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THE TERMS TOOLEBUC LIMESTONE AND KAMILEROI LIMESTONE

by

J. Smart*

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SUMMARY

Inconsistent usage of the term Toolebuc Limestone in the Eromanga Basin is described and recommendations made for defining it as the calcareous unit between the Allaru Mudstone and Wallumbilla Formation. This definition is adopted for the Carpentaria Basin where the term Toolebuc Limestone replaces Kamileroi Limestone.

The Toolebuc Limestone in the Eromanga Basin

In the Eromanga Basin, where the name Toolebuc Limestone was originally used, it is generally applied to the calcareous unit between the Allaru Mudstone and the Wallumbilla Formation (Vine, 1966; Vine et al., 1967). The boundary between the Toolebuc Limestone and the Wallumbilla Formation is conceptually ambiguous. The term Toolebuc was originally used in the Boulia area for a calcareous member of the Wilgunya Formation (J.N. Casey, 1959). Vine et al. (1967) raised the Wilgunya to the status of a sub-group, consisting of Wallumbilla Formation, Toolebuc Limestone and Allaru Mudstone. The lithology of the Toolebuc member was given in the original definition as 'about 30 feet (9.1 m) of sandy calcarenite, calcareous siltstone and coquinite, with some calcareous concretions' (Casey, 1959). The type area has a surface cover of flaggy limestone rubble and concretions. Poor and incomplete outcrop is characteristic. In view of past (and current) inconsistency in the use of the term Toolebuc Limestone, it is important to remember that the name was originally applied to a calcareous member of the Wilgunya Formation. It was not defined as a limestone unit. The term 'limestone' was added by Vine et al. (1967).

No complete section of Toolebuc Limestone in the Eromanga Basin has been published. The most complete to date (Vine, pers. comm.) is an outcrop north of Richmond presented by Vine et al. (1963), but about a third of what these authors considered to be the Toolebuc Limestone interval is unexposed, so the lithology of the whole unit is still uncertain. In the subsurface the best available data (Vine, pers. comm.) in the Eromanga Basin are from BMR Longreach No. 5 scout hole (Vine & Galloway, 1969), in which part of the unit was cored. The thickness was reported as 1.33 m (6 feet), and the lithology reported as 'thinly interbedded limestone and calcareous siltstone'. The core of this interval is calcareous, bituminous siltstone, with bands of Inoceramus fragments. No gamma-ray logs were run but water bores in the area show an anomaly over less than 6 m (20 feet), with a peak in the lowest part, thought to correspond at least in part with the

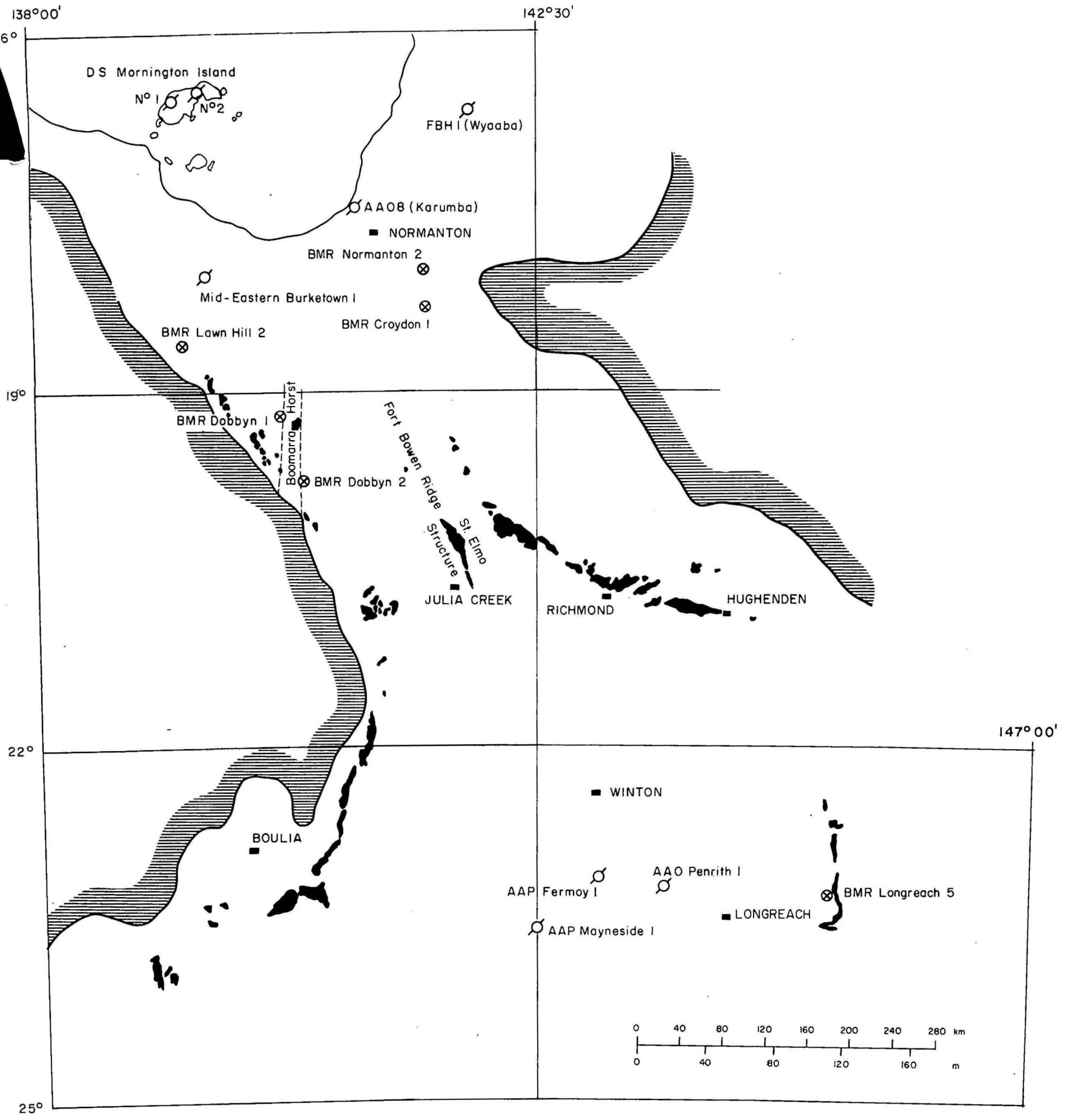

FIG 1- DISTRIBUTION OF TOOLEBUC LIMESTONE

Mapped outcrop of Toolebuc Limestone

Outcrop margin of Pre-Mesozoic basement rocks

Town

Petroleum exploration well (abandoned)

Stratigraphic hole

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Toolebuc Limestone. The thickness of the Toolebuc Limestone is believed to vary markedly over relatively short distances, so no firm conclusions can be drawn as to the direct quantitative relations of the water bore anomalies to the unit described as Toolebuc Limestone in Longreach No. 5. However, the unit invariably gives a positive anomaly on gamma-ray logs.

In the outcrop section north of Richmond (Fig. 1) described by Vine et al. (1963), the unit described as Toolebuc Member is underlain by 5.5 m (18 feet) of soft calcareous shaley claystone, with thin coquinitic bands of Inoceramus plates and fragments, which they included in the Ranmoor Member of the Wallumbilla Formation. The Ranmoor Member is described by Vine & Day (1965) as being commonly carbonaceous and containing laminae of Inoceramus plates near the top. This description is similar to those from the Carpentaria Basin of the calcareous unit overlying the Wallumbilla Formation (see below; Doutch et al., 1970; Grimes & Smart, 1970).

Vine et al. (1963) and D.J. Casey (1968) quote the log of Magellan Corfield No. 1, (R.14125), Manuka 1:250 000 Sheet area, when discussing the Toolebuc Limestone, and quote a thickness of 11.3 m (37 feet). However, the driller's log shows 'brown mudstone and grey sandstone' over an interval of 18.3 m (60 feet), and this corresponds with a gamma-ray anomaly over the same interval. The biggest peak of the anomaly is between 10.7 m (35 feet) and 12.2 m (40 feet) from the top of the anomaly. The boundary between the Toolebuc and Wallumbilla chosen by Vine et al. (1963) and D.J. Casey (1968) appears to coincide with the peak of the anomaly. By this interpretation, the lower part of the anomaly would be placed in the Wallumbilla Formation.

Jauncey (1967) attempted to restrict the term Toolebuc Limestone to the limestone at the top of calcareous beds between the Allaru Mudstone and Wallumbilla Formation. In the three petroleum exploration wells he discussed, there is a marked gamma-ray anomaly of about 30.5 m (100 feet)

corresponding closely to a unit of 'brown, calcareous shale', 'black marl', and minor limestone. In two of the wells (AAP Mayneside No. 1 and AAO Penrith No. 1) the top 2.4 m (8 feet) of the unit is limestone which Jauncey called Toolebuc Limestone. The third well (AAP Fenroy No. 1) penetrated 12.2 m (40 feet) of 'black marls and argillaceous limestone with numerous calcite veins', overlying black marl. Jauncey called the top 12.2 m (40 feet) Toolebuc Limestone. The inconsistency apparent in this approach reinforces the author's contention that the whole calcareous sequence is the only meaningful unit, which is consistent with the original definition of J.N. Casey (1959).

Williamson (1967) showed that the limestone is discontinuous and absent in the subsurface down dip of outcrop in many areas. This may be the result of limestone deposition in a series of favourable restricted areas, separated by others in which more muddy conditions prevailed, and in which the calcareous shale was formed.

D.J. Casey (1968, 1970) attempts to confine the name Toolebuc Limestone to the limestone part of the calcareous sequence, but implies that the situation is simply that of a continuous limestone band overlying a shale unit, the latter giving radioactive peaks as big as, or bigger than, those of the limestone. In his Figure 14 (1970) he presents a gamma-ray correlation diagram, in which he follows Vine (1966) and labels the whole anomaly as Toolebuc Limestone. The logs on this figure have peaks ranging from the base of the anomaly to its upper half, but never at the top. Similarly Vine (1966; 1970), who had implied that the name Toolebuc Limestone applies only to the limestone part (Vine et al., 1963), used the whole radioactive anomaly in his correlation diagrams.

Senior (1972; inprep.) refers to a 'Toolebuc gamma-ray anomaly' in the central Eromanga Basin area and makes the point that part of the sequence corresponding to the anomaly is calcareous shale and not limestone. However, comparison of his anomalies with gamma-ray logs from the Northern Eromanga and Carpentaria Basins suggests that his 'Toolebuc gamma-ray anomaly' does not consistently correspond to a particular lithological unit. In some places it appears to be equivalent to the Toolebuc Limestone (sensu stricto) but in others it includes substantial thicknesses of the adjacent Allaru Mudstone and Wallumbilla Formation.

In the Northern Eromanga Basin, where the anomaly is much more distinct than in the Central Eromanga Basin, Vine (1966, 1970) and others have used the gamma-ray anomaly as equivalent to the Toolebuc Limestone. Lithological logs of water bores show that the anomaly corresponds to a unit of calcareous shale, limestone, and bituminous shale. Thus the term Toolebuc 'Limestone' is not strictly correct as applied to the calcareous unit which corresponds to the gamma-ray anomaly, and the term 'Toolebuc Formation' might be more suitable.

However, it is premature to suggest this at present in view of the uncertainty existing in the Eromanga Basin.

Although the whole radioactive anomaly is easily recognized and correlated, the meaning of details of the anomaly is less clear. The peak or peaks within the anomaly vary considerably in magnitude and position even over short distances between bores (e.g. Vine, 1966, figs 4 & 5; Doutch et al., 1970). Therefore it is impracticable to divide the rocks corresponding to different parts of the radioactive anomaly into different units on a regional scale. Given detailed data, it would be possible to do this for small areas.

The Toolebuc Limestone is a most important marker bed in the stratigraphy of the Eromanga and Southern Carpentaria Basins and merits

further investigation. Re-examination of known sections should be supplemented with shallow drilling and wireline logging to obtain a concise picture of the formation.

The Toolebuc Limestone in the Carpentaria Basin

The name Toolebuc Limestone as applied to the calcareous rocks separating the Allaru Mudstone and the Wallumbilla Formation is now extended into the Carpentaria Basin for calcareous rocks in the same stratigraphic position, to which the names 'Kamileroi Limestone' and 'Kamileroi Formation' have previously been applied. As in the Eromanga Basin correlating the unit by its gamma-ray anomaly is the most practicable approach to understanding it, particularly as water bores and petroleum exploration wells have yielded much more information than outcrop.

The term 'Kamileroi Limestone' has been used north of Lat. 20°S, for what is an approximately equivalent stratigraphic unit to the Toolebuc Limestone (e.g. Laing, 1960; Warner, 1968; Meyers, 1969), but usage has been unsystematic. It was applied by Laing & Power (1959) to the hard, crystalline limestone exposed at Kamileroi homestead (Lat. 19°22'S, Long. 140°03'E). The lithology was given as 'fine, grey to pink limestone, with abundant fossil remains'; the fossils indicated a 'Lower Tambo' age. The formation was said to overlie 'Roma equivalent' beds. Harrison et al. (1961) included the unit in their 'Tambo Formation'.

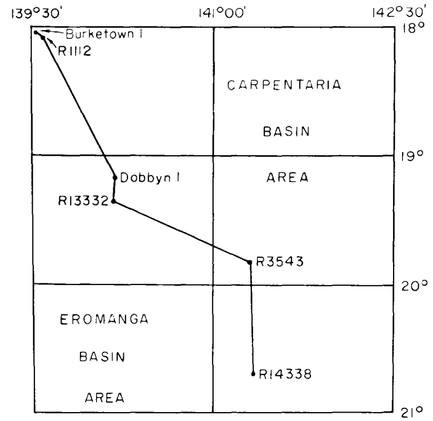
The 'Roma equivalent' beds are now included in the Wallumbilla Formation (Smart et al., in press). The Tambo, as a faunal division, extends from the top of the Wilgunya Subgroup down to the Toolebuc Limestone, and the top part of the formation it overlies, the Wallumbilla Formation.

Laing & Power (1960) placed the Kamileroi Limestone between the 'Normanton' and 'Blackdown' Formations (Laing & Power, 1959). The lithology

given was similar to that in the formal definition by Laing & Power. Smart et al. (1971) revised the 'Normanton Formation' into an upper unit, the Normanton Formation, and a lower one, the Allaru Mudstone; the term 'Blackdown Formation' has been replaced in the Carpentaria Basin by Wallumbilla Formation (Smart et al., in press). In terms of the latest nomenclature in the Carpentaria Basin, the Kamileroi Limestone would lie between the Allaru Mudstone and the Wallumbilla Formation, as does the Toolebuc Limestone in the Eromanga Basin. In the Carpentaria Basin, the Allaru Mudstone and Wallumbilla Formation are continuations of rock bodies defined in the Eromanga Basin. It follows that the names 'Kamileroi Limestone' and Toolebuc Limestone appear to be synonyms, and that in discussing this, the unit's relations with the Allaru Mudstone and the Wallumbilla Formation are critical.

Outcrops originally called 'Kamileroi Limestone' (Laing & Power, 1959) are few and limited in extent. Nowhere in the vicinity of the type area is a continuous section from Allaru Mudstone to Wallumbilla Formation exposed (cf. Toolebuc Limestone outcrops) and most outcrops are flaggy greyish pink crystalline limestone rubble as described by Laing & Power (1959). The outcrop at Kamileroi Homestead is of this type and the thickness of 6.1 m (20 feet) given in the definition is said to be taken from the log of Reg. Bore 12298, which is at the homestead. However, the driller's log of this hole, held by IWSC, reads '10 feet (3 m) of surface limestone', underlain by 22 feet (6.7 m) of 'yellow clay'.

Near Kamileroi homestead, in bore R. 13332 a gamma-ray anomaly was logged over about 12 m (40 feet); the driller's log of this bore shows 2.4 m (8 feet) of 'white rock', presumably limestone, corresponding to the top part of the anomaly. Thus the gamma-ray anomaly is not solely attributable to the limestone, but corresponds mainly to immediately underlying rocks. Gamma-ray logging of water bores carried out under contract for BMR has



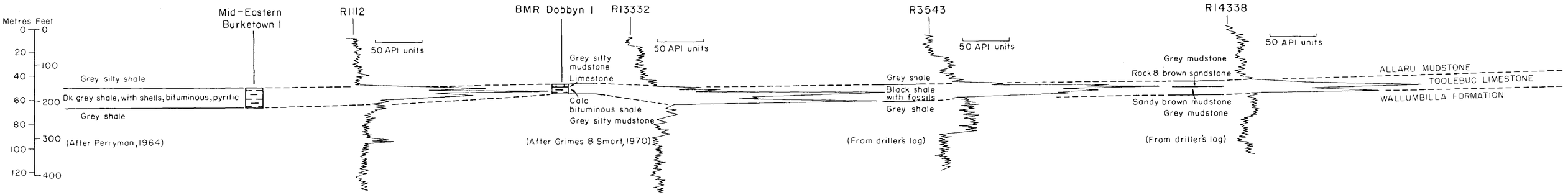


FIG 2 - THE TOOLEBUC LIMESTONE AND ITS GAMMA RAY ANOMALY

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greatly facilitated recognition of the calcareous unit. Copies of these logs are available from BMR, Canberra, and G.S.Q., Brisbane.

Gamma-ray logs of water bores in the Carpentaria Basin almost invariably record relatively high readings roughly corresponding with the 'Kamileroi Limestone'.

The most recent and complete data for the Carpentaria Basin have come from BMR drilling. Four drill holes have penetrated the calcareous unit; in two it was almost completely cored. The others penetrated only part of it (Grimes & Smart, 1970; Needham et al., 1971). None of the completely cored holes were gamma-ray logged, but in adjacent logged water bores gamma-ray anomalies correspond to a calcareous unit in the BMR bores. This unit consists mainly of calcareous, bituminous shale commonly interbedded with thin (up to 2 cm) limestone beds; thick crystalline limestone beds are only present in the upper part. Generally in gamma-ray logs of those water bores which have a detailed driller's log, the anomaly shows a close correlation with a unit described as 'black shale with fossils', 'tar shale' etc. (see Fig. 2), which is distinct from the underlying and overlying units. It is important to note that the bituminous shale is generally highly calcareous (over 50% carbonate) and could strictly speaking be called limestone. However, as used here, the term 'limestone' refers to the thick beds of crystalline limestone, which corresponds to the usage of the Eromanga Basin.

The term 'Kamileroi Limestone' has been little used away from the type area. In the only petroleum exploration well completion report to use the term (AAO 8, Karumba) the name was incorrectly applied to a calcareous part of the Allaru Mudstone (Laing, 1960; Reynolds, 1960). Calcareous units have been noted in other well reports but were not specifically named. In all petroleum exploration wells in the southern Carpentaria Basin (Meyers, 1969)

and in five BMR scout holes (Grimes & Smart, 1970; Needham et al., 1971) a calcareous unit is present between the Allaru Mudstone and the Wallumbilla Formation. The unit has been called 'Kamileroi Limestone' by Warner (1968), 'Kamileroi Formation' by Meyers (1969), and Toolebuc Limestone by Doutch et al. (1970).

In the Carpentaria Basin, interpretation of gamma-ray anomalies is commonly straight-forward, and lithologies and anomalies can be tentatively correlated (Fig. 2). A typical gamma-ray log, e.g. R 3543 on Figure 2, shows a zone of above average radioactivity over about 64 m (210 feet), which would probably correspond to Senior's 'Toolebuc gamma-ray anomaly'. Within this zone, there is about 13.7 (45 feet) of very much higher radioactivity, which corresponds well to the drillers report of 'black shale with fossils', over the same thickness. This unit is considered by the author to be equivalent to the Toolebuc Limestone, and the adjacent zones of above average radioactivity are regarded as belonging to the Allaru Mudstone and Wallumbilla Formation.

All the logs on Figure 2 are basically similar but the zone of above background radioactivity in some of them is not marked, although still recognizable. In general, the only distinctive feature which can be differentiated on most logs is the larger anomaly, and this appears to correspond well with the calcareous unit reported from bores. In addition, the peak or peaks of the anomalies correspond to the calcareous, bituminous shale and not limestone.

Thus in the Carpentaria Basin, it seems reasonable to equate the larger anomaly with the calcareous unit between the Allaru Mudstone and Wallumbilla Formation and call the unit the Toolebuc Limestone. The presence of the zone of above background radioactivity above and/or below the larger anomaly may reflect the deposition of radioactive material in the basin around the time that the carbonate was deposited. Organic marine

shales usually show much higher radioactivity than other sedimentary rocks and the anomaly may be directly related to organic content. Further, it is incorrect to apply the term 'Kamileroi Limestone' to the whole calcareous unit corresponding to the gamma-ray anomaly, in view of the original defined lithology and thickness. The 'Kamileroi Limestone' exposed at the type areas and in other outcrops is not the same as the calcareous unit called 'Kamileroi Limestone' in petroleum exploration wells and BMR scout drilling (Warner, 1968; Grimes & Smart, 1970), or 'Kamileroi Formation' by Meyers (1969). In wells and bores the whole calcareous unit between the Allaru Mudstone and the Wallumbilla Formation can easily be traced on wireline logs, and, to a lesser extent, lithological logs, but it does not constitute a mappable unit at the surface. The discontinuous crystalline limestone part of the interval is easily mapped on the ground or on air-photographs, but is not commonly recognizable on gamma-ray logs; the calcareous bituminous shale part of the unit is rarely exposed at the surface, and when weathered is difficult to distinguish from the adjacent mudstone formations. Also it seems that mapped outcrops of crystalline limestone generally correspond to structural highs - for example the St Elmo Ridge (Vine, 1964), the Fort Bowen Ridge (Grimes, in press), the Kamileroi High, and the Boomarra Horst (Smart, in press). Away from these highs, the crystalline limestone is thinner or absent, as found by Williamson (1967), and the formation is wholly represented by a calcareous shale unit.

Thus the most meaningful formation, that forming a continuous rock body, is the whole calcareous unit, which is distinguished from the adjacent formations by its high carbonate content, and by its correspondence to a marked anomaly on gamma-ray logs. This is the unit the author calls Toolebuc Limestone in the Carpentaria Basin.

In the eastern part of the Carpentaria Basin, in the Staaten River Embayment, the calcareous unit is absent, and the Allaru Mudstone apparently

rests on the Trimble Member of the Wallumbilla Formation (Smart & Grimes, 1971; Smart et al., in press). Gamma-ray logs in this area commonly show small anomalies at about the level of the Trimble/Allaru boundary (Smart & Grimes, 1971). The calcareous unit is also missing from ZCL Weipa No. 1 (cf. Meyers, 1969) in the northern part of the basin.

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