. of Tresswell Homestead.
Springsure North, Run 2, Photo 5020, Pt. SP 354/1.

(Unit - "Ducabrook Formation ")

Specimens F 22334

Equisetalean stems

Age : Indeterminate.

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12. Locality SP 374/1B: 2 miles S.E. of Nandowrie Needle.

Springsure North, Run 3, Photo 5016, Pt.SP 374/1

(Unit - "From probable upper parts of Joe Joe Formation")

Specimens F 22403.

A decorticated stem impression is the only plant fossil present. It appears to be lepidodendroid.

Age: ? Devonian or Carboniferous.

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13. Locality SP 41: 3 miles W.S.W. of Mount Hall.

Springsure North, Run 2, Photo 5022, Pt.SP 41.

(Unit - "Top of Mount Hall Conglomerate, in the Telemon anticline. Formation regarded as Lower Carboniferous as it forms the base of the apparently conformable sequence, the top of which, (Ducabrook Formation) is regarded as Lower Carboniferous.")

Specimens F 22332.

Stem impressions of all sizes are present. Most are indeterminate with irregular vertical striations. One shows decorticated lepidodendroid form of elongated leaf trace scars widely spaced. It appears to be referable to *Lepidodendron* but is too deeply decorticated to be allocated to a species.

Age : Probably Carboniferous

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14. Locality SP 363/4B: 2 miles West of Connemarra Homestead.

Springsure North, Run 1, Photo 5117, Pt.SP 363/4.

(Unit - "Top of Ducabrook Formation.")

Specimens F 22391

Lepidodendron veltheimianum Stbg. is identified in these specimens from surface impressions of young stems. There are many decortication forms present as well. Some ribbon-like impressions with a median sulcus may represent large leaves of *Lepidodendron*, or may be stem impressions of the sort frequently found with *Rhacopteris* in Carboniferous horizons.

Age: Carboniferous

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15. Locality SP 364/1: 1½ miles South of Glenlee Homestead. Springsure North, Run 1, Photo 5115, Pt. SP 364/1.

(Unit - "Ducabrook Formation.")

Specimens F 22392.

A cast of a lepidodendroid stem is referred to Lepidodendron sp. An impression of a decorticated stem is indeterminate.

Age: Carboniferous

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16. Locality SP 363/4A. 2 miles West of Connemarra Homestead. Springsure North, Run 1, Photo 5117, Pt. SP 363/4.

(Unit - "From a thin unit probably unconformably overlain by Colinlea Sandstone, apparently unconformably on the Ducabrook Formation. Lithologically like Joe Joe Formation.")

Specimens F 22393

Preservation of the fossils is poor. Leaves tentatively referred to Glossopteris indica Sch. and Glossopteris ampla Dana are present.

Age: Permian

This unit is not Joe Joe Formation to which it is lithologically similar. It is not Carboniferous Ducabrook Formation. It is presumably Lower Permian, and is probably part of the Colinlea Sandstone.

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17. Locality SP 4: 3 miles S.W. of Mount Sirius in a North Branch of Orion Creek.

Springsure North, Run 2, Photo 5012, Pt. SP 4.

(Unit - "Orion Formation").

Specimens F 22335.

A large leaf of Glossopteris indica Sch. is associated with a fragment of leaf of Gangamopteris sp., whose presence suggests a Lower Permian age.

Age: Permian. Probably Lower Permian.

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18. Locality SP 4A: 3 miles S.W. of Mount Sirius, in a North Branch of Orion Creek.

Springsure North, Run 2, Photo 5012, Pt. 100 yds. W. of SP 4.

(Unit - "Orion Formation")

Specimens F 22336.

Glossopteris sp.

Glossopteris scale leaf.

Age: Permian.

19. Locality SP 3: 2½ miles S.W. of Mount Sirius, in a North Branch of Orion Creek.

Springsure North, Run 2, Photo 5012, Run , Pt.SP 3.

(Unit - "Orion Formation, the lowest formation exposed in the northern culmination of the Springsure anticline.")

Specimens F 22365.

A well preserved *Glossopteris* flora is present in these specimens. The venation is clearly shown. The following are identified :-

Glossopteris communis Feist.

Glossopteris indica Sch.

Glossopteris angustifolia Brong.

Glossopteris stricta Bunb.

Glossopteris browniana Brong.

Glossopteris tortuosa Zeiller.

Glossopteris scale leaves.

Noeggerathiopsis hislopi Bunb.

Age : Permian. Probably Lower Permian.

Note on the age of the Orion Formation:

Evidence from the plant fossils at localities Sp 4, SP 4A and SP 3 for a Lower Permian age is somewhat meagre. A fragment of *Gangamopteris* venation at SP 4 suggests Lower Permian, but at SP 4A and SP 3, plants of general Permian distribution occur. The *Noeggerathiopsis hislopi* Bunb. at SP 3 is not of the coarse type restricted to Lower Permian.

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20. Locality SP 387/7: 3½ miles N.W. of Croydon Hills Homestead.

Springsure North, Run 3, Photo 5008, Pt.SP 387/7.

(Unit - "Near the top of the Lower Permian Staircase Sandstone".)

Specimens F 22394

Gangamopteris cyclopteroides Feist.

Glossopteris ampla Dana.

Age : Lower Permian

Gangamopteris cyclopteroides does not persist into Upper Permian.

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21. Locality SP 392/3: 2 miles west of Mount Kelman Homestead.
Springsure North, Run 3, Photo 5008, Pt. SP 392/3.

(Unit - "Basal part of Lower Permian Aldebaran Sandstone").

Specimens F 22395

Sulcate stems are present. They are indeterminate but are of the same type as those which occur with *Rhacopteris* in Carboniferous floras.

Age : Indeterminate

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22. Locality SP 112/1: Aldebaran Creek, South branch, about 3 miles East of Mount Catherine.
Springsure North, Run 4, Photo 5068, Pt. SP 112/1.

(Unit - "Base of Aldebaran Sandstone, Lower Permian").

Specimens F 22404

Large numbers of impressions of *Vertebraria indica* Royle, some with numerous lateral appendages, are present.

Vertebraria indica occurs throughout Permian, and there is nothing to indicate whether the specimens are Upper or Lower Permian.

Age : Permian.

Note on Aldebaran Sandstone: A Permian age is indicated by the plant fossils. There is no plant evidence for Lower Permian as the plant species present ranges throughout Permian.

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23. Locality SP 392/4: 3 miles N.W. of Mount Kelman Homestead.
Springsure North, Run 3, Photo 5008, Pt.SP 392/4.

(Unit - "Lower Permian Sirius Formation").

Specimens F 22396

Fragments of *Glossopteris* venation

Age: Permian.

No indication whether Upper or Lower Permian.

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24. Locality SP 406/3: 2 miles South of Stanleigh Homestead. Springsure North, Run 3, Photo 5008, Pt. SP 406/3.

(Unit - "Top of Lower Permian Stanleigh Formation").

Specimens F 22397

Equisetalean stems

Fragments of *Glossopteris* venation.

Age: Permian

No plant evidence for Lower Permian

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25. Locality SP 374/1A: 2 miles S.E. of Nandowrie Needle. Springsure North, Run 3, Photo 5016, Pt. SP 374/1

(Unit - "From shale underneath the Colinlea Sandstone".)

Specimens F 22405

Vertebraria indica Royle

Gangamopteris cyclopteroides Feist.

? *Glossopteris ampla* Dana.

Glossopteris indica Sch.

Age : Lower Permian.

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26. Locality SP 120 : About 1 mile East of Vandyke Homestead. Springsure North, Run 2, Photo 5016, Pt.SP 120.

(Unit - "Colinlea Sandstone.")

Specimens F 22406

These specimens are poorly preserved. The following are identified :-

Vertebraria indica Royle.

Glossopteris indica Sch.

? *Gangamopteris* sp.

? *Palaeovittaria* sp.

Sphenopteris sp. pinnules

Age: Permian ?Lower Permian.

Note on Colinlea Sandstone : Plant evidence supports a Lower Permian are for the Colinlea Sandstone.

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27. Locality SP 607: 5 miles West of Joe Joe Homestead.
Springsure North, Run 1, Photo 5107, Pt. SP 607.

(Unit - "From the Colinlea Sandstone")

Specimens F 22324

Plants identified :-

Glossopteris indica Sch.

Glossopteris angustifolia Brong.

Glossopteris scale leaf.

Age : Permian. No indication whether Upper or Lower Permian.

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28. Locality SP 639: 3½ miles N.W. of Mantuan Downs Homestead.
Springsure North, Run 3, Photo 5022, Pt. SP 639.

(Unit - "Bandanna Formation")

Specimens F 22333.

The following are identified:

Glossopteris communis Feist.

Glossopteris ampla Dana.

Glossopteris taeniopteroides Feist.

Glossopteris conspicua Feist.

Equisetalean stems.

Age: Upper Permian (on presence of G. *conspicua* and G. *taeniopteroides*)

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29. Locality SP 93: ½ mile South of Avoca Homestead, in Freitag Creek.
Springsure North, Run 4, Photo 5066, Pt.SP 93.

(Unit - "Bandanna Formation").

Specimens F 22340.

Glossopteris communis Feist.

Equisetalean stems

Phyllotheca etheridgei Arber leaf whorls.

Sphenopteris polymorpha Feist.

Part of small cone - probably Equisetalean.

Age : Permian. Probably Upper Permian on the presence of *Phyllotheca etheridgei*

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30. Locality SP 102: 4 miles S.S.W. of Goathland Homestead, in Cona Creek.

Springsure, Run 1, Photo 5102, Pt. SP 102.
(Unit - "Bandanna Formation")

Specimens F 22341

These very coaly speciemsn contain the following plants :-

Glossopteris conspicua Feist.

Glossopteris ampla Dana

Vertebraria indica Royle.

Equisetalean stems.

Age : Upper Permian.

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31. Locality SP 377/1: 1½ miles South of Kareela Homestead.

Springsure North, Run 4, Photo 5064, Pt.SP 377/1.
(Unit - "Bandanna Formation")

Specimens F 22398

The plant remains in these specimens are fragmentary. The following are identified :-

Glossopteris communis Feist.

Glossopteris conspicua Feist.

Glossopteris tortuosa Zeiller.

Vertebraria indica Royle.

Equisetalean stems.

Age : Upper Permian.

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32. Locality SP 396/2: 3¾ miles E.N.E. of Freitang Homestead.

Springsure North, Run 3, Photo 5010, Pt. SP 396/2.
(Unit - "Upper Permian Bandanna Formation").

Specimens F 22399.

Fragments of leaves of the following are present :-

Glossopteris conspicua Feist.

Glossopteris ampla Dana

Glossopteris indica Sch.

Glossopteris parallela Feist.

Age : Upper Permian.

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33. Locality SP 396/4: 3½ miles E.N.E. of Freitag Homestead.
Springsure North, Run 3, Photo 5010, Pt. SP 396/4

(Unit - "Bandanna Formation above SP 396/2")

Specimens F 22400 and F 22401

Fragments of leaves of Glossopteris conspicua Feist. and Glossopteris indica Sch. are associated with Equisatalean stems. There are also three foliar organs which are believed to be fertile male scale fronds of Glossopteris type. They were apparently flat, thin, leaf-like structures. Each has elongated, narrow depressions following the gangamopteroid venation pattern. The depressions are believed to represent sporangia.

Age: Upper Permian

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34. Locality SP 713: Reid's dome, Mitchell Creek, a mile above the junction with Rocky Creek.
Springsure, Run 3, Photo 5149, Pt. SP 713.

(Unit - "Upper part of the Bandanna Formation")

Specimens F 22407, F 22408, F 22409.

Beautifully preserved leaves of the following species of Glossopteris are present :

Glossopteris conspicua Feist.

Glossopteris communis Feist.

Glossopteris angustifolia Brongn.

Glossopteris indica Sch.

Glossopteris damudica Feist.

Obscure fructification: A thin stalk 1.5 cm. long and .15 cm. wide has an expanded head with four lobes. Each has a raised rib along its centre. The lobes are blunt. No reliable guess can be made as to the nature of this specimen.

Age: Upper Permian.

Note on the age of the Bandanna Formation

Evidence from the plant fossil collections confirms an Upper Permian age for the Bandanna Formation.

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35. Locality SP 160: At base of Mount Carnarvon.

Springsure, Run 4, Photo 5231, Pt. SP 160.

(Unit - "from lower part of Clematis Sandstone")

Specimens F 22410

Equisetalean stems

Age: Indeterminate.

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36. Locality SP 508: 7 miles South of Consuelo Homestead, Rewan Syncline.

Springsure, Run 3, Photo 5145, Pt. SP 508.

(Unit - "Top part of Clematis Sandstone).

Specimens F 22411, F 22412

In specimen F 22411, two magnificent fronds of Dicroidium odontopteroides (Morr) Gothan are present. Carbonised cuticular material covers the impression surface and preparations of cuticles will be made in due course for microscopic examination.

Specimens F 22412 contain Equisetalean stems and small fragments of Dicroidium odontopteroides.

Dicroidium odontopteroides ranges from Middle Triassic to Middle Jurassic.

Age: Triassic or Jurassic

Note on the Clematis Sandstone: On plant evidence a Triassic or Lower Jurassic age is indicated.

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37. Locality SP 664: 30 miles South of Mantuan Downs Homestead.

Springsure, Run 3, Photo 5181, Pt. SP 664.

(Unit - "Moolayember Formation".)

Specimens F 22413

The following are identified :-

Pterophyllum nathorsti (Seward).

Dicroidium odontopteroides (Morr) Gothan

Pterophyllum abnorme Eth. fil.

? Sphenopteris superba Shirley

Dicroidium coriacium (Johnst.) Townrow.

Dicroidium odontopteroides occurs in Triassic and Lower Jurassic. Dicroidium coriacium occurs in the Ipswich Series in Queensland and in Triassic of Tasmania etc. Pterophyllum nathorsti and P. abnorme occur in the Walloon Series in Queensland.

Age: Triassic or Jurassic

Note on Moolayember Formation: There is no plant evidence in this collection to limit the Moolayember Formation to Triassic. It could equally well be Lower Jurassic.

APPENDIX 3

SUMMARY REPORT ON A SUITE OF SPECIMENS FROM THE NOGOA AND TELEMON ANTICLINES

by

Beverley R. Houston

The pre-Devonian rocks of the Telemon Anticline are represented by sheared and silicified diorite and biotite-quartz phyllite only.

DUNSTABLE FORMATION

The Dunstable Formation is predominantly volcanic; basalt is the commonest rock type followed by andesite, trachyte, rhyolite and tuff. One specimen of spilitised basalt was also described. These rocks were compared with material described (1961) from the Silver Hills Volcanics (Emerald Sheet area); no specific correlation of a specimen from the Dunstable Formation with one from the Silver Hills Volcanics could be made; when the assemblage of rock types, however, together with the composition, type and degree of alteration and texture of the rocks from both formations are examined, there can be no hesitation in correlating the two formations.

Sediments are less abundant than volcanics and are essentially of the lithic greywacke/subgreywacke type. As can be seen from the accompanying diagram, there is no distinct pattern in the composition or origin of the detritus of the Dunstable and Telemon (Emerald) Formations. The abundance of detritus derived from the Dunstable volcanics in some of the Dunstable sediments supports the theory of a hiatus or disconformity within the formation.

The examination of specimens from the area of "Tertiary Basalt" (Shell) in the Telemon Anticline has shown, without doubt, that this material is Palaeozoic - not Tertiary. By comparison, the specimens appear to belong to the Dunstable Formation.

Minor localised shearing has occurred within the Dunstable Formation; there is no other effective evidence for placement of the rocks GSQ 3366-3368 in the Dunstable or Telemon Formations.

TELEMON FORMATION

This formation is represented by lithic subgreywacke (see accompanying diagram). These rocks are not distinctly different from sediments of the Dunstable Formation or similar to the Telemon Formation of the Emerald Sheet area. The specimens GSQ 3361 (sandy calcarenite) and GSQ 3262 (vitric tuff) appear to belong to this formation also; no similar material is represented in the Dunstable Formation.

For all specimens :
Map : Springsure 1:250,000
Airphotoset: Springsure North, 1:80,000
Specimen submitted by:BMR-GSQ Springsure Party

Note: Field locality numbers are shown in Enclosure 7.

PRE-DEVONIAN METAMORPHICS

Telemon Anticline

Microslide GSQ 3363 ex Specimen GSQ/R 2489 Field No. SP 38

Run 1/ Photo 5115/ Point 38.

Macro:- A massive, medium-grained, dark grey, foliated granitic rock.

Micro:-

Texture: Originally hypidiomorphic-granular, 0.5 to 2 mm. The rock has been sheared and consists of anhedral to subhedral lath-shaped crystals 0.5 to 2 mm. interstitial pools of strain mosaic about 1 mm (anhedra 0.04 to 0.2mm) and irregular ragged strings of coarse bent flakes and very fine fresh flakes.

Constituents: Andesine-labradorite: about 60% of rock, lath-shaped crystals.

Quartz: about 15% of rock; interstitial pools consisting of fine, strained, interlocking anhedra.

Mica: about 25% of rock; coarse ragged brown biotite, fine fresh greenish biotite and associated chlorite and minor epidote.

Origin:- Shearing and partial recrystallisation of a plutonic rock. Some of the quartz may have been introduced.

Name:- SHEARED SILICIFIED DIORITE

Microslide GSQ 3364 ex Specimen GSQ/R 2490 Field No. SP 39

Run 1/ Photo 5115/ Point 39

Macro:- Essentially similar to GSQ/R 2489

Micro:- Essentially similar to GSQ 3363 except in the following details :-

1. GSQ 3364 contains only about 10% quartz.
2. GSQ 3364 contains little or no biotite; coarse poikilitic hornblende crystals are abundant together with chlorite and epidote.

Name:- SHEARED AND SILICIFIED DIORITE.

Microslide GSQ 3365 ex Specimen GSQ/R 2491 Field No. SP 36/2

Run 1/ Photo 5115 / Point 36/2

Macro :- A light grey, fine-grained, layered rock with evidence of slickensiding on the surfaces.

Micro :-

Texture:- Lepidoblastic, about 0.09 mm.

Constituents: Quartz: about 70% of rock

Biotite: about 30% of rock.

Origin:- Shearing of a siliceous-argillaceous sediment.

Name :- BIOTITE-QUARTZ PHYLLITE

DUNSTABLE FORMATION

Telemon Anticline

Microslide GSQ 3348 ex Specimen GSQ/R 2474 Field No. SP 22A

Run 1/ Photo 5113 / Point 22

Macro :- A massive, very fine-grained, pink rock.

Micro:-

Texture: Porphyritic; the phenocrysts (about 10% of rock) are subhedral, somewhat corroded, 0.17 to 1 mm. The groundmass is cryptocrystalline to microcrystalline, extremely altered. About 5% "patches" of secondary quartz mosaic are distributed at random.

Phenocrysts: Oligoclase-andesine: about 10% of the rock considerably altered.

Groundmass: Hematite-stained altered feldspar with about 5% secondary quartz.

Origin:- Alteration of volcanic, extrusive.

Name:- SILICIFIED TRACHYTE.

GSQ/R
Microslide GSQ 3355 Ex Specimen 2481 Field No. SP 26B

Run 1/ Photo 5113 / Point 26

Macro:- A massive, fine-grained, purplish-brown, clastic rock, bedded in part.

Micro:-

Texture: Clastic; the clasts (about 70% of rock) are rounded to subrounded, of moderate to high sphericity, about 0.5 mm. Three distinct cements occur between the clasts.

Clasts: Lithic material: about 55% of rock; essentially Dunstable volcanics with minor chert and mica schist.

Feldspar: $>$10% of rock; dominantly oligoclase

Quartz: $<$5% of rock; strained.

Cements: Cryptocrystalline quartz: about 25% of rock.

Zeolite: about 5% of rock.

Opaque mineral: minor.

Origin:- Sedimentary

Name:- SILICEOUS LITHIC GREYWACKE

GSQ/R
Microslide GSQ 3345 ex Specimen 2471 Field No. SP 27

Run 1/ Photo 5113 / Point 27

Macro:- An extremely altered, very fine-grained, red-brown, amygdaloidal rock. Amygdales make up about 25% of rock.

Micro:-

Texture: Intersertal, cryptocrystalline to 0.07 mm. Seconadry veins and amygdales make up about 25% of rock.

Constituents: Andesine about 40% of rock; crystallites and subhedral laths.

Secondary minerals: about 35% of rock; filling interstices; translucent, consisting dominantly of opaques and hematite.

Veins and Amygdales: Quartz and chlorite: about 25% of rock; fine mosaic.

Origin:- Extreme alteration of volcanic extrusive.

Name:- ALTERED ? ANDESITE

Microslide GSQ 3347 ex Specimen GSQ/R 2473 Field No. SP 35

Run 1/ Photo 5113 / Point 35

Macro:- A massive, very fine-grained, dark grey, amygaloidal rock.

Micro:-

Texture: Porphyritic; the phenocrysts (about 5% of rock) are subhedral, lath-shaped, 0.5 to 3 mm. The groundmass is intersertal, about 0.2 mm. Amygdules make up about 5% of rock

Phenocrysts: Oligoclase: about 5% of rock; chloritised and calcitised in part.

Iddingitised olivine: minor.

Groundmass: Plagioclase: about 65% of rock; extremely altered, lath-shaped.

Secondary minerals: about 25% of rock; dominantly opaques, hematitic clay minerals, calcite, chlorite, serpentine etc.

Amygdules: Calcite: about 5% of rock.

Origin:- Volcanic, extrusive.

Name:- SPILITE

Microslide GSQ 3339 ex Specimen GSQ/R 2465 Field No. SP 48 A

Run 1/ Photo 5113 / Point 48

Macro:- A massive, fine-grained, pinkishgrey rock.

Micro:- Essentially similar to GSQ 3336 except that the phenocrysts are not so coarse and secondary ironstaining is much more abundant; unaltered pyroxene is less abundant in GSQ 3339.

Name:- ALTERED BASALT

Microslide GSQ 3338 ex Specimen GSQ/R 2464 Field No. SP 48B

Run 1/ Photo 5113 / Point 48

Macro:- A massive, fine-grained, grey rock with abundant phenocrysts to 2 mm.

Micro:- Essentially similar to GSQ 3336 except that the maximum size of phenocrysts in GSQ3338 is 2 mm and secondary ironstaining is much more abundant.

Name:- ALTERED BASALT

Microslide GSQ 3342 ex Specimen GSQ/R 2468 Field No SP 48 C

Run 1/ Photo 5113 / Point 48

Macro:- An extremely altered, fine-grained, pink and grey igneous rock.

Micro:-

Texture: Porphyritic, amygdaloidal. The phenocrysts (about 5% of rock) are subhedral to anhedral, lath-shaped, 1 to 2 mm. The groundmass is intersertal, 0.08 to 0.3 mm. The amygdules are irregular, of the order of 2 mm (about 10% of rock).

Phenocrysts: Acid Andesine: $\leqslant$5% of rock; considerably altered.

Alkali feldspar: minor ; altered.

Groundmass: Plagioclase: about 60% of rock; extremely altered.

Interstitial minerals: about 25% of rock; including
- epidote
- opaques (about 0.003 mm)
- chlorite
- uralite

Amygdules:- Zeolite: about 10% of rock

Origin:- Alteration of volcanic extrusive.

Name:- ALTERED ANDESITE

Microslide GSQ 3344 ex Specimen GSQ/R 2470 Field No. SP 49 A

Run 1 / Photo 5113 / Point 49

Macro:- A massive, fine-grained, dark grey rock with about 10% phenocrysts up to 10 mm.

Micro:-

Texture: Porphyritic; the phenocrysts (about 10% of rock) are subhedral, lath-shaped, about 10 mm in length. The groundmass is intersertal, to subophitic, about 0.25 mm.

Phenocrysts: Andesine-labradorite: about 10% of rock; considerably altered.

Groundmass: Plagioclase: about 50% of rock; altered.

Clinopyroxene: about 20% of rock; uralitised in part.

Opaques: about 5% of rock.

Secondary minerals: about 15% of rock; filling interstices; essentially chlorite.

Origin:- Volcanic, extrusive.

Name:- ALTERED BASALT

Microslide GSQ 3357 ex Specimen GSQ/R 2483 Field No. SP 50

Run 1/ Photo 5113 / Point 50

Macro:- A massive, coarse-grained, light-grey, clastic rock.

Micro:-

Essentially similar to GSQ 3354 except that this rock, apparently, has not been sheared. Two generations of calcite occur and rare volcanic grains are clearly recognisable.

Name: CHERT-VOLCANIC BRECCIA

Microslide GSQ 3356 ex Specimen GSQ/R 2482 Field No. SP 53B

Run 1/ Photo 5115 / Point 53

Macro:- A massive, very fine-grained, pink to purplish-brown "ribbonstone".

Micro:-

Texture: Clastic; the clasts (about 40% of rock) are subhedral, lath-shaped, partly corroded, about 0.04 to 0.3 mm and rarely, subrounded grains. The matrix is very fine-grained. Minor random "patches" of secondary mosaic occur.

Clasts: Acid to intermediate plagioclase: about 40% of rock; highly altered.

Lithic material: minor; volcanic

Matrix: Argillaceous (tuffaceous): about 55% or rock hematite-stained to a greater or less degree hence the "ribbonstone" effect.

Secondary Minerals: Quartz and zeolite: about 5% of rock.

Origin: Pyroclastic

Name: ALTERED CRYSTAL TUFF

Microslide GSQ 3341 ex Specimen GSQ/R 2467 Field No. SP 55

Run 1/ Photo 5115 / Point 55

Macro:- A massive, fine - to medium-grained grey rock.

Micro:-

Texture: Uneven-grained, intersertal, 0.04 to 3 mm.

Constituents: Labradorite: about 65% of rock; in general, extremely altered.

Clinopyroxene: about 30% of rock; in general, pseudomorphed by uralite or bastite.

Chlorite: about 5% of rock; filling interstices.

Origin:- Volcanic, high-level intrusive, or extrusive.

Name:- ALTERED BASALT

Nogoa Anticline: Nogoa River, upstream from the "Telemon"Crossing

Microslide GSQ 3353 ex Specimen GSQ/R 2479 Field No. SP 60 A

Run 2 / Photo 5018/ Point 60

Macro:- A massive, medium-grained, dark grey clastic rock, traversed by numerous fine veins.

Micro:- Essentially similar to GSQ 3352 except in the following:

1. Fragments of Pre-Devonian granite are present in GSQ 3353.
2. Brown chlorite cement occurs in GSQ 3353 instead of detrital matrix.

Name:- LITHIC SUBGREYWACKE

Microslide GSQ 3343 ex Specimen GSQ/R 2469 Field No. SP 60 B

Run 2/ Photo 5018 / Point 60

Macro:- A massive, fine-grained, dark grey rock with about 5% greenish amygdales and numerous very fine veins.

Micro:-

Texture: Porphyritic; the phenocrysts (about 5% of rock) are 0.3 to 2+ mm, subhedral to anhedral, lath-shaped. The groundmass is extremely altered ? intersertal, about 0.12 mm. About 10% veins and amygdales traverse the rock.

Phenocrysts: Andesine: About 5% of rock; extremely altered commonly chloritised.

Groundmass: Plagioclase: about 50% of rock; extremely altered.

Opaques: about 5% of rock; very fine.

Quartz: about 5% of rock; interstitial.

Secondary minerals: about 25% of rock; filling interstices; unidentified.

Veins and Amygdales: Epidote, prehnite, and zeolite: about 10% of rock; intimately associated.

Origin: Volcanic, extrusive.

Name:- ALTERED ANDESITE

Microslide GSQ 3352 ex Specimen GSQ/R 2478 Field No. SP 60 C

Run 2 / Photo 5018 / Point 60.

Macro:- A massive, coarse-grained, grey clastic rock.

Micro:-

Texture: Clastic; the clasts (about 90% of rock) are 0.5 to 4+ mm, subrounded to subangular, of moderate to low sphericity. The matrix (about 10% of rock) is very fine-grained.

Clasts: Lithic material: about 90% of rock - Dunstable volcanics.

Matrix: Argillaceous - ?tuffaceous: about 10% of rock.

Origin: Sedimentary, derived from Dunstable volcanic terrain.

Name:- ?TUFFACEOUS - LITHIC SUBGREYWACKE

Microslide GSQ 3335 ex Specimen GSQ/R 2461 Field No. SP 60 D

Run 2/ Photo 5018 / Point 60

Macro:- A massive, fine-grained, grey rock with about 25% feldspar phenocrysts up to 4 mm.

Micro:-

Texture: Porphyritic; the phenocrysts (about 40% of rock) are subhedral to anhedral lath-shaped and embayed anhedra, 0.25 to 5 mm. The groundmass is intersertal to fluidal, microcrystalline to 0.06 mm. The rock is traversed by fine veins.

Phenocrysts: Feldspar: about 25% of rock; extremely altered.

Quartz: about 10% of rock; corroded.

Augite: about 5% of rock; in general, pseudomorphed by calcite, chlorite (penninite and another variety) and epidote with minor associated opaques and prehnite.

Groundmass: Intermediate plagioclase: about 40% of rock; extremely altered.

Chlorite: about 20% of rock; filling interstices.

Origin:- Alteration of a volcanic extrusive.

Name:- ALTERED AUGITE ANDESITE.

Microslide GSQ 3349 ex Specimen GSQ/R 2475 Field No. SP 60 E

Run 2/ Photo 5018 / Point 60

Macro: A massive, medium-grained, pinkish-grey clastic rock.

Micro:

Texture: Clastic; clasts (about 70% of rock) are subrounded, of moderate sphericity, 0.35 to 3 mm (dominantly about 1.0 mm). About 30% crystalline cement (about 1 mm) occurs also.

Clasts: Quartz: about 60% of rock; strained, with abundant minute inclusions.

Quartzite: about 5% of rock; foliated.

Volcanics: about 5% of rock; altered basic Dunstable flows.

Cement: Calcite: about 30% of rock.

Origin:- Sedimentary; derived from Pre-Devonian rocks and Dunstable Formation volcanics.

Name:- CALCAREOUS SUBGREYWACKE

Microslide GSQ 3354 ex Specimen GSQ/R 2480 Field No. SP 62

Run 2/Photo 5018/ Point 62

Macro:- A massive, uneven-grained, light grey, siliceous clastic rock.

Micro:-

Texture: Indefinable, clastic, The rock consists of abundant ?sheared volcanic with chert fragments and abundant secondary calcite.

Origin:- ?Sedimentary

Name:- ? SHEARED CHERT-VOLCANIC SEDIMENT.

Nogoa Anticline; north-west of "Telemon".

Microslide GSQ 3333 ex Specimen GSQ/R 2459 Field No. SP 63

Run 2 / Photo 5018 / Point 63

Macro:- A massive, very fine-grained, purplish-grey, altered rock containing som 45% pink zeolite amygdales or spherulites.

Micro:-

Texture: Amygdaloidal (about 45% rock). The remainder of the rock is cryptocrystalline to microcrystalline, essentially allotriomorphicgranular. Numerous very fine (about 0.09 mm), roughly parallel, discont-inuous veins occur. The veins consist of fibrous mineral, oriented with a double row of fibres aligned with their long axes normal to the length of the veins.

Constituents: Zeolitised feldspar: essential; unidentified.

Epidote: accessory; dark red brown.

Veins: chalcedony.

Amygdales: Phillipsite in the core surrounded by quartz minor chalcedony may be present also.

Origin: Alteration of a volcanic extrusive; the alteration may be due to hydrothermal activity or to sub-aqueous deposition.

Name:- ALTERED TRACHYTE

Microslide GSQ 3351 ex Specimen GSQ/R 2477 Field No. SP 67 A

Run 2 / Photo 5018 / Point 67

Macro:- A massive, fine-grained, greenish-grey clastic rock.

Micro:-

Essentially similar to GSQ 3350 except in the following:-

1. The clasts in GSQ 3351 are 0.08 to 1 mm. dominantly about 0.25 mm.
2. Mica makes up about 5% of GSQ 3351
3. The matrix of GSQ 3351 is argillaceous - micaceous with little or no hematite.

Name:- GREYWACKE

Microslide GSQ 3350 ex Specimen GSQ/R 2476 Field No. SP 67 B

Run 2/ Photo 5018 / Point 67.

Macro:-A massive, fine-grained, pink, clastic rock with the bedding marked by fine, dark layers of limonite.

Micro:-

Texture: Clastic; the clasts (about 90% of rock) are subrounded to subangular, of moderate sphericity, 0.04 to 0.25 mm dominantly about 0.12 mm. Detrital matrix makes up about 25% of rock.

Clasts: Quartz: about 40% of rock; strained.

Feldspar: about 5% of rock; altered.

Lithic material: about 30% of rock; dominantly altered Dunstable volcanics with minor Pre-Devonian siliceous material.

Muscovite: minor.

Matrix: Hematite-Argillaceous: about 25% of rock.

Origin:- Sedimentary, derived from a Dunstable Volcanic and pre-Devonian terrain. The origin of the matrix is doubtful but it was possibly derived from the abrasion of volcanic detritus.

Name:- GREYWACKE

Microslide GSQ 3336 ex Specimen GSQ/R 2462 Field No. SP 68 A

Run 2 / Photo 5018 / Point 68.

Macro:- A massive, fine-grained, dark grey rock with coarse feldspar phenocrysts.

Micro:-

Texture: Porphyritic; the phenocrysts (about 20% of rock) are subhedral to anhedral, lath-shaped, 0.5 to 6 mm. The groundmass is intersertal, about 0.08 mm. Several fine veins traverse the rock.

Phenocrysts: Labradorite: about 20% of rock; extremely altered.

Mafic mineral: minor; pseudomorphed by chlorite and serpentine.

Groundmass:- Plagioclase: about 50% of rock; extremely altered.

Secondary mineral: about 30% of rock; filling interstices.

Opaques: about 10% of rock; very fine granular.

Veins:- Prehnite.

Origin:- Alteration of a volcanic extrusive.

Name: - ALTERED BASALT

Microslide GSQ 3337 ex Specimen GSQ/R 2463 Field No SP 68 B

Run 2 / Photo 5018 / Point 68.

Macro: A massive, fine-grained, grey rock with about 20% altered phenocrysts (to 4 mm) and 5% green amygdales (to 3 mm).

Micro:-

Texture: Porphyritic; the phenocrysts (about 25% of rock) are anhedral to subhedral, 0.2 to 2 mm. The groundmass is intersertal to intergranular, about 0.01 to 0.03 mm. Amygdales are abundant.

Phenocrysts: Andesine: about 20% of rock; extremely altered.

Clinopyroxene: about 5% of rock; pseudomorphed in part by serpentine, chlorite and calcite.

Groundmass: Plagioclase: about 35% of rock; extremely altered.

Clinopyroxene: about 10% of rock; granular, pseudomorphed in part.

Chlorite and serpentine: about 25% of rock; filling interstices.

Opaques: about 5% of rock; euhedral to anhedral.

Amygdales: Chlorite with or without a core of zeolite.

Origin: Alteration of volcanic extrusive.

Name:- ALTERED BASALT

Microslide GSQ 3346 ex Specimen GSQ/R 2472 Field No SP 68 C

Run 2/ Photo 5018 / Point 68

Macro:- A massive, fine-grained, pinkish-brown, fluidal rock with about 5% phenocrysts up to 2 mm.

Micro:-

Texture: Porphyritic; the phenocrysts (about 5% of rock) are subhedral, lath-shaped, 1 to 2 mm. The groundmass is pilotaxitic, about 0.02 mm.

Phenocrysts: Alkali feldspar: about 5% of rock; somewhat altered.

Groundmass: Feldspar: about 85% of rock; altered acicular crystals.

Secondary mineral: about 10% of rock; dominantly hematite-stained clay mineral.

Origin:- Volcanic extrusive.

Name:- ALTERED TRACHYTE

Nogoa Anticline; south of "Shadeville".

Microslide GSQ 3340 ex Specimen GSQ/R 2466 Field No. SP 70

Run 2 / Photo 5018 / Point 70

Macro:- A massive, fine-grained, pinkish-grey rock.

Micro:-

Texture: Intersertal to intergranular, 0.04 (granular) to 0.5 (acicular) mm with rare lath-shaped crystals to 1 mm.

Constituents: Andesine: about 60% of rock; extremely altered.

Clinopyroxene: about 25% of rock; uralitised in part.

Chlorite: about 10% of rock; secondary; filling interstices.

Opaques: about 5% of rock; hematitised in part; associated with pyroxene and uralite.

Origin:- Alteration of volcanic extrusive.

Name:- ALTERED BASALT

Microslide GSQ 3334 ex Specimen GSQ/R 2460 Field No. SP 71

Run 2 / Photo 5018 / Point 71

Macro:- A massive, very fine-grained, dark purplish-coloured rock.

Micro:

Texture: Microcrystalline, allotriomorphic-granular traversed by fine veins.

Constituents: Quartz-feldspathic material: predominant.

Chalcedony : abundant. }
Iron-staining: minor } secondary
Zeolite: minor }

Origin:- Alteration of a volcanic extrusive

Name :- ALTERED RHYOLITE

TELEMON FORMATION

Telemon Anticline

Microslide GSQ 3366 ex Specimen GSQ/R 2492 Field No. SP 36/6A

Run 1/ Photo 5113 / Point 36/6

Macro:- A decomposed , fine to coarse-grained, pinkish-grey schistose rock.

Micro:-

Texture: Dominantly lepidoblastic, 0.04 to 0.3 mm. but numerous "eyes", 0.3 to 4 mm, occur within the stringers.

Constituents: Quartz : about 50% of rock; elongate stringers of strain mosaic formed of interlocking fine anhedra.
Biotite: about 30% of rock; ragged crystals in stringers; altered.
"Eyes": about 20% of rock; in general heavily ironstained; dominantly altered volcanic fragments with minor "granite."

Origin:- Shearing of a sediment derived from a Pre-Devonian/ Dunstable terrain. Some of the quartz may be introduced but much of it probably represents sheared recrystallized quartz clasts.

Name:- SHEARED GREYWACKE

Microslide GSQ 3367 ex Specimen GSQ/R 2493 Field No. SP 36/6B

Run 1 / Photo 5113/ Point 36/6

Macro:- A massive, fine to medium-grained, purplish brown, foliated clastic rock.

Micro:-

Texture: Clastic; the clasts (about 80% of rock) are 0.04 to 4 mm (dominantly about 0.4 mm), angular to rounded, of low to moderate sphericity, commonly deformed. There is a suggestion of "drawing out" of the grains and parallelism of their long axes. The interstices are filled with finely crystalline cement.

Clasts: Lithic material: about 75% of rock; essentially calcitised and ironstained volcanics with minor granite and quartzite.
Quartz : about 5% of rock; sheared.

Cement: Ironstained carbonate : about 20% of rock; fine stringers, roughly parallel to the long axes of the grains.

Origin:- Shearing and associated alteration of a sediment derived from a volcanic - Pre-Devonian terrain.

Name:- SHEARED LITHIC SUBGREYWACKE

Microslide GSQ 3368 ex Specimen GSQ/R 2494 Field No. SP 36/6C

Run 1/ Photo 5113 / Point 36/6

Macro:- A massive, fine-grained, light grey rock traversed by innumerable very fine veins. Dendritic staining is abundant.

Micro:-

Texture: Clastic; the clasts (about 20% of rock) are 0.02 to 0.3 mm (dominantly about 0.03 mm), angular to subangular, of moderate sphericity. The interstices are filled with argillaceous material masked by about 40% secondary crystalline material.

Clasts: Quartz and feldspar: about 15% of rock; sheared.

Lithic material: about 5% of rock; intrusives.

Matrix: Argillaceous (tuffaceous): about 80% of rock; considerably calcitised.

Veins: Hematite

Origin: Alteration associated with minor shearing of a pyroclastic rock.

Name: ALTERED LITHIC-CRYSTAL TUFF

Microslide GSQ 3361 ex Specimen GSQ/R 2487 Field No. SP 41

Run 2 / Photo 5022 / Point 41

Macro:- A massive, fine-grained, pinkish-grey rock.

Micro:-

Texture: Clastic; the clasts (about 20% of rock) are 0.02 to 0.6 mm, dominantly about 0.2 mm. About 70% are rounded, somewhat corroded; <5% are irregular grains, about 0.02 mm and >5% are formless, heavily ironstained, about 0.6 mm. About 20% matrix fills the interstices.

Clasts: Limestone: about 70% of rock; rounded.
Quartz and feldspar: <5% of rock; very fine grains.
Lithic material: >5% of rock; ironstained argillaceous calcite - replaced ? volcanics

Matrix: Lime mud: about 20% of rock.

Origin:- Sedimentary.

Name:- SANDY CALCARENITE

GSQ/R
Microslide GSQ 3362 ex Specimen 2488 Field No. SP 43

Run 2/ Photo 5022 / Point 43

Macro:- A massive, very fine-grained, light grey and cream-coloured mottled rock.

Micro:-

Texture: Essentially clastic. The mottling is due to the random distribution of rock variants, typical of a flow-banded tuff. The light-coloured material contains about 60% clasts, 0.04 to 0.25 mm and the grey material about 5% clasts, about 0.17 mm. Each type makes up approximately half rock.

Clasts: Light Bands

Divitrified shards: about 40% of rock
Altered intrusives: about 15% of rock
Quartz and feldspar and mica: about 5% of rock; broken crystals.

Grey Bands

Quartz and feldspar and mica: about 5% of rock
Divitrified glass: minor

Matrix: Argillaceous (tuffaceous): 35 to 40% of rock impregnated with about 5% secondary cryptocrystalline quartz.

Origin:- Pyroclastic

Name:- VITRIC TUFF

GSQ/R
Microslide GSQ 3359 ex Specimen 2485 Field No. SP 54

Run 1/ Photo 5115 / Point 54

Macro:- A massive, coarse-grained, red-brown clastic rock.

Micro:-

Essentially similar to GSQ 3358 except in the following:-

1. The clasts in GSQ 3359 are 0.25 to 4 mm, dominantly about 1 mm.
2. In GSQ 3359 minor zeolite and cryptocrystalline quartz cements occur.
3. Rare clasts of fine-grained sediment occur in GSQ 3359.

Name:- LITHIC SUBGREYWACKE

Nogoa Anticline, north-west of "Telemon".

Microslide GSQ 3358 ex Specimen GSQ/R 2484 Field No. SP 65

Run 2 / Photo 5018 / Point 65

Macro:- A massive, medium-grained, buff coloured, clastic rock with rare rounded pebbles to 1 cm.

Micro:-

Texture: Clastic; the clasts (about 90% of rock) are rounded to subrounded, of moderate sphericity 0.3 to 2 mm (dominantly about 0.5 mm). The matrix is very fine-grained.

Clasts: Lithic material: about 80% of rock; essentially Dunstable volcanics with minor mica schist and chert.
Quartz: about 5% of rock; strained.
Acid feldspar: about 5% of rock; altered

Matrix: Argillaceous: about 10% of rock; dominantly micaceous, ironstained in part.

Origin: Sedimentary; derived from Dunstable and Pre-Devonian Terrain.

Name:- LITHIC SUBGREYWACKE

Microslide GSQ 3360 ex Specimen GSQ/R 2486 Field No. SP 66

Run 2 / Photo 5018 / Point 66.

Macro:- A massive, fine- to medium-grained, pinkish-brown clastic rock.

Micro:-

Texture: Clastic; the clasts (about 95% of rock) are commonly embayed due to "pressure welding" of contiguous grains, 0.1 to 0.6 mm. (dominantly about 0.3 mm). Very fine-grained detrital matrix makes up about 5% of rock.

Clasts: Quartz: about 40% of rock
Lithic material: about 45% of rock; including:-
    Quartzite and granite - about 35% of rock
    Dunstable volcanics - about 10% of rock
Feldspar: about 5% of rock; altered
Muscovite: about 5% of rock.

Matrix: Argillaceous: about 5% of rock; ironstained

Origin:- Sedimentary; derived from Pre-Devonian and Dunstable formations.

Name:- QUARTZ-LITHIC SUBGREYWACKE

DIAGRAM SHOWING

COMPOSITION OF SEDIMENTS

FROM SILVER HILLS VOLCANICS AND TELEMON FORMATION
(EMERALD 4 MILE SHEET AREA)
DUNSTABLE AND TELEMON FORMATIONS
(SPRINGSURE 4 MILE SHEET AREA)

EMERALD 4 MILE SHEET

GSQ No.		NAME	EST. PERCENTAGE COMPOSITION	LITHICS	REMARKS
2657	SILVER HILLS VOLCANICS	*Sandy micaceous Mudstone*		*pre-Devonian*	*Argillaceous Mtx.*
2675	SILVER HILLS VOLCANICS	*Mica Qtz. Sandstone*		*pre-Devonian*	*Sericite Matrix*
2680	SILVER HILLS VOLCANICS	*Sandy micaceous Mudstone*		*pre-Devonian*	*Miscellaneous <5% Argillaceous Mtx.*
2687	SILVER HILLS VOLCANICS	*Silty micaceous Mudstone*		*pre-Devonian*	*Miscellaneous <5% Argillaceous Mtx.*
2619	TELEMON FORMATION	*Metd. Greywacke*		*pre-Devonian and Volcanics*	*Biotite Mica, Miscell. 10% Argill. Mtx.*
2620	TELEMON FORMATION	*Metd. Greywacke*		*pre-Devonian and Volcanics*	*Biotite Mica Miscell. 10% Argill. Mtx.*
2625	TELEMON FORMATION	*Metd. Greywacke*		*pre-Devonian and Volcanics*	*Biotite Mica Miscell. 10% Argill. Mtx.*
2643	TELEMON FORMATION	*Lithic Sandstone*		*pre-Devonian <70% Volcanics >20%*	*Argillaceous Mtx.*
2644	TELEMON FORMATION	*Tuffaceous Lithic Sandstone*		*Volcanics pre-Devonian*	*Tuffaceous Mtx.*
2645	TELEMON FORMATION	*Tuffaceous Lithic Conglomerate*		*Volcanics 60% pre-Devonian 35%*	*Tuffaceous Mtx.*
2646	TELEMON FORMATION	*Lithic Sandstone*		*Dom. pre-Devonian*	*Argillaceous Mtx*
2647	TELEMON FORMATION	*Lithic - Quartz Sandstone*		*pre-Devonian*	*Argillaceous Mtx*
2648	TELEMON FORMATION	*Lithic Sandstone*		*pre-Devonian*	*Sericitic Matrix*
2628	TELEMON FORMATION	*Lithic Sandstone*		*pre-Devonian*	*Sericitic Matrix*
2652	TELEMON FORMATION	*Lithic Sandstone*		*pre-Devonian and Volcanics*	*Opaque Cement*
2654	TELEMON FORMATION	*Tuffaceous Lithic Sandstone*		*pre-Devonian*	*Tuffaceous Mtx.*

SPRINGSURE 4 MILE SHEET

GSQ No.		NAME	EST. PERCENTAGE COMPOSITION	LITHICS	REMARKS
3350	DUNSTABLE FORMATION	*Greywacke*		*Dom. Dunstable Volcs. Minor pre-Devonian*	*Argillaceous Matrix*
3351	DUNSTABLE FORMATION	*Greywacke*		*Dom. Dunstable Volcs. Minor pre-Devonian*	*Argillaceous Matrix*
3355	DUNSTABLE FORMATION	*Siliceous Lithic Greywacke*		*Dom. Dunstable Minor pre-Devonian*	*Cryptocryst Qtz. Cem. 25% Zeolite Cem 5%*
3349	DUNSTABLE FORMATION	*Calcareous Subgreywacke*		*pre-Devonian Qite 5% Dunstable 5%*	*Calcareous Cem.*
3352	DUNSTABLE FORMATION	*Tuffaceous - Lithic Subgreywacke*		*Dunstable*	*Arg. ? Tuff. Matrix*
3353	DUNSTABLE FORMATION	*Lithic Subgreywacke*		*Dunstable and pre-Devonian (Minor)*	*Chlorite Cem.*
3366	? DUNSTABLE ?	*Sheared greywacke*		*pre-Devonian / Dunstable*	*Biotite = Recryst. Arg. Matrix 30%*
3367	? DUNSTABLE ?	*Sheared Lithic Subgreywacke*		*Dunstable / minor pre-Devonian*	*Carbonate Cem.*
3358	TELEMON FMN.	*Lithic Subgreywacke*		*Dunstable and pre-Devonian*	*Arg. (Mica) Mtx.*
3359	TELEMON FMN.	*Lithic Subgreywacke*		*Dunstable and Rare Sediments*	*Arg. (Mica) 10% with Minor Qtz. Zeol. Cem.*
3360	TELEMON FMN.	*Quartz - Lithic Subgreywacke*		*pre-Devonian Dunstable*	*Muscovite Mica Argillaceous Mtx.*

0% 50% 100%

LEGEND

Quartz — *Mica (Muscovite Biotite)*

Lithic Material — *Matrix (Arg. Tuf. Sericitic)*

Feldspar — *Cement*

To accompany report by B. R. Houston, B.Sc. Geologist.

. RR. 17.12.63

APPENDIX 4

PRELIMINARY REPORT ON A COLLECTION OF CORALS FROM PEBBLES IN CONGLOMERATES IN THE JOE JOE FORMATION, SPRINGSURE 1:250,000 SHEET AREA

by

Dorothy Hill

(localities are shown in Enclosure 1)

SP. 360/5 (2½ miles NNW Riverside Homestead)

Favositidae, slenderly branching, genus and species indeterminable.

Atrypa and other brachiopods; returned for determination at the Geological Survey of Queensland.

SP. 360/6 (2½ miles NNW Riverside Homestead)

Favostella (Dendrostella) cf. *rhenana* (Frech)

SP.600 (7 miles NE Joe Joe Homestead)

1a. *Litophyllum konincki* (Etheridge & Foord) and stromatoporoid.

1b. *Alveolites* sp. *Litophyllum konincki*. *Grypophyllum* sp. Stromatoporoids

1c. Rugosa solitary, gen. et sp.nov.? (insufficient material; retained for further study).

2. New branching Favositid. Slide and piece of specimen retained for further study.

3. Favositidae. Indeterminable.

4. *Favistella (Dendrostella)* cf. *rhenana* (Frech)
Amphipora ramosa
branching stromatoporoid

5. *Favistella (Dendrostella)* cf. *rhenana* (Frech)
Amphipora ramosa
branching stromatoporoid

6. *Litophyllum konincki* (Etheridge & Foord)

7. Rugosa, small, solitary, indeterminable

a. ? *Cladopora* sp.

b. ? *Cladopora* sp. and Rugosa, small, solitary, dissepimented, indeterminable.

The pebbles from SP. 360 and SP.600 are derived from Middle Devonian limestones. None of the coral species represented is quite identical with any of those I have previously reported from the Springsure, Emerald and Clermont 1:250,000 Sheet areas for the BMR/GSQ parties.

Favistella cf. _rhenana_ Frech. and _Grypophyllum_ sp. are present in some pebbles from the Joe Joe Formation collected by Shell (Qld) Development Pty Ltd. which in 1942 I suggested might be derived from Upper Middle Devonian limestones. _Litophyllum konincki_ in addition to the above two species occurs in the present collections and adds some support to this view. However, no Upper Middle Devonian limestones outcrop on the map areas. _Litophyllum konincki_ with thinner walls is known from the Lower Middle Devonian limestones outcropping on the above map areas, and _Favistella_ (_Dendrostella_) _prerhenana_ Glinski, a species closely related to _F. rhenana_ occurs in the Lower Middle Devonian of the Eifel, and it is not impossible for all the pebbles to have been derived from Lower Middle Devonian Limestones.

The specimens and slides, except for pieces from SP. 600/1c and SP.600/2 have been returned to the Geological Survey of Queensland.

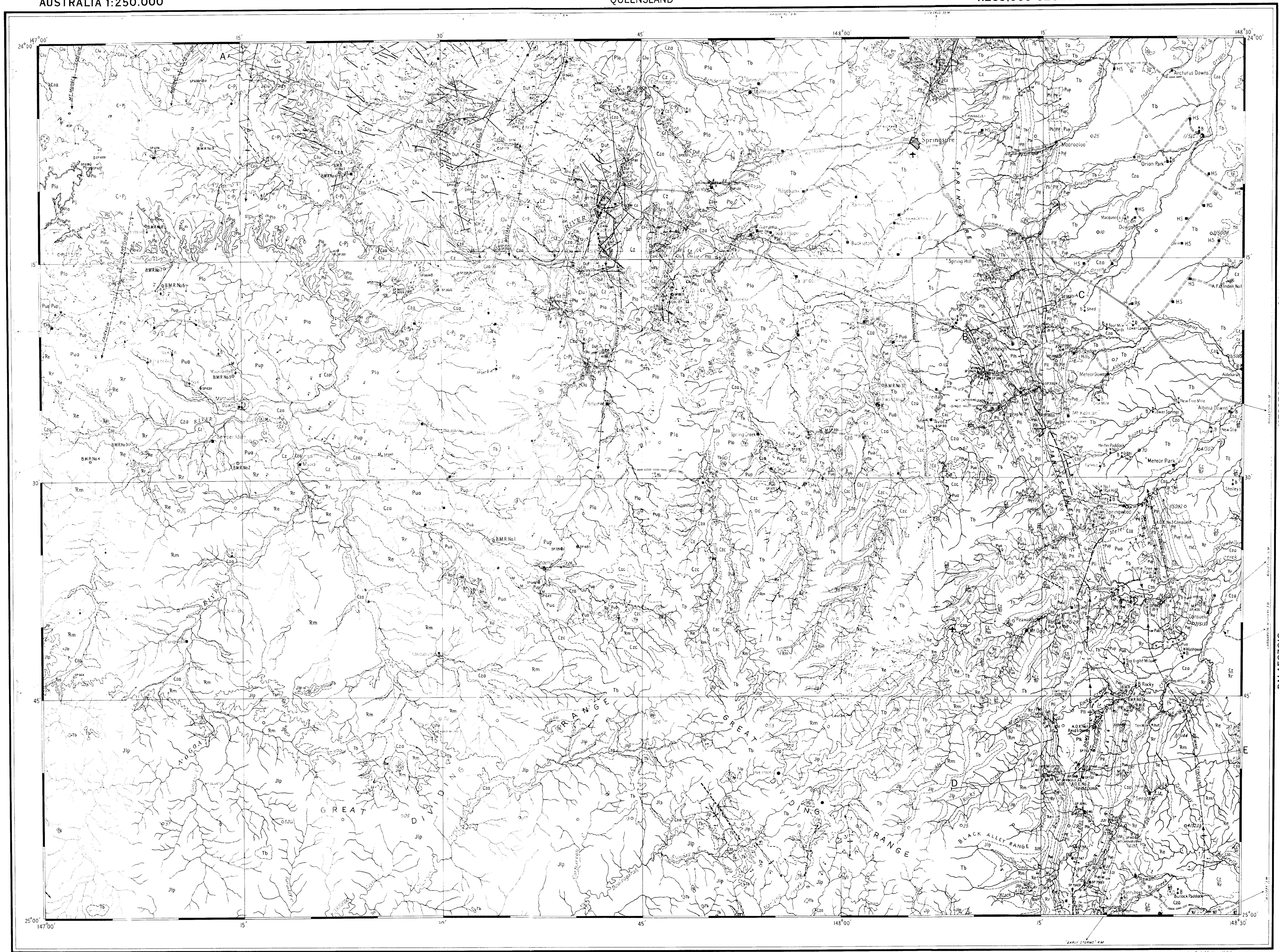
AUSTRALIA 1:250,000

SPRINGSURE
QUEENSLAND

1:250,000 GEOLOGICAL SERIES SHEET SG 55-3

PRELIMINARY SECOND EDITION, 1964

SUBJECT TO AMENDMENT



Reference

- Geological boundary
- Anticline, showing plunge
- Syncline, showing plunge
- Fault (♦ - downthrown side)
- Where location of boundaries, folds and faults is approximate, line is broken; where inferred, queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes
- Strike and dip of strata
- Unmeasured dip
- Vertical strata
- Horizontal strata
- Generalised strike and dip of undulating strata
- Strike and dip of foliation
- Dip < 15° } air-photo interpretation
- Dip 15°–45°
- Dip > 45°
- Horizontal strata
- Dip slope < 15°
- Bedding trend lines
- Volcanic vent or plug
- Dyke: r - rhyolite, b - basalt
- Marinian *Productus* Bed outcrop
- Macrofossil locality
- Macrofossils in erratics
- Plant fossil locality
- Fossil wood locality
- Fossil locality, general (algae, fish scales, megaspores)
- Fossil locality numbers
- Coal
- Dry oil well (abandoned)
- Abandoned well with show of gas
- Abandoned well with show of oil and gas
- Stallow stratigraphic drill hole
- Measured type-section
- Measured section
- Where dashed, section transferred along strike
- Section reference number
- Bore with windpump
- Well with windpump
- Tank
- Swamp
- Road
- Vehicle track
- Railway with station
- Homestead
- Landing ground
- Stockyards
- Height in feet, barometric } datum mean sea level
- Height in feet, instrument levelled
- Air photo centre point - run/number

Reference

CAINOZOIC			Cz	Soil, gravel, billy, scree, alluvium
			Cza	Alluvium
			Czc	Collapsed basalt sheets
	TERTIARY			Laterite
			Ts	Conglomerate, sandstone
		Minerva Hills Volcanics	Tr	Plugs, domes and dykes of alkaline quartz trachyte and rhyolite
			Tb	Basalt
MESOZOIC	LOWER JURASSIC	Precipice Sandstone	Jlp	Quartz sandstone
	TRIASSIC	Moolayember Formation	Rm	Micaceous siltstone, lithic sandstone, shale, minor coal
		Clematis Sandstone	Rc	Quartz conglomerate and sandstone, micaceous siltstone
		Rewan Formation	Rr	Red and green silty mudstone, green lithic quartz sandstone
PALAEOZOIC			gr	Granite
	UPPER PERMIAN	Bandanna Formation	Pua	Sandstone, siltstone, shale, tuffaceous clay, cherty fossil plant beds, coal
		Peawaddy Formation	Pup	Lithic quartz sandstone, carbonaceous siltstone, lenticular coquinite (Marinian *Productus* Bed)
	LOWER PERMIAN	Catherine Sandstone	Plf	Feldspathic quartz sandstone
		Ingelara Formation	Pli	Conglomeratic siltstone, shale and sandstone; calcareous nodules
		Aldebaran Sandstone	Pll	Quartz conglomerate and sandstone, minor siltstone and coal
		Colinlea Sandstone	Plo	Quartz conglomerate and sandstone, minor siltstone
		Sirius Formation	Pls	Carbonaceous siltstone, sandstone, shale
		Staircase Sandstone	Plr	Quartz conglomerate and sandstone, siltstone, minor shale
		Stanleigh Formation	Plh	Lithic quartz sandstone, siltstone, dark shale, minor limestone
		Cattle Creek Formation	Plk	Conglomeratic silty sandstone, siltstone, coquinitic limestone
		Orion Formation	Plg	Lithic quartz sandstone, carbonaceous shale with rootlets, fossil plant beds. Equivalent to 'undivided freshwater beds' of A.O.E. Reid's Dome Nos. 1 and 2
			Plj	Micaceous siltstone with abundant plant fossils, sandstone
	CARBONIFEROUS-PERMIAN	Joe Joe Formation	C-Pj	Lithic conglomerate, quartz-lithic sandstone, siltstone, minor shale
	LOWER CARBONIFEROUS	Ducabrook Formation	Clu	Lithic sandstone, siltstone, shale, tuff, minor algal limestone
		Raymond Sandstone	Clr	Flaggy quartz sandstone, minor siltstone
		Mount Hall Conglomerate	Clh	Quartz conglomerate and sandstone
	UPPER DEVONIAN	Telemon Formation	Dul	Lithic quartz conglomerate and sandstone, multicoloured tuffaceous siltstone and shale, algal limestone
	MIDDLE DEVONIAN	Dunstable Formation	Dmn	Andesitic, basaltic, trachytic, and rhyolitic volcanics, lithic quartz conglomerate, sandstone, cherty siltstone, lenses of coralline limestone
	PRE-DEVONIAN		pD	Gneiss, phyllite, and sheared diorite

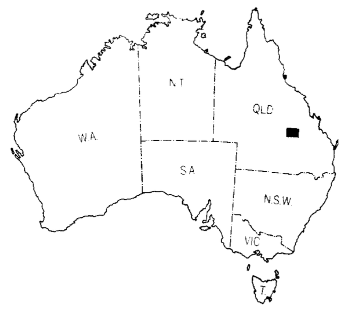
Compiled and issued by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development, in conjunction with the Geological Survey of Queensland. Slotted templates supplied by the Division of National Mapping, Department of National Development. Aerial photography by Adastra Airways Pty.Ltd.; complete vertical coverage at 1:85,000 scale. Transverse Mercator Projection.

Scale 1 : 250,000

MILES 5 0 5 10 15

KILOMETRES 5 0 5 10 15 20 25

Geology and compilation, 1963, by R.G.Mollan, N.F.Exon, (B.M.R.), and A.G.Kirkegaard, (G.S.Q.).
Drawn by E.H.J Feeken

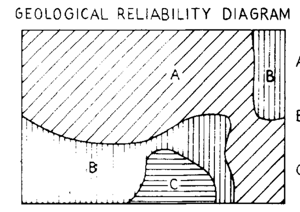


INDEX TO ADJOINING SHEETS
Showing Magnetic Declination

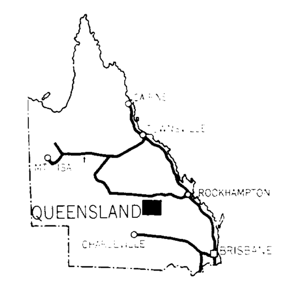
MUTTABURRA SF 55-9	GALILEE SF 55-10	CLERMONT SF 55-11	ST LAWRENCE SF 55-12	PORT CLINTON SF 56-9
LONGREACH SF 55-13	JERICHO SF 55-14	EMERALD SF 55-15	DUARINGA SF 55-16	ROCKHAMPTON SF 56-13
BLACKALL SG 55-1	TAMBO SG 55-2	SPRINGSURE SG 55-3	BARALABA SG 55-4	MONTO SG 56-1
ADAVALE SG 55-5	AUGATHELLA SG 55-6	EDDYSTONE SG 55-7	TAROOM SG 55-8	MUNDUBBERA SG 56-5
QUILPIE SG 55-9	CHARLEVILLE SG 55-10	MITCHELL SG 55-11	ROMA SG 55-12	CHINCHILLA SG 56-9

ANNUAL CHANGE 3' E

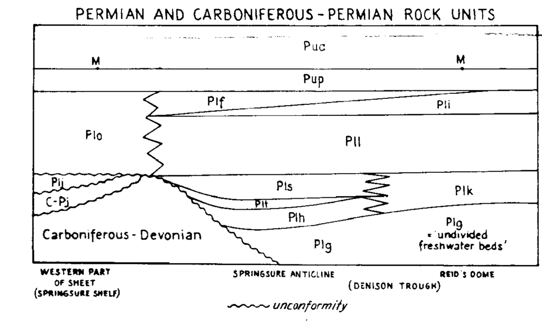
GEOLOGICAL RELIABILITY DIAGRAM



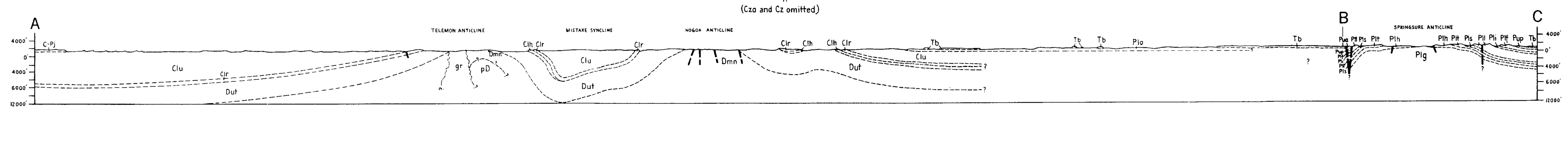
- A Detailed reconnaissance - numerous traverses
- B Reconnaissance - several traverses
- C Air-photo interpretation

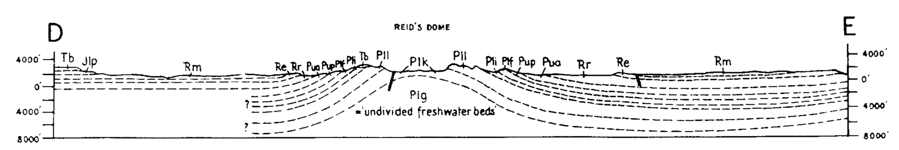


DIAGRAMMATIC RELATIONSHIP OF PERMIAN AND CARBONIFEROUS-PERMIAN ROCK UNITS



Sections
Scale $\frac{V}{H} = 3$
(Cza and Cz omitted)





ENCLOSURE 2

REFERENCE FOR COLUMNAR SECTIONS

(Measured sections S1 - S30 — plotted in Enclosure 1)

claystone

shale and mudstone

silty shale and silty mudstone

siltstone

clayey siltstone

sandy siltstone

sandstone

conglomeratic sandstone

conglomerate

limestone

tuff

tuffaceous sandstone

basalt

coquinite

Gaps in sections
are concealed areas

SP 112/1	locality number (1963)
Z5	locality number (1962)
AF12	lithological specimen number (Fehr, 1962)

Grain Size

v.f. - very fine	0·06 - 0·12 mm.
f - fine	0·12 - 0·25 mm.
m - medium	0·25 - 1·0 mm.
c - coarse	1·0 - 2·0 mm.
granule (v.c.)	2·0 - 4·0 mm.
pebble	4·0 - 64·0 mm.
cobble	64 - 256 mm.
boulder	> 256 mm.

si	siliceous	ss. & sst.	- sandstone
fe	ferruginous	siltst.	- siltstone
mic	micaceous	mudst.	- mudstone
calc	calcareous	clayst.	- claystone
feld	feldspathic		
carb	carbonaceous		

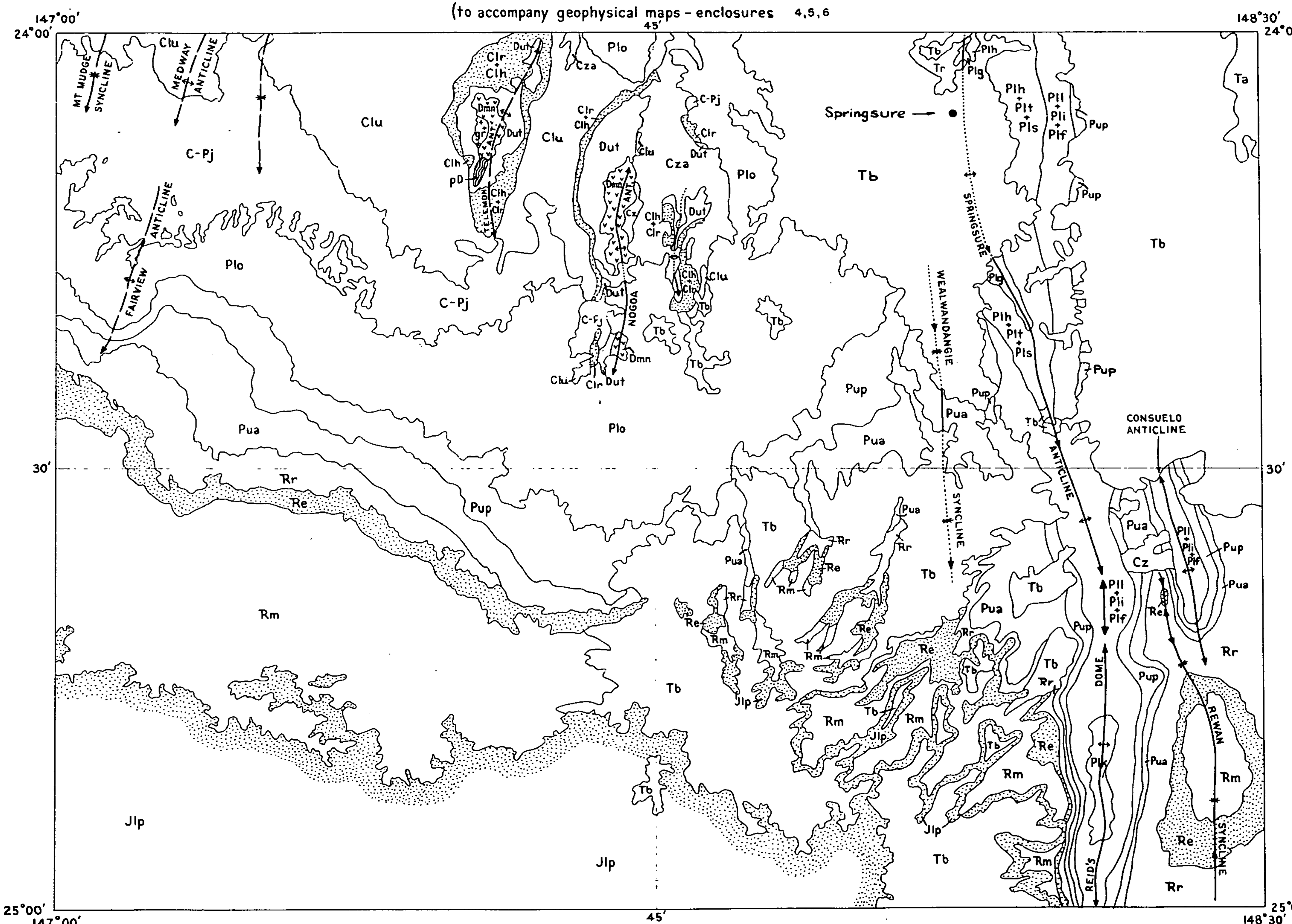
Bedding

very thick	> 40 inches
thick	12-40 inches
medium	4-12 inches
thin	0·4-4 inches
laminate	< 0·4 inches
cross bedded	
cross laminated	
festoon bedding	
graded bedding	
undulate	
slumped	
ripple marks - current	
concretions	
trails and/or burrows	
macrofossil	
microfossil	
plant fossil	
fossil wood	
scour and fill	
fluting	
load cast	

GEOLOGICAL SKETCH MAP OF THE SPRINGSURE SHEET AREA

Enclosure. 3

(to accompany geophysical maps - enclosures 4,5,6



SCALE

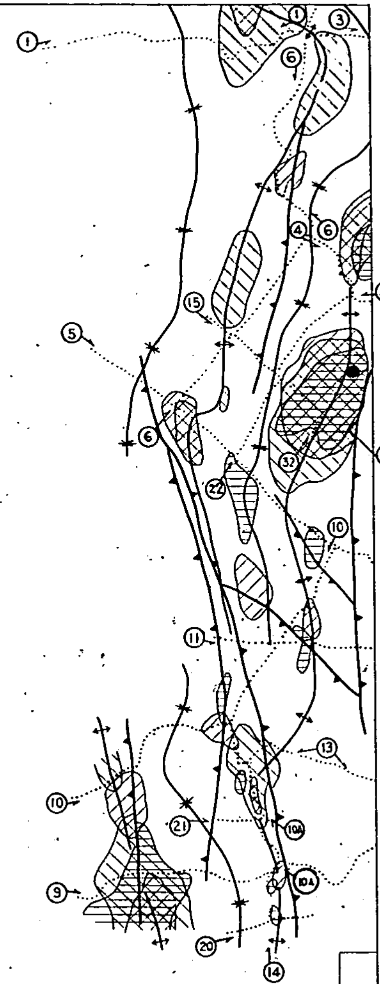
5 0 5 10 15 MILES

For reference see enclosure 1. units Plj and Czc omitted

SEISMIC WORK

STRUCTURAL TREND MAP of a part of the Rolleston-Springsure Seismic Survey — which covered part of ATP 55/56P.

Survey for Associated Freney Oilfields, N.L., by Geophysical Service Int., in February, 1963.



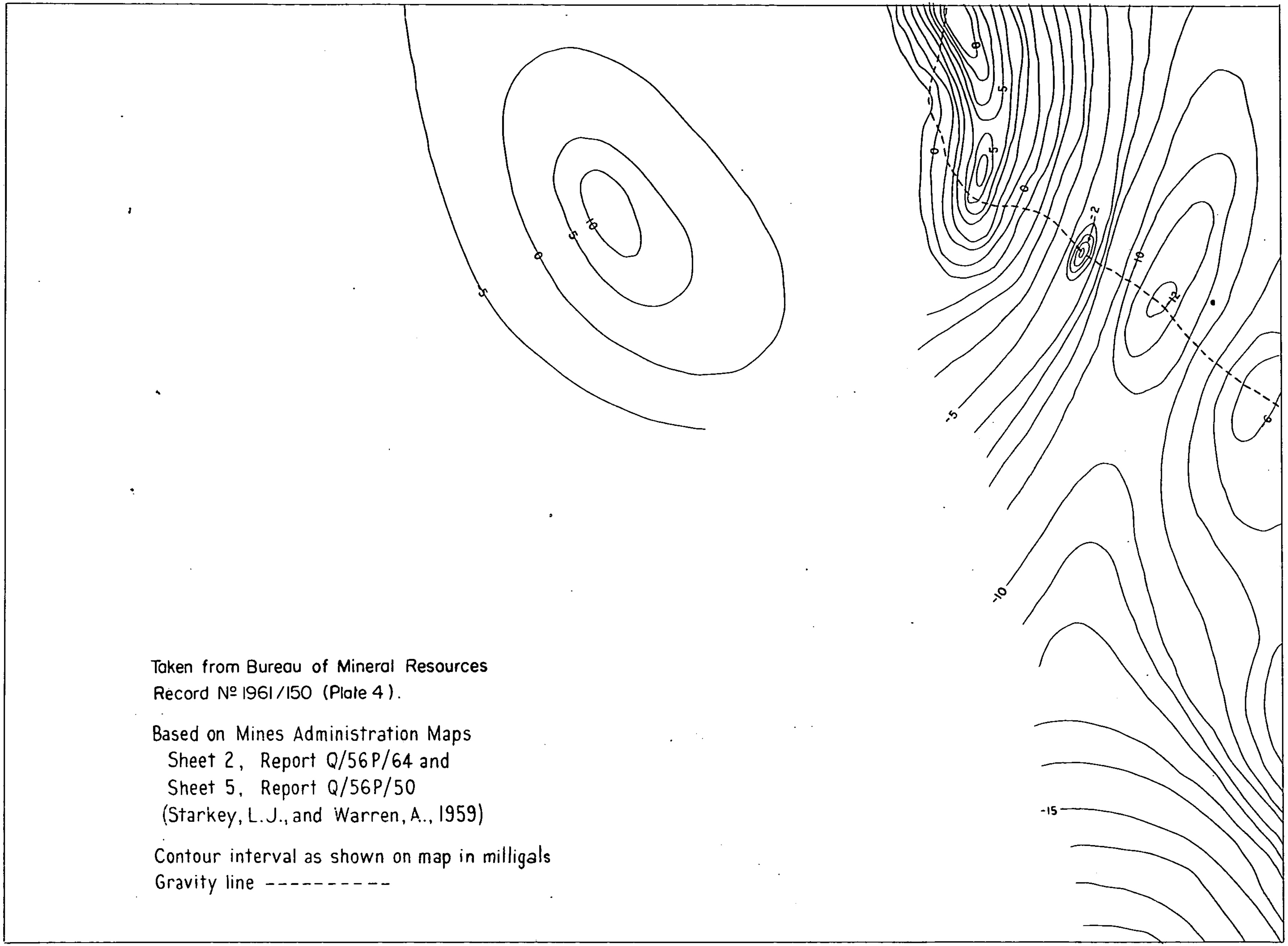
ATP 100P; Reflection Seismograph Survey of the Rolleston Area by Austral Geo. Prospectors Pty. Ltd. for Planet Exploration Co. Pty. Ltd. in November, 1962.

LEGEND

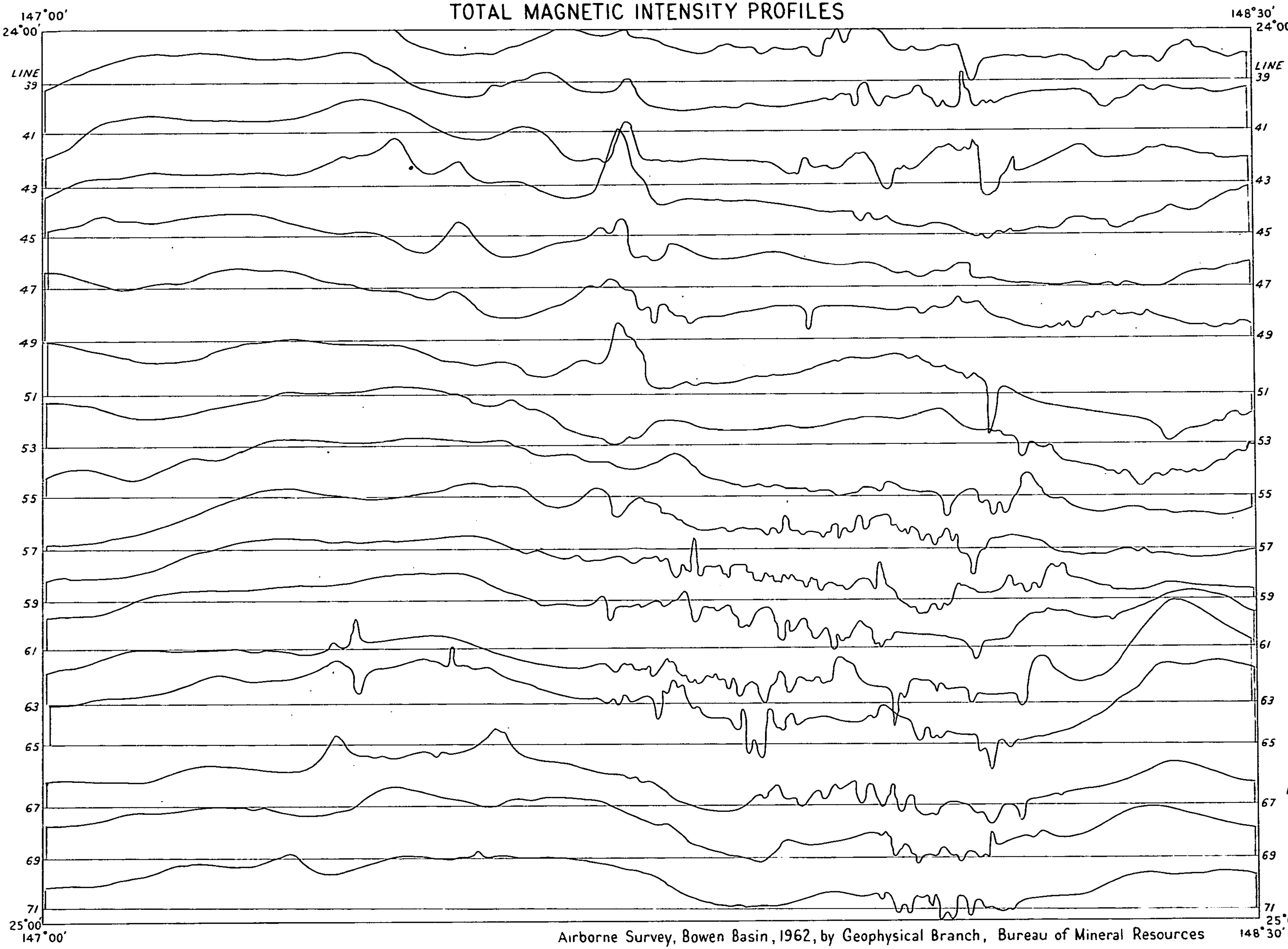
- Seismic Line 5
- Fault
- Syncline
- Anticline
- Horizon "A" Closure (Probable Upper-Lower Bandanna Boundary)
- Horizon "B" Closure (Probable Base of Aldebaran Sandstone)
- Horizon "C" Closure (Probable Base of Stanleigh Formation)
- A.F.O. Inderi No. 1 well

Enclosure 5

BOUGUER GRAVITY MAP



TOTAL MAGNETIC INTENSITY PROFILES



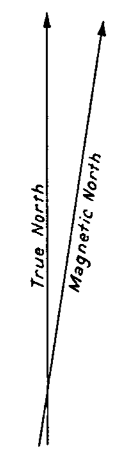
Airborne Survey, Bowen Basin, 1962, by Geophysical Branch, Bureau of Mineral Resources

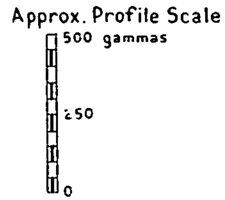
EXPLANATORY NOTES

The survey was flown at an altitude 2000' above sea level. Lines spaced two miles apart. The profiles recorded at intervals of four miles are shown on the map.

The profiles have been corrected for the south component of a regional gradient in total intensity of 11 gammas per mile in a direction S9°W.

The flight lines, which also serve as baselines to the profiles, have a probable error of ± ¼ mile on the map.





Enclosure 7

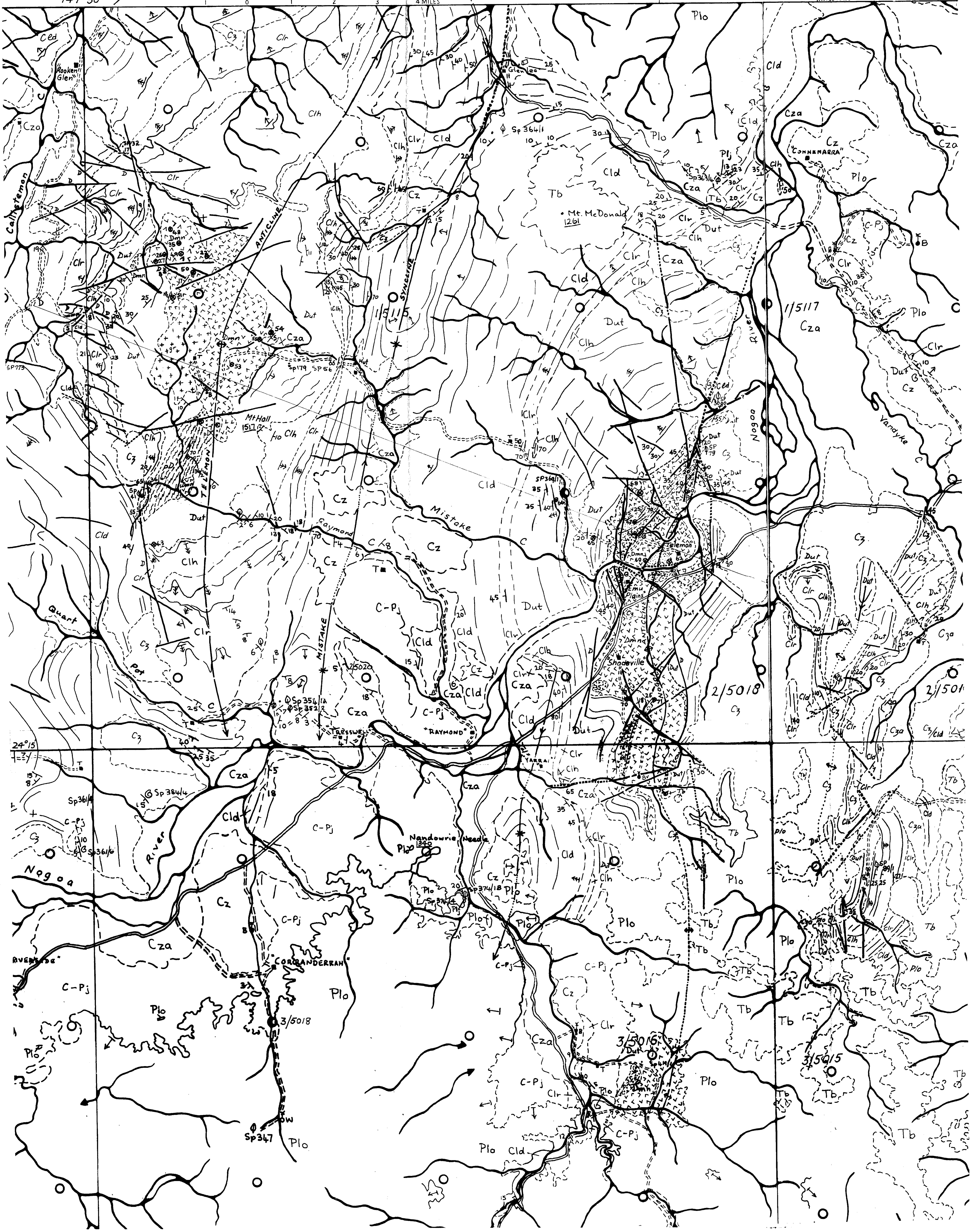
PHOTO-SCALE COMPILATION OF THE NOGOA AND TELEMON ANTICLINES

(FOR REFERENCE SEE ENCLOSURE I)

reference to lithological subdivision of pI:
- gneiss
- phyllite
- sheared diorite

22 ⊗ locality number of specimens described in Appendix 3

reference to lithological subdivision of the Dunstable Formation:
- volcanics
- spherular trachyte
- lens of coralline limestone
- sediments



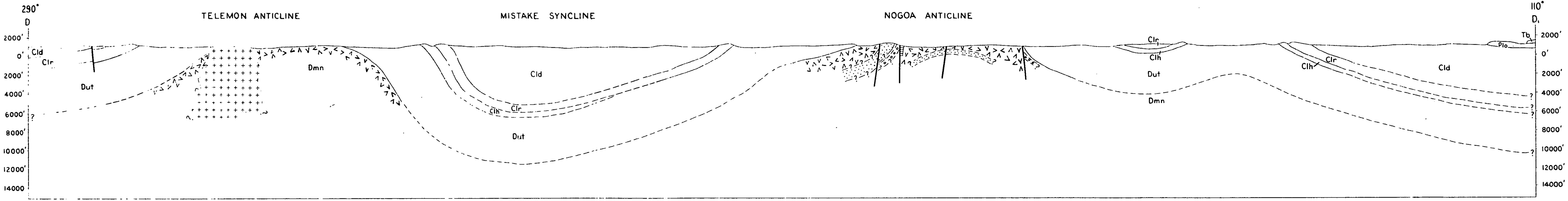
Enclosure 8

CROSS SECTION THROUGH THE TELEMON AND NOGOA ANTICLINES

For Reference to LITHOLOGICAL SYMBOLS see Enclosure 7

SECTION D – D₁

SCALE: V/H = 1



Bureau of Mineral Resources, Geology and Geophysics. March 1964.

To accompany Record No 1964/27.

G55/A3/15

Enclosure 9

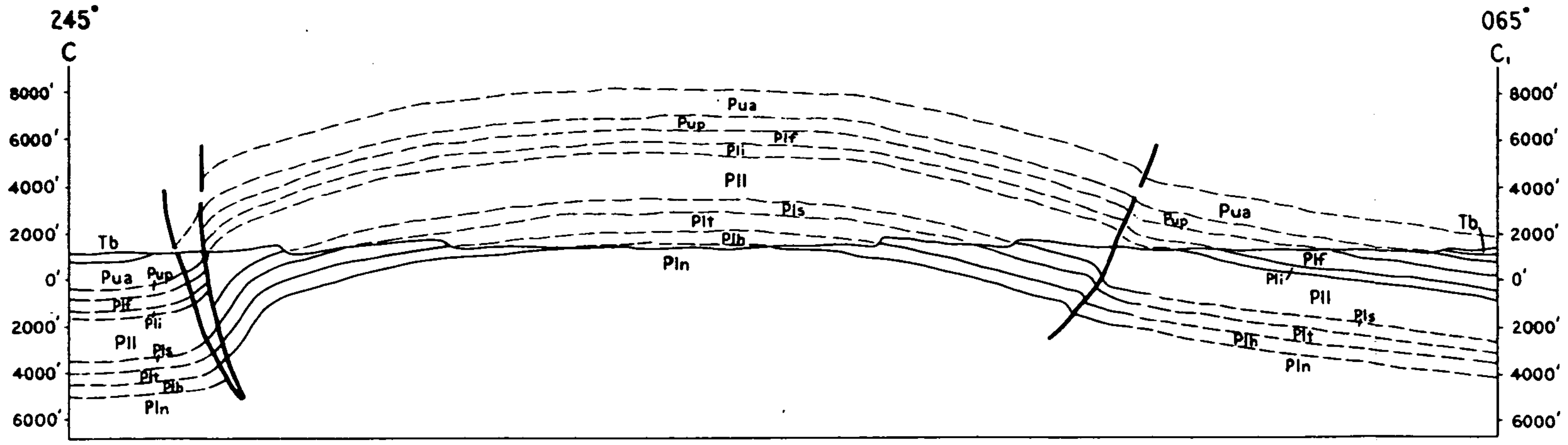
PHOTO-SCALE COMPILATION OF THE SPRINGSURE AND CONSUELO ANTICLINES AND REID'S DOME

(FOR REFERENCE SEE ENCLOSURE I)

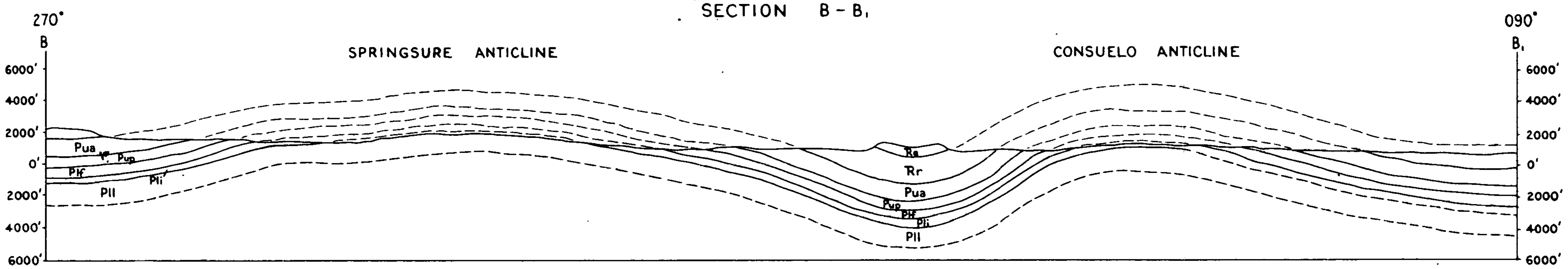
CROSS SECTIONS THROUGH THE SPRINGSURE ANTICLINE

SCALE: $\frac{V}{H} = 1$

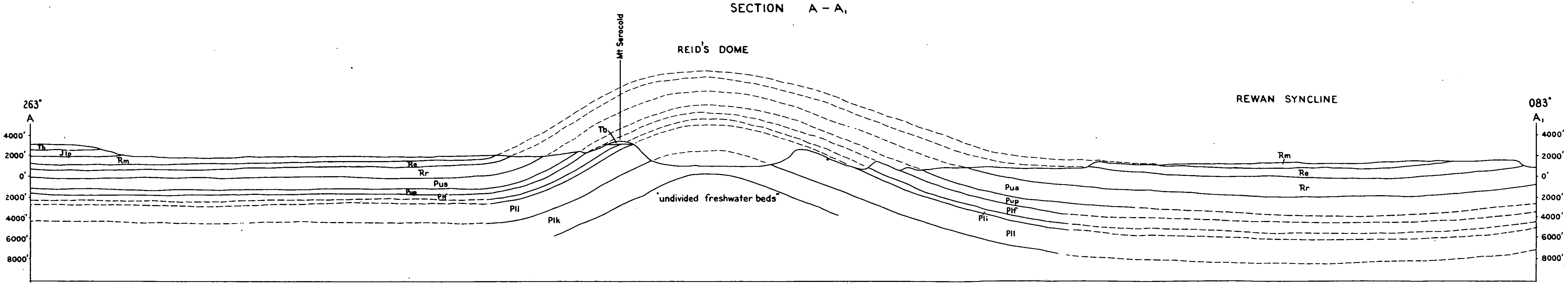
SECTION C – C₁



SECTION B – B₁



SECTION A – A₁



ENCLOSURE 1

Enclosure 11