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BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS.

REPORT No. 1949/24.
(Geol. Ser. No. 9).

THE GEOLOGY OF THE NERRIMA STRUCTURE, KIMBERLEY DIVISION, W.A.

by

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CANBERRA, A.C.T.

11th February, 1949.

THE GEOLOGY OF THE NERRIMA STRUCTURE,

KIMBERLEY DIVISION, W.A.

TABLE OF CONTENTS.

FIGURES - Locality Map.
Geological Map.
Structural Contour Map.

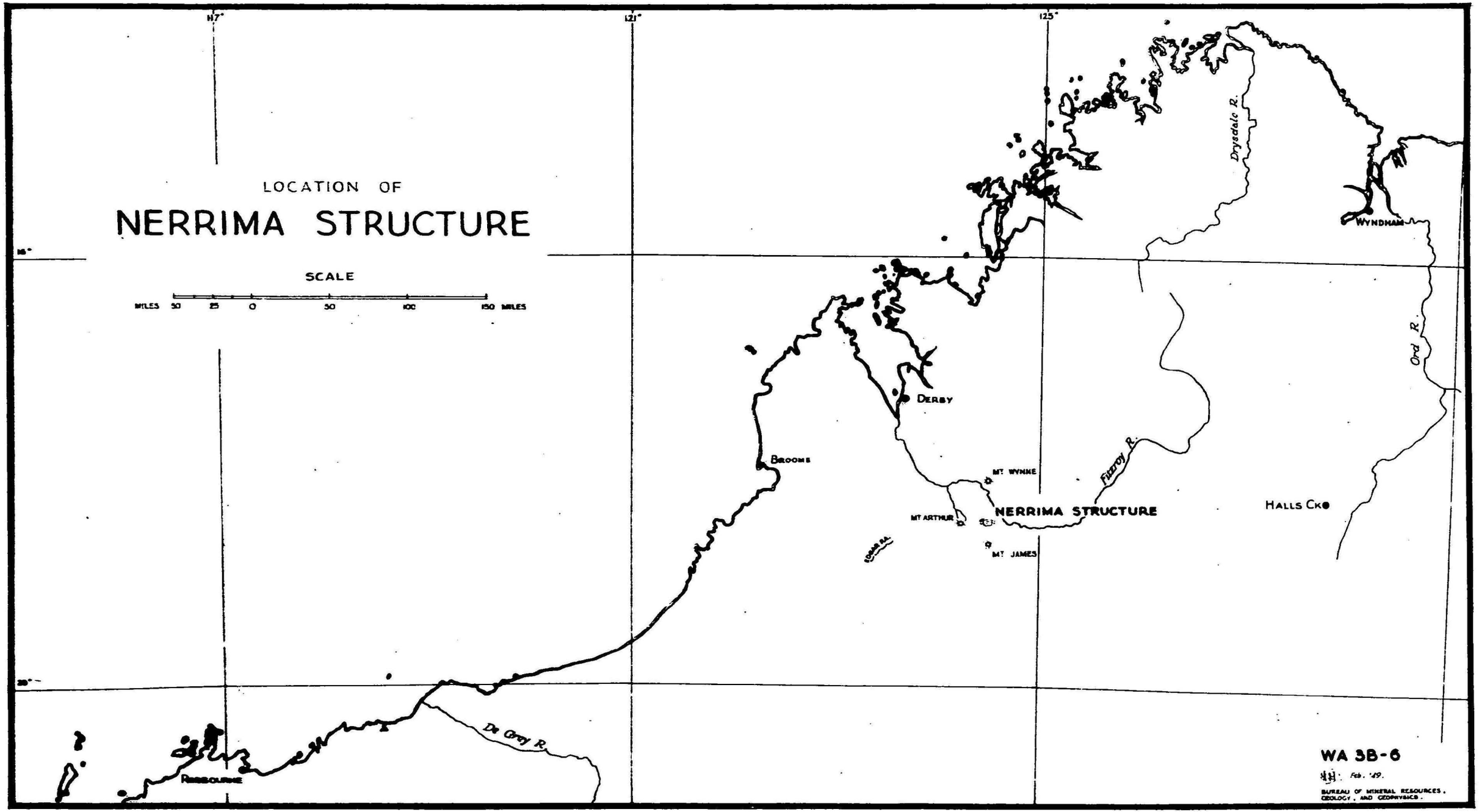
SECTIONS - A-B, C-D, E-F.

PHOTOGRAPHS - Nos. 1-3.

ERRATUM.

On page 6 N.G.17 should precede N.G.23 in the list of fossil determinations.

CANBERRA, A.C.T. 11th February, 1949.


117°
121°
125°
18°
20°
LOCATION OF
NERRIMA STRUCTURE
SCALE
MILES 50 25 0 50 100 150 MILES
Drysdale R.
WYNDHAM
Ord R.
DERBY
BROOME
MT WYNNE
Fitzroy R.
MT ARTHUR
NERRIMA STRUCTURE
HALLS CK
MT JAMES
De Grey R.
ROEBOURNE
WA 3B-6
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1. SUMMARY

A. The Nerrima dome is situated in an area of gentle folding 90 miles south-east of Derby in the Kimberley Division of Western Australia. Access is by road from Broome or Derby except during the monsoonal period between November and March. The vegetation is approximately half open scrub and grassland, and half thick "pindan" scrub.

B. The topography is essentially flat with local ridges formed of the more resistant sandstone beds of the Liveringa Formation.

C. Outcropping formations are Permian and include the lower part of the Liveringa and the top part of the Noonkanbah Formations. The Liveringa Formation consists mainly of sandstones and grits and forms ridges which practically surround the structure; the Noonkanbah is mainly clays and limestones which have been reduced to flat plains with low outcrops of limestone and calcareous sandstone.

D. Vertical closure of the structure is about 250 feet over an area of 30 square miles. The cores of Nerrima No.1 Bore have been examined and at the present depth of 4271 feet the bore appears to be still in Permian rocks although no reliable interpretation of the subsurface geology at Nerrima can be made without further detailed information from areas to the north.

II. INTRODUCTION

A. Situation

The Nerrima Structure covers an area of about 50 square miles immediately south-west of Nerrima Homestead which is 90 miles south-east of the town of Derby in the Kimberley Division of Western Australia.

B. Access.

The structure is approximately 140 miles by road from Derby. A sand and gravel road runs for 82 miles from Derby to Upper Liveringa Homestead. A track then branches across the Fitzroy River, passes through Myroodah Homestead and continues to Nerrima.

Another track runs south of the Fitzroy River from Myroodah Station through Luluigui and Udialla Stations to connec with the Broome-Derby road at Langey Crossing which is 102 miles from Broome and about 30 miles from Derby.

Prior to 1941 the Freney Kimberley Oil Co. was based at Broome, not Derby as at present and used a track running adjacent to the northern side of the Edgar Range to connect at Luluigui with the track to Nerrima.

Owing to the character of the road surfaces it is impossible to communicate by road during the wet season.

There are landing strips at Upper Liveringa and Myroodah Stations and small aircraft could also land on the north-western edge of the Nerrima Structure.

C. Climate and Vegetation

The North-west Monsoon continues from November to March and under present circumstances it is impossible to operate satisfactorily anywhere in the area during this period. For the remainder of the year weather conditions are congenial.

Most of the central portion of the structure is covered with pindan scrub, but elsewhere the vegetation consists of large areas of grass and spinifex with scattered Bauhinia and Eucalypts. In some cases vegetation changes coincide with geological boundaries.

D. Mapping Methods.

An area of about 130 square miles was covered by plane-table traverses. Intersection, resection and stadia methods were used on a scale approximating that of the aerial photographs, 1:60,000. A photogeological map was compiled using the plane-table base map as control. This was later combined with the plane-table traverse map on a scale of 2 inches to the mile. The composite is the geological map included in this report.

The area was contoured at intervals of 20 feet. Barometer readings indicated that ground level at the site of Nerrima No.1 Bore is 372 feet above sea level and all elevations have been determined from this datum.

A structural contour map has been drawn on the surface of a limestone bed in the Noonkanbah Formation. The contour interval is 100 feet and all contours are referred to sea level.

E. Previous Work

The surrounding basins were noticed by Woolnough (1933) during an aerial reconnaissance in the area. He suggested the presence of associated anticlinal structures but no ground work was carried out to determine the possibility of closure.

Wade, assisted by Waterford, (1935-1936), examined and mapped the area for the Commonwealth Government and concluded that the structure is closed.

Kraus (1942) incorporated a plane-table survey of the Nerrima Structure in a general report on parts of the Kimberleys. He was not satisfied that the eastern end of the structure was closed.

III. PHYSIOGRAPHY

Topographically the area occupied by the Nerrima Structure falls into three main divisions:-

A. The Nerrima Ridge forms the northern rim of the dome. This ridge strikes almost east-west and curves slightly towards the south at the eastern end before losing relief. Towards the western end of the structure the Nerrima Ridge trends southwards and then swings back to continue for some miles in a westerly direction before losing relief.

B. The ridges flanking the southern side of the structure are not as distinctive as the Nerrima Ridge but they form a general east-west strip of high ground which swings to the north at the western end of the structure and trends slightly to the south on the eastern end. The high ground tends to enclose the structure completely.

The southerly trend of the eastern end of the

southern ridge is due to the proximity of a basin, the axis of which strikes away to the south-east.

C. An extensive flat area with a gradual fall towards the east occupies the axial region of the structure.

Drainage is poorly developed and most of the axial region is water-logged during the wet season and for some time afterwards. Small channels diverging from a north-south divide near the western end of the structure drain easterly towards the Fitzroy River and westerly towards Nerrima Creek.

IV. STRATIGRAPHY

A. General

The Permian succession (cf. Wade 1935-1936, Kraus 1942) probably begins in the Lower Permian with the glacial sandstones of the Grant Range Formation, and continues upwards with a disconformity into the shallow marine Lower Ferruginous Formation (middle Permian). The Nura Nura Limestone occurs as a disconformable lens between these formations. The Noonkanbah Formation follows conformably on the Lower Ferruginous and passes up without a break into the Liveringa Formation (Upper Permian). The Noonkanbah and Liveringa Formations are of marine origin..

Wade estimated a total thickness of between 7500 and 8000 feet for the Permian but states that there is "considerable variation in the thicknesses of different members of the group when traced from one area to another."

The outcrops on which the field work is based belong to the Noonkanbah and Liveringa Formations but represent only those parts of the section near the junction of the two formations.

(i) The Noonkanbah Formation

According to previous reports (Wade 1935-1936, Kraus 1942) the Noonkanbah Formation consists of shales and clays with some sandy bands, flaggy and massive limestones and calcareous sandstones. Wade estimates a thickness of 1200 feet for this formation, but this could not be verified as the section exposed at Nerrima is incomplete.

Owing to the lithology of the various beds in the formation, outcrops in general are poor. The uppermost more calcareous beds are the most resistant to erosion and occur as low outcrops or as lines of floaters on the black soil and sandy plains typical of the Noonkanbah Formation.

The lithology and palaeontology of this formation indicate deposition under shallow marine conditions.

The Noonkanbah Formation passes conformably into the underlying Lower Ferruginous Formation (Wade 1935-1936)

(ii) The Liveringa Formation

This formation consists of heavily ferruginised, coarse-grained sandstones with coarse grit and gravel lenses. Bands of finer sandstones and micaceous sandy shales are characteristic of the lower parts of the formation. The ferruginisation, at least in part, is a surface effect due to weathering and is much more prevalent in the coarser-grained sediments.

These sediments are typically of shallow marine origin and contain pelecypods and gasteropods with occasional plant remains.

The Liveringa Formation is conformable with the underlying Noonkanbah Formation and passes upward into the basal clays of the Erskine Beds. (Wade, 1935).

B. The Nerrima Area.

(1) Lithology.

(a) Noonkanbah Formation.

Only the upper portion of the formation is exposed, and as the shale and clay beds are not recognisable as such, attention is concentrated on the more calcareous members. The lowest beds recognisable occur as discontinuous lines of floaters of fossiliferous limestone and calcareous sandstone between 200 and 250 feet stratigraphically below the junction with the Liveringa Formation. Above these are alternating thin limestones and calcareous sandstones but only in the upper 180 feet of the formation are beds sufficiently defined to be regarded as mappable units.

The calcareous sandstones are finegrained and micaceous, the amount of mica decreasing notably near a fossiliferous limestone bed. No mica occurs in the fossiliferous limestone.

Although the sediments are regarded as finegrained throughout the section, there is a slight increase in grain size towards the junction of the Noonkanbah and Liveringa Formations.

Thin bands of red marl occur interbedded with some of the shaly fossiliferous limestones and persist for some distance along the strike, but no correlation between separated outcrops can be made on this basis.

The upper junction of the Noonkanbah Formation is gradational. The uppermost fossiliferous limestone bed is overlain by micaceous, calcareous sandstones which alternate with and and finally give way to the ferruginous, micaceous sediments of the Liveringa Formation. Some thin beds of calcareous sandstone persist into the Liveringa Formation.

An arbitrary junction has been drawn 75 feet above a well-defined fossiliferous limestone bed outcropping along the northern side of the structure. The junction here coincides with the first calcareous sandstone below Liveringa fossils.

(b) The Liveringa Formation.

The outcrops of this formation show to varying degrees the development of a laterite capping which with associated concretionary structures obscures the character of some of the finer sediments near the base of the formation. These lower members are siltstones, fine-grained, ferruginous sandstones (in places felspathic) and medium-grained ferruginous sandstones. Coarser sandstones and grits outcrop higher in the section. In general these sediments are more micaceous than those of the Noonkanbah Formation.

The variety of concretionary forms present appears to be due to variations in the original rocks in which they are formed.

(ii) Palaeontology.

(a) The Noonkanbah Formation.

The lowest fossiliferous bed traced in the

formation is a polyzoal limestone 190 feet below the proposed junction. The outcrops are lines of small floaters which are composed mainly of fragmental polyzoa.

A more clearly defined bed occurs 15 feet higher in the section. This bed consists mainly of limestone floaters containing remains of polyzoa and brachiopods (NS23).

Both these beds are continuous on the south-eastern flank of the structure. Elsewhere in the axial region they are not well defined but occur as broken lines of floaters which can be traced on aerial photos.

Other limited outcrops of polyzoal limestone occur as floaters in the central portion of the area but their position in the stratigraphic sequence and their relation to one another is uncertain.

At locality NS17 limestone floaters containing pelecypods, brachiopods and foraminifera occur in association with polyzoal limestone floaters. No similar collection was found elsewhere on the structure and this occurrence is apparently portion of a large lens about 140 feet below the junction.

The well-defined limestone bed from which the position of the upper junction of the Noonkanbah Formation is determined occurs as low outcrops of slabs and boulders around the northern side and on part of the southern flank of the structure. This bed consists of two distinct, well-developed fossil bands with a stratigraphic interval of 10 feet. The lower of these bands (NS6) is composed mainly of fragments of Spirifer with some crinoids. The upper band consists almost entirely of complete fossils of Strophalosia Kimberleyensis Prendergast, which is so numerous as to form a solid mass up to 18 inches thick.

The Strophalosia and Spirifer beds are mapped as a unit and form the basis of most of the planetable work on the structure. The surface of the Noonkanbah Formation has been fixed with relation to the Strophalosia band and the calcareous sandstones near the top of the formation and is 75 feet above the Strophalosia band.

In at least three localities about 25 feet below the boundary of the Noonkanbah and Liveringa Formations a fossiliferous limestone containing large brachiopods occurs (N.S.8,18)

(b) The Liveringa Formation

Fossil bands cannot be traced as readily in this formation owing to the lithological similarity of the section and to the development of laterite. However, marker horizons can be followed on the north-eastern edge of the structure.

The outstanding difference between the faunal assemblages of the two formations is the predominance of brachiopods in the upper part of the Noonkanbah Formation, and gasteropods and pelecypods in the beds at the base of the Liveringa Formation.

(c) Fossil Determinations.

Below is a list of specimens arranged in stratigraphic sequence beginning with the youngest, with determination of fossil forms present.

N.S.14 Ferruginous intraformational conglomerate with worm tubes

N.S.9 Pleurophorus nov. sp.

N.S. 10 Stutchburia nov. sp.

N.S. 11 Pleurophorus nov. sp., Allorisma nov. sp., Stutchburia nov. sp., Oriocrassatella ? sp., Cardiomorpha sp., Atomodesma cf. exarata Wanner, Streblochondria nov. sp., Warthia cf. micromphala (Morris).

N.S. 13 Aphanaia nov. sp.

N.S. 12 Cardiomorpha sp., Bellerophon sp., Euphemites cf. emerii (Eth.), Mourlonia nov. sp., Shansiella nov. sp.

N.S. 19 Euphemites emerii (Eth.), Prodentalium nov. sp.

N.S. 21 Nuculana cf. basedowi (Eth.), Euphemites sp. ind., Warthia sp., Prodentalium nov. sp.

N.S. 15 Euphemites emerii (Eth.), Warthia cf. micromphala (Morris), Shansiella nov. sp., Prodentalium nov. sp.

N.S. 22 Small fragments of brachiopod and pelecypod shells.

N.S. 8 Bryozoan and crinoid limestone with Chonetes sp. ind., Streptorhynchus luluigui Hosking, Streptorhynchus sp., Spirifer sp. ind., Bellerophon sp. ind.

N.S. 18 Chonetes sp., Streptorhynchus nov. sp., Spirifer sp. ind., Aviculopecten cf. sprenti Dana, Aviculopecten sp.

N.S. 7 Strophalosia kimberleyensis Prendergast, Aviculopecten sp. ind.

N.S. 6 Calceolispongia sp. ind., Spirifer nov. sp.

N.S. 5 Strophalosia kimberleyensis Prendergast, Linoproductus cf. cancriniformis Tschern., Taeniothaerus subquadratus (Morris).

N.S. 23 Bryozoan limestone with Chonetes sp.

N.S. 17 Calceolispongia sp. ind., Chonetes sp., Linoproductus sp. ind., Spirifer sp. ind., Cleiothyridina cf. maccleyana Eth., Posidonomya ? nov. sp., Hyalina ? sp. Hyperammoides acicula Parr.

N.S. 16 Bryozoan limestone with Hexagonella sp., Stenopora sp.

N.S. 1 Bryozoan limestone.

From these determinations the section may be divided into three zones:-

(a) Pelecypod zone (N.S. 9, 10, 11, 13).

(b) Gasteropod zone (N.S. 12, 19, 21, 15).

(c) Brachiopod zone (N.S. 22 and down to the bottom of the section).

The top of the Brachiopod zone coincides approximately with the junction of the Noonkanbah and Liveringa Formations.

V. STRUCTURAL GEOLOGY.

A. General.

The Nerrima Structure lies in an area of low-dipping strata which form a series of basins and domes of low relief. The limits of this extensive gently folded area are not known as detail is obscured by sand and alluvium.

From aerial photographs three basins are visible in the vicinity of the Nerrima dome. One to the north-west extends to the west tributary of Nerrima Creek, a distance of 24 miles. This basin is not obvious on the ground as the area is flat and outcrops poor.

A marked change in the strike of beds on the southern flank of the Nerrima dome is due to the proximity of a basin to the south-east. This basin can be traced for about 12 miles to the south-east on aerial photographs before it is obscured by sand immediately north-east of Mount James.

To the north-east across the Fitzroy River is a basin with a nearly east-west axis. Its eastern limit is uncertain but it can be traced for some miles before its continuity is broken in a faulted area.

Between the Nerrima dome and Nerrima Creek there is evidence of a further domal structure but most of the area is sand-covered and detail is lacking.

A major zone of faulting extends from Mount Fenton, through Mount James and continues to the north-west towards Nerrima Creek. Wade suggested that this is a shallow compression rift valley.

B. The Nerrima Dome.

The Nerrima Structure is a low, extensively faulted dome. The axis curves in a gentle arc from the south-east to the west-south-west.

In general dips are low but are variable and not always reliable. Along the northern flank they vary from 3° to 5° and show a gradual decrease from west to east. There is a general flattening of the fold on the southern limb where the beds dip at angles of 3° or less although local irregularities due to minor folding result in readings as high as 7°.

(i) Faulting.

The structure is extensively faulted particularly on the northern flank and western end.

Apart from the major doming of the beds, subsidiary folding occurs and the subsequent shearing of these minor folds gives rise to faulting, at least along the northern limb of the dome. Most of the faults along this limb show an apparent displacement to the south of beds on the eastern side of the fault together with a swing of the strike towards the south. The greatest horizontal displacement measured is 9,000 feet. These faults can be traced some miles to the north but none can be followed to the south into the axial region of the structure. Although small faults occur on the southern flank there is no obvious relation between them and those on the northern flank. Apparently the faulting dies out in the Noonkanbah Formation which by nature of its lithology may be expected to be more competent than the Liveringa Formation.

Any faulting which may occur to the east is obscured by sand and alluvium. No evidence was found to substantiate a suggestion (Kraus, 1942) that a fault runs adjacent to the line of billabongs south of Nerrima Homestead.

The structural features of the western end are not readily apparent. The beds outcropping on the northern flank are faulted

along the strike and appear again in the axial region as a low ridge of the Liveringa Formation and a small flat area in which the Strophalosia and Spirifer marker beds of the Noonkanbah Formation outcrop. The vertical displacement is about 400 feet. The ridge and the limestone beds terminate towards the east against a transverse fault striking in a south-westerly direction. This fault is the eastern boundary of a down-faulted block and has a maximum vertical displacement of 300 feet but this diminishes towards the south. To the west the Strophalosia and Spirifer beds curve southwards and end abruptly against an east-west fault. They do not reappear elsewhere on the south-west portion of the structure. The rocks exposed on the southern side of this east-west fault belong to the Liveringa Formation. They are heavily lateritised and no reliable dips were determined. From the comparison of fossil assemblages of the Liveringa Formation to the north and south of this fault the downward displacement to the south is small. As the dips are low it appears that beds of the Noonkanbah Formation are close to the surface south of this fault.

The faulting and fracturing of subsidiary folds on the structure in general indicates that cover was comparatively thin at the time of folding. If this was the case it is unlikely that these faults extend to any great depth and consequently should not affect the closure although there are indications of slickensiding in the bore cores in the underlying formations.

(ii) Closure.

The highest bed on which closure was established in the field is the polyzoal limestone in the Noonkanbah Formation, 175 feet below the junction with the Liveringa Formation. Outcrops are for the most part confined to lines of floaters but these can be traced with some difficulty in areas where the higher, more distinct beds swing away to the adjacent basins. The structural contour map is based on the upper surface of this bed. The contours are at intervals of 100 feet above sea level and the highest part of this polyzoal limestone bed is 700 feet above sea level.

The eastern end is closed down to the 300 feet contour. At the western end the closure extends only to the 500 feet or possibly to the 450 feet contour giving a probable depth of closure of 250 feet extending over an area of approximately 30 square miles.

VI. NERRIMA No. 1 BORE.

The Nerrima No. 1 Bore apparently begins a little over one third way through the Noonkanbah Formation, about 400 below the junction with the Liveringa Formation. Calcareous beds of the Noonkanbah Formation persist to a depth of 500 feet and fossils occur as far as 583 feet below surface. Beyond this depth the lithology changes to give a rapidly alternating sequence of micaceous mudstones, siltstones and fine sandstones (some felspathic). This rapid alternation of rock types together with the amount of pyrites present indicates the base of the Noonkanbah Formation was reached at a depth of about 800 feet. This depth combined with information obtained from the structure contour map gives a thickness of 1,200 feet for the Noonkanbah Formation. Not enough is known of the underlying formations to differentiate between them but the bore has probably penetrated the Lower Ferruginous Formation and may be at present in sandstones of the Grant Range Formation.

ACKNOWLEDGMENTS.

The writers are indebted to Dr. Teichert of the University of Melbourne, and Miss Crespin, Commonwealth Palaeontologist, for determination of fossils collected.

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PHOTOGRAPHS.

1.

2.

3.

1. Outcropping slab of limestone showing Strophalasia kimberleyensis marker bed.

2. Tracing the Strophalosia kimberleyensis marker bed at the north-east end of the structure.

3. Plane table setup over polyzoal limestone marker bed on south side of the structure.

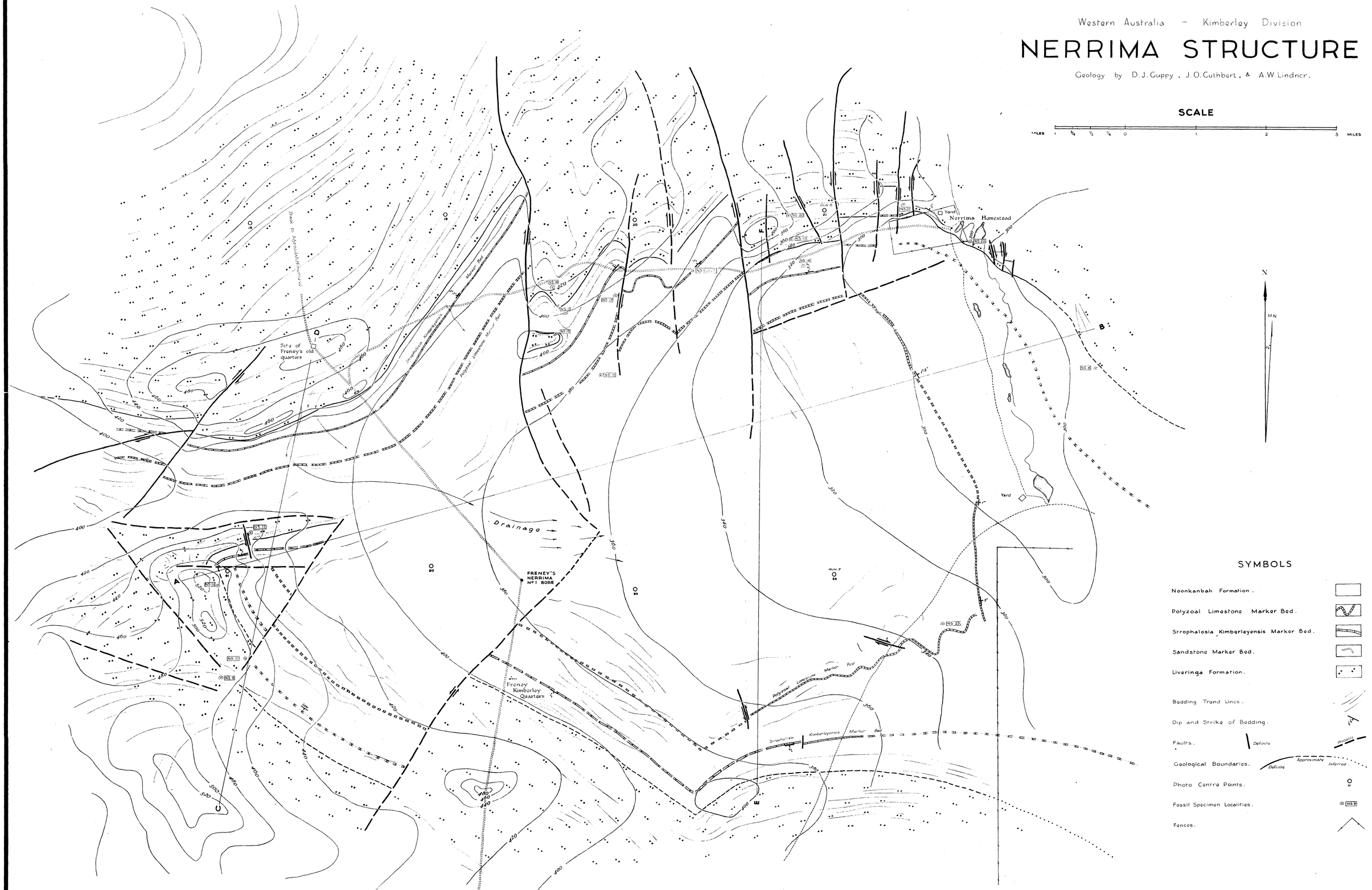
Western Australia – Kimberley Division

NERRIMA STRUCTURE

Geology by D.J. Guppy, J.O. Cuthbert, & A.W. Lindner.

SCALE

MILES 1 ¾ ½ ¼ 0 1 2 3 MILES



SYMBOLS

- Noonkanbah Formation.
- Polyzoal Limestone Marker Bed.
- Strophalosia Kimberleyensis Marker Bed.
- Sandstone Marker Bed.
- Liveringa Formation.
- Bedding Trend Lines.
- Dip and Strike of Bedding.
- Faults. Definite. Probable.
- Geological Boundaries. Definite. Approximate. Inferred.
- Photo Centre Points.
- Fossil Specimen Localities.
- Fences.

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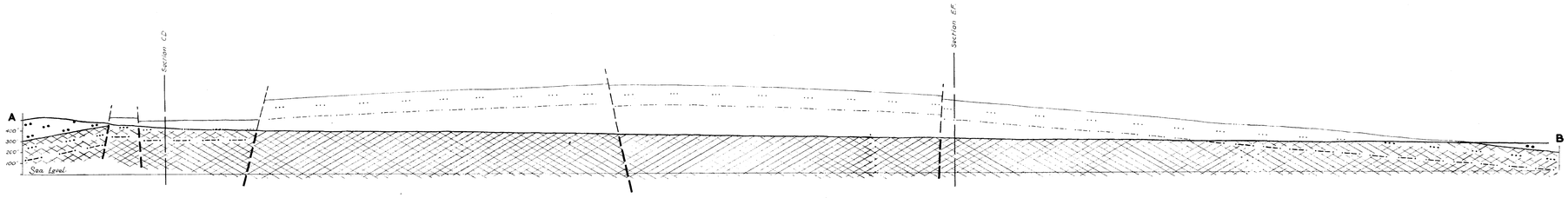
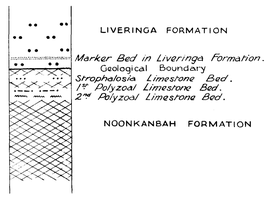
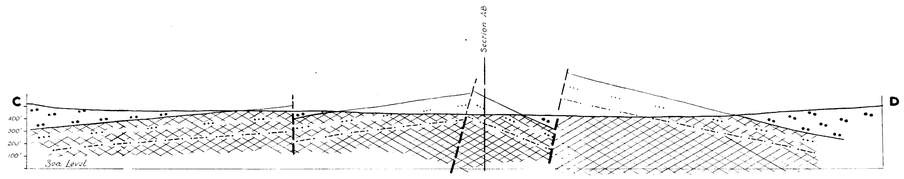
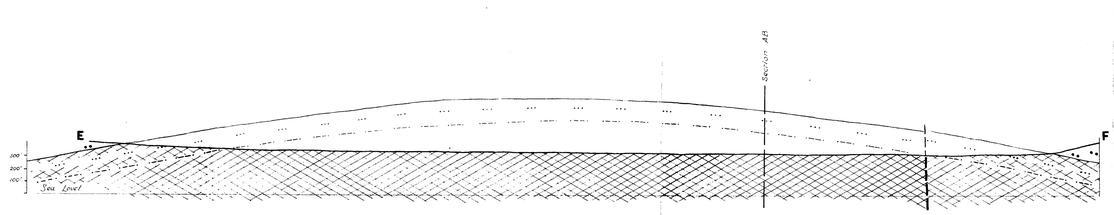
WA 3B-3





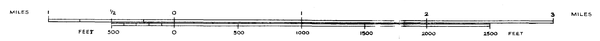




NERRIMA STRUCTURE

SECTIONS FROM PLAN WA 3B-3

HORIZONTAL SCALE



VERTICAL SCALE

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WA 3B - 4

Western Australia – Kimberley Division

NERRIMA STRUCTURE

STRUCTURAL CONTOUR MAP

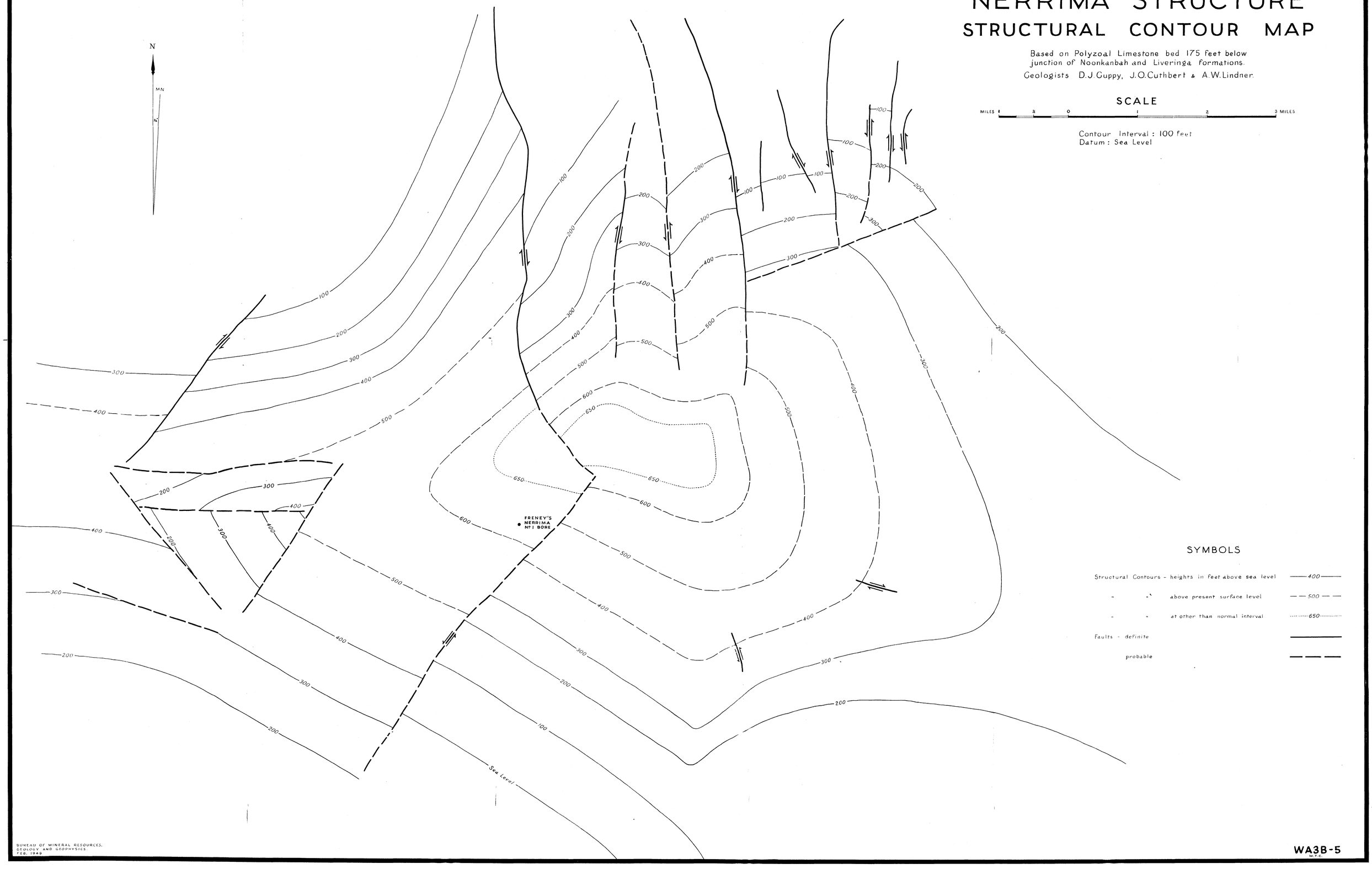
Based on Polyzoal Limestone bed 175 feet below junction of Noonkanbah and Liveringa formations.

Geologists D.J. Guppy, J.O. Cuthbert & A.W. Lindner.

SCALE

MILES ½ 0 1 2 3 MILES

Contour Interval : 100 feet
Datum : Sea Level



SYMBOLS

Structural Contours – heights in feet above sea level — 400 —

– " – above present surface level — — 500 — —

– " – at other than normal interval ····· 650 ·····

Faults – definite ———

probable — — —

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WA3B-5
W.T.C.