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DEPARTMENT OF MINERALS AND ENERGY

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

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NOTES ON THE COOPER BASIN IN QUEENSLAND

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*Bureau of Mineral Resources, Canberra, A.C.T. Published with the permission of the Director.

Summary

The Cooper Basin consists of Early Permian to Middle Triassic sedimentary rocks and extends beneath the Eromanga Basin from South Australia into Queensland; this paper describes the relatively poorly known Queensland portion.

The sequence in Queensland thins towards the preserved margins of the basin, where disconformities are common. It also thins towards the northeast and extends across the Canaway Fault into the Galilee Basin.

The oldest sedimentary rocks (Merrimelia Formation) of the Cooper Basin sequence unconformably overlie low-grade metamorphic basement rocks of probable Ordovician age. The overlying Gidgealpa Group is recognized in the southwest adjacent to the State border, but to the northeast, in an area west of the Canaway Fault, its equivalents are thin coal measures.

The structural axis of the Basin in Queensland is marked by a sinuous line of interconnected downwarps - The Wilson Depression and the Cooper and Thomson Synclines. The Jurassic and Cretaceous Eromanga Basin sequence unconformably overlies and conceals the Cooper Basin but most fold structures are reflected, though in diminished amplitude, in these cover rocks.

Introduction

The Cooper Basin is an early Permian to Middle Triassic intracratonic basin beneath the Eromanga Basin; it extends from South Australia northeastwards into southwestern Queensland, where it underlies an area of about 80 000 km^2.

The geology of the Cooper Basin, with special emphasis on the South Australian part, has been discussed by Greer (1965), Wopfner (1966), Martin (1967a, b), and Papalia (1969). Several gas and gas-condensate fields and an oil and gas field have been found in South Australia and information is available from over 100 petroleum exploration and development wells. However, there are only 23 exploration wells in the Queensland part, and 11 of these are close to the South Australian border. The Queensland part of the basin remains relatively poorly known, therefore, but sufficient information is now available to outline the regional geology. The extension into Queensland of relatively recently defined units of the Gidgealpa Group in South Australia by Kapel (1972) and Gatehouse (1972) is examined.

Stratigraphy

The most common basement rocks encountered in petroleum exploration wells drilled through the Cooper Basin sequence in Queensland are low-grade metamorphic rocks of probable Ordovician age. Late Proterozoic or Early Palaeozoic sedimentary rocks form basement below the Innamincka Dome in the south; northeast, near the Canaway Fault, the underlying sequence consists of Middle Devonian rocks of the Adavale Basin (Warrabin Trough). Granitic basement is present in the southwest at TEA Tickalara 1 and acid igneous rocks in the extreme northeast at LOL Stormhill 1 (Fig. 1).

The Lower Permian to Middle Triassic Cooper Basin sequence in Queensland, which is up to 1700 m thick, is summarized in Table 1. The Triassic Nappamerri Formation has been recognized throughout the Cooper Basin in Queensland, but the South Australian Permian units are only recognized in the southwest; elsewhere (e.g. Fig. 2) coal measure type facies are present, but their relation to the formal stratigraphy is poorly known.

Merrimelia Formation

The basal Merrimelia Formation (Martin, 1967b) in Queensland consists of up to 400 m of glacigene rocks resting unconformably on basement. It is probably discontinuous, although it has been penetrated by most petroleum exploration wells. It is absent in an area marginal to the Canaway Fault where coal measures, apparently of the same age, have been encountered (Paten, 1968). The northern extent of the Merrimelia Formation, and of Permian units in general, is incompletely known. Some 20 m of quartzose sandstone overlying basement in LOL Stormhill 1 (Fig. 1) and 55 m in the adjacent Henry B. Kelsey Ban Ban 1 well are possibly Permian. Palynological examination of cuttings from the supposed Permian section in Stormhill 1 yielded a Cretaceous flora, but this is probably due to contamination (Dr E. Kemp, pers. comm.).

Gidgealpa Group

The Merrimelia Formation is disconformably overlain by rocks of the Gidgealpa Group, the extent and thickness of which is shown on Figure 2. In general the units of the group in South Australia (Kapel, 1972; Gatehouse, 1972) can be recognized in Queensland except in the northeast, where undifferentiated coal measures occur. The Tirrawarra Sandstone is the basal unit of the group, but it has not previously been positively identified in Queensland. However, correlation of the interval 2950 - 3049 m in the AOD Packsaddle 1 with parts of DFS Innamincka 2 and FP Tallalia 1 (Fig. 4 Line 1) implies its presence in at least the western part of the Queensland Cooper Basin. It may also be present in the Wilson Depression to the south of these drillholes where seismic studies indicate an abnormally thick Permian sequence.

Above the Tirrawarra Sandstone the Gidgealpa Group (Table 1) consists of three coal-bearing units (Patchawarra, Epsilon, and Toolachee Formations) interbedded with three units without coal (Murteree and Roseneath Shales, Daralingie Beds). These can be traced into Queensland, and the upper unit, the Toolachee Formation, over a larger area owing to the presence within it of coal beds which are widespread seismic reflectors (Fig. 1).

In the southwest part of the basin in Queensland the basal Gidgealpa Group thins to the northeast owing to onlap across the older Merrimelia Formation and Ordovician basement of the Orientos Anticline (Fig. 4 Line 3). This may also be the situation towards the southeast basin margin.

Elsewhere, the divisions of the Gidgealpa Group are unclear, and in places abrupt thickening or condensing of some units reflects contemporaneous structural movement, for instance in the vicinity of the Innamincka Dome. In the section from AOD Packsaddle 1 to FP Tallalia 1 (Fig. 4, Line 1) there is a prominent sandstone bed, tentatively identified as Tirrawarra Sandstone, overlain by a thick sequence of interbedded sandstone, siltstone, mudstone, and coal identified by gamma-ray and sonic log characteristics as Patchawarra Formation. The marked increase in thickness of the Patchawarra Formation (855 m in Innamincka 2) over the typical reference section in Brumby 1 indicates rapid sedimentation in the Early Permian (Stage 3) near the present position of the Innamincka Dome. Sedimentation was curtailed by fold movements in the late Early and Late Permian. In contrast, slow sedimentation due to gradual uplift in the area during the interval from Lower Stage 4 to Upper Stage 5 (Table 1) resulted in a condensed sedimentary sequence, which represents the Murteree Shale to Toolachee Formation. As a result this sequence is represented by only 57 m in Packsaddle 1.

In the area to the north of the Innamincka 2, Tallalia 1, and Arrabury 1 wells only AOD Gilpeppee 1 provides subsurface data on the Gidgealpa Group. The well penetrated 330 m of Gidgealpa Group rocks on a small anticline lying between the Yamma Yamma Depression and Cooper Syncline; the flora was carbonized and unuseable. However, the gamma-ray and sonic logs show some similarity with the reference section at Brumby 1 well (380 km to the south), and tentative divisions of the Gidgealpa Group are made (Fig. 4 Line 2). It appears that the Gilpeppee Anticline was active in the Late Permian, and the Toolachee Formation was condensed or truncated. This uplift was short-lived, however, as over 500 m of Lower to Middle Triassic Nappamerri Formation rocks accumulated across the structure. In common with most other fold structures in southwest Queensland, slight movement in the basement below the Gilpeppee Anticline in Cainozoic time produced a gentle fold in the Eromanga Basin sequence and Lower Tertiary Glendower Formation.

The thin sequence of Gidgealpa Group equivalents in the DS Mt. Howitt 1 well (Fig. 4, Line 2) comprises numerous coal seams interbedded with sandstone, siltstone, and shale; the sequence has not been formally divided.

In the AOD Chandos 1 well in the eastern part of the basin (Fig. 1) 55 m of coal measures were intersected between the Devonian Log Creek Formation and the Lower to Middle Triassic Nappamerri Formation. The section can be regarded as typical of the coal measure facies which exist in a large part of the northeast Cooper Basin. Palynological Stages 2, 3 and Upper 5 in this well (Paten, 1968) and common occurrence of palynomorphs typical of Stage 3 and Upper 5 in nearby wells are found in juxtaposition in a stratigraphic interval that is generally less than 60 m thick. The lower part of the coal measure sequence in Chandos 1 is the same age as the Merrimelia Formation and the upper part is coeval with the Toolachee Formation (Evans, 1966; Paten, 1969). This condensed succession indicates a stable shelf-like margin in the east, with discontinuous but slow sediment accumulation. The absence of palynological Stage 4 indicates at least one substantial break in sedimentation.

Nappamerri Formation

The Triassic Nappamerri Formation (Papalia, 1969), which comprises fluviatile and lacustrine shale, sandstone, siltstone, and coal, unconformably overlaps the Gidgealpa Group onto basement, particularly in the southeast, where it extends onto the west margin of the Thargomindah Shelf (Figs. 2, 3).

STRUCTURE

The Cooper Basin in Queensland is roughly rectangular and has a sinuous southwest-trending axis which coincides with the present position of the Thomson River and Cooper Creek. The basin axis diverges at the northern end of the Cooper Syncline to form the Yamma Yamma Depression.

Basin margin features

To the northeast the Canaway Fault forms an arbitrary boundary to the Cooper Basin, although very thin Gidgealpa Group and up to 300 m of Nappamerri Formation rocks are preserved across the northern end of this fault in continuity with the Galilee Basin sequence.

In the northwest the Cooper Basin sequence abuts against or overlaps onto a linear basement ridge which is now coincident at the surface with a series of en echelon structures in Eromanga Basin and Cainozoic rocks, including the Curalle Dome, Morney Anticline, and Warbreccan Dome (Fig. 1). In contrast, a southeast-trending faulted basement block forms a low ridge flanked by Gidgealpa Group and overtopped by the Nappamerri Formation near the FPC Galway 1 well.

The northerly extent of the Cooper Basin sequence is poorly known, although the Permian rocks probably thin northwards from a local centre of deposition in the Thomson Syncline area (Figs 2 & 3). Possible Permian rocks are identified in the Stormhill 1 and Ban Ban 1 wells.

Folds and Faults

The major folds and faults are reflected by the structure contours on top of the Gidgealpa Group (Fig. 1). There is good structural concordance between the Cooper Basin and overlying Eromanga Basin sequence (Senior, in press), and although structure in the cover rocks is subdued, data from the Eromanga Basin sequence were used in Figure 1 to give additional shape control in areas with little or no seismic coverage.

Geological History

The first sediments deposited in the Cooper Basin in Queensland were silt, sand, and gravel (Merrimelia Formation) laid down in probably fluvioglacial, glaciolacustrine, periglacial, and fluvial environments in earliest Permian time.

During the Early Permian the deposition of quartzose fluvial sand (Tirrawarra Sandstone) spread from the South Australian part of the basin into the Wilson Depression and Innamincka Dome area. Alternating fluvial, deltaic-lacustrine, and paludal sediments followed, the thicker accumulations being in the Cooper Syncline, Yamma Yamma Depression, and Thomson Syncline.

In the southwest, regular changes in environment produced an alternation of argillaceous and arenaceous sediment; coal swamps flourished at times and differential movements of structures resulted in marked thickness variations.

In the northeast, deposition was much slower. Coal swamps flourished, and at the close of Permian time deposition was probably continuous with that of the Galilee Basin across what later became the northern part of the Canaway Ridge.

After Gidgealpa Group time the margins of the basin and on uplifted areas within the basin were eroded, and simultaneously the Lower Triassic fluvial and lacustrine sediments of the Nappamerri Formation have deposited. Initially these sediments were restricted to the main downwarps (e.g. Cooper Syncline, Yamma Yamma and Wilson Depressions) but later even the flanking basement areas were also inundated. By Middle Triassic time deposition had ceased and erosion begun; there followed the deposition of the Eromanga Basin sequence in the Early Jurassic.

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Table 1. The Cooper Basin Sequence in South Australia and Queensland

AGE	PALYNOLOGICAL DIVISIONS *	Sequence in South Australia and southwest Queensland: NOMENCLATURE		Sequence in South Australia and southwest Queensland: LITHOLOGY	Coal measure facies in northeast (Fig. 2): NOMENCLATURE	Coal measure facies in northeast (Fig. 2): LITHOLOGY
Early to Middle Triassic		Nappamerri Fm.		Shale, sandstone, silt-stone, minor coal	Nappamerri Fm.	Carbonaceous shale a siltstone, quartzose sandstone, minor coal
Late Permian	Upper Stage 5	GIDGEALPA GROUP	Toolachee Fm.	Sandstone, conglomerate, carbonaceous siltstone, coal	Unnamed	Coal with thin beds of quartzose sand-stone and dark carbonaceous shale
Early Permian	Upper Lower Stage 5	GIDGEALPA GROUP	Daralingie Beds	Sandstone, shale, minor coal		
	Lower Stage 5	GIDGEALPA GROUP	Roseneath Shale	Shale, minor siltstone		
	Upper Upper Stage 4	GIDGEALPA GROUP	Epsilon Fm.	Sandstone, shale, minor coal		
	Upper Stage 4	GIDGEALPA GROUP	Murteree Shale	Shale		
	Lower Stage 4	GIDGEALPA GROUP	Patchawarra Fm.	Sandstone, siltstone, shale, coal		
	Stage 3	GIDGEALPA GROUP	Tirrawarra Sst	Quartzose sandstone with clay matrix	Unnamed	Coal with quartzose, sandstone and carbon-aceous shale
Early Permian & pre-Permian	Stage 2	Merrimelia Fm.		Conglomerate, sandstone siltstone, shale, varves		

* Based on Paten (1969) with modifications as reported by Gatehouse (1972)

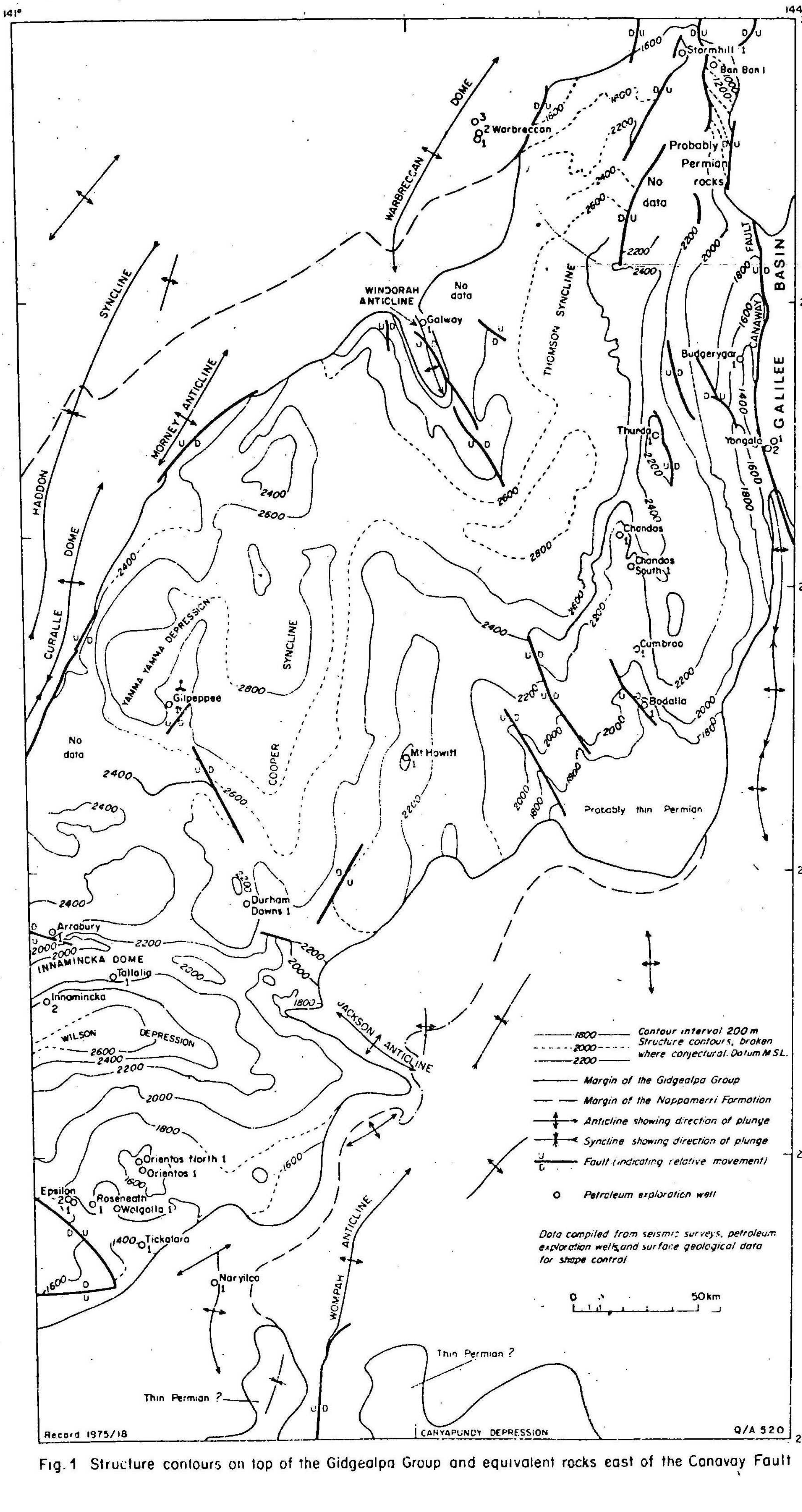

Fig. 1 Structure contours on top of the Gidgealpa Group and equivalent rocks east of the Canaway Fault

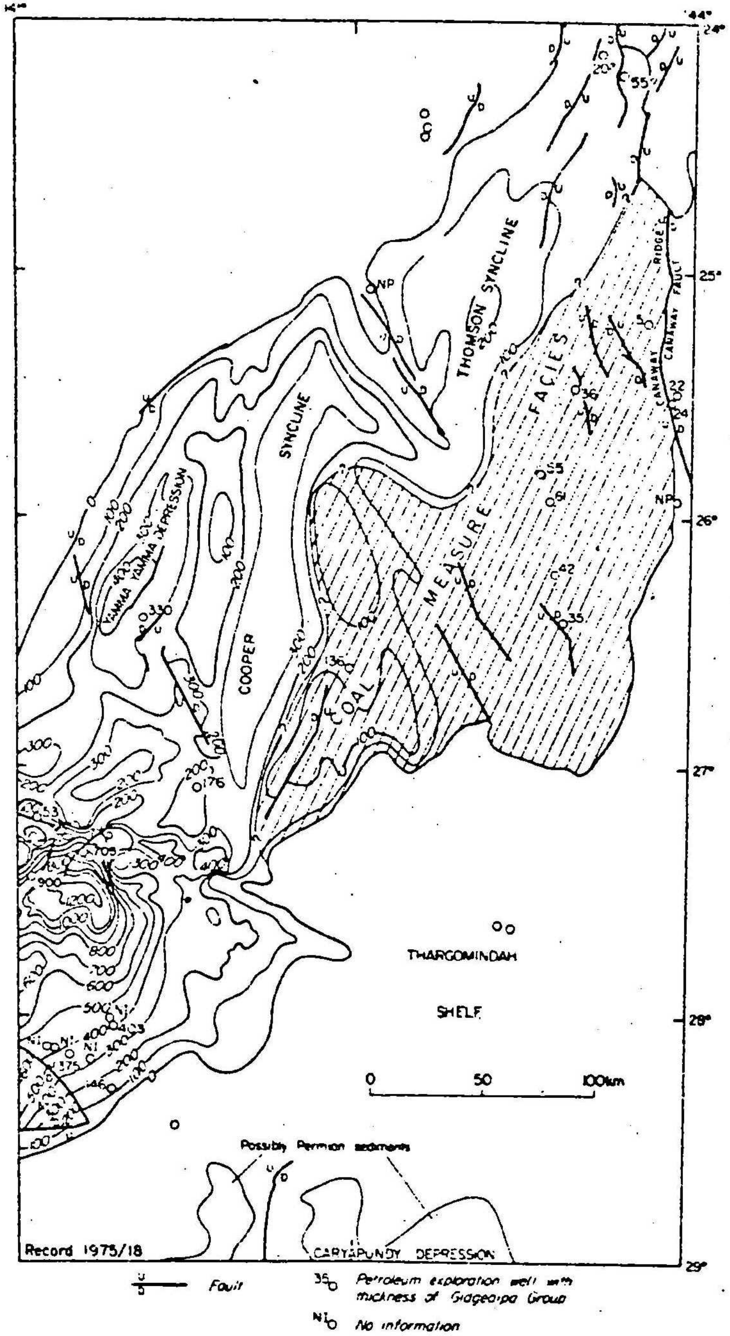

Fig. 2 Isopach map of the Gidgealpa Group and equivalent rocks east of the Canavay Fault

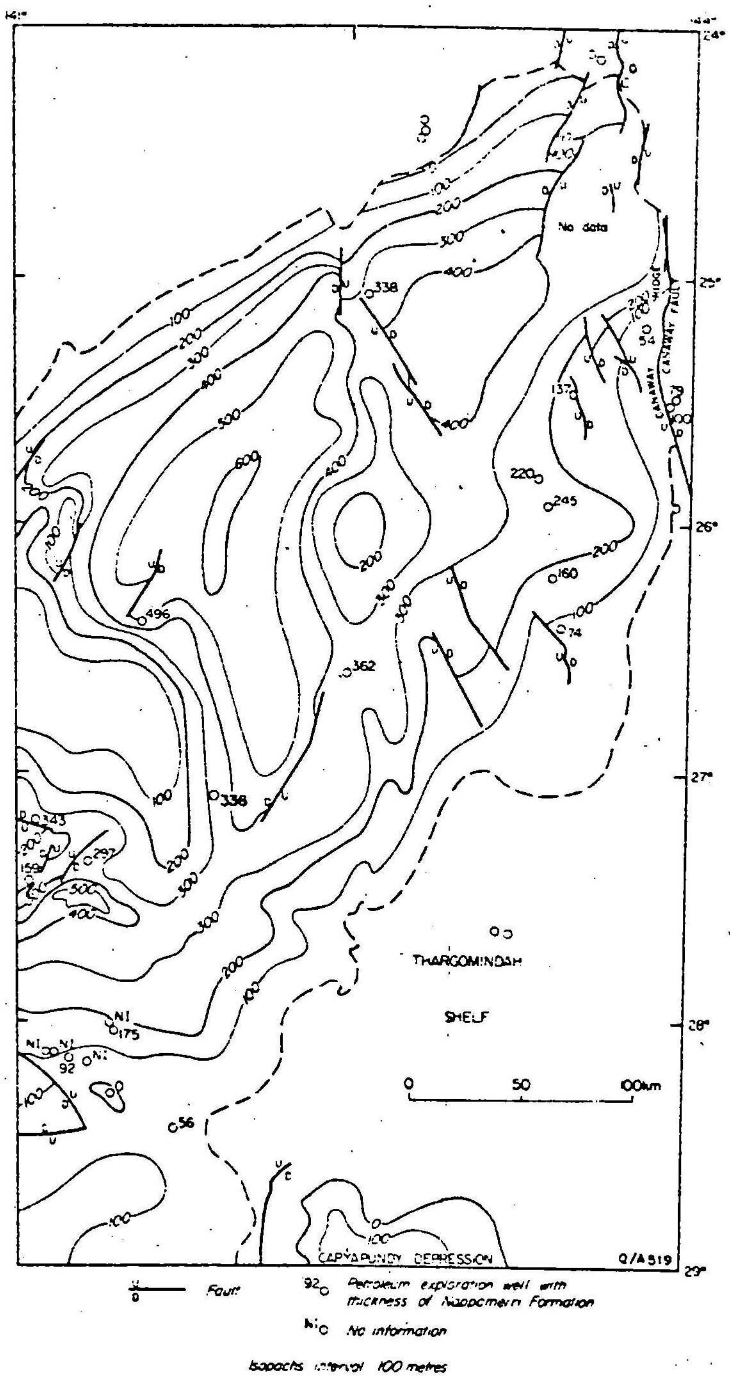

Fig. 3 Isopach map of the Nappamerri Formation

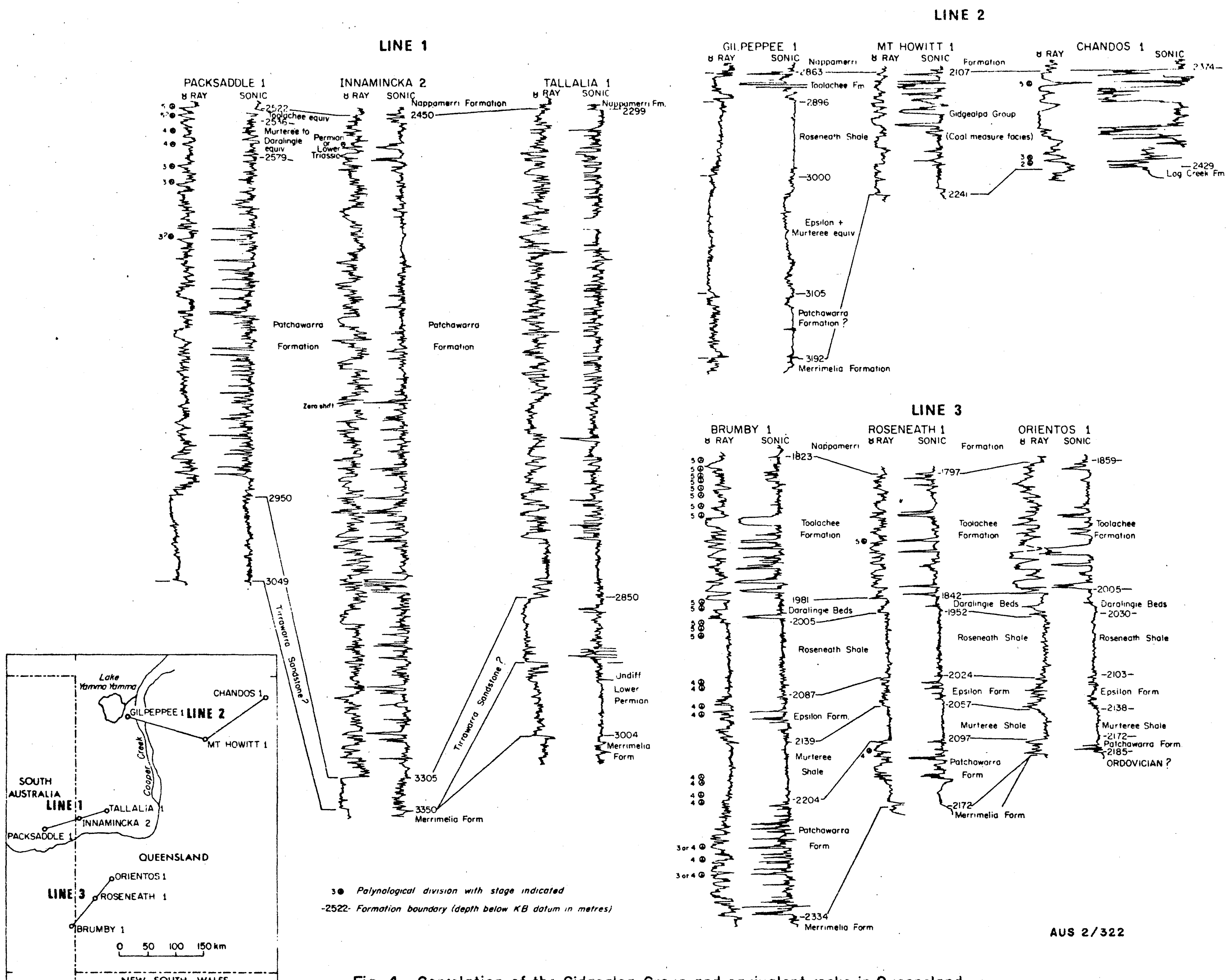

Fig. 4 Correlation of the Gidgealpa Group and equivalent rocks in Queensland

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