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1960/94



## ORDOVICIAN FOSSILS FROM GOLDWYER NO. 1, THANGOO NO.1, AND THANGOO NO.1A BORES WESTERN AUSTRALIA

by

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# INTRODUCTION

Sub-surface Ordovician in Western Australia. Knowledge of the Ordovician faunas of Western Australia has been greatly enlarged by additional discoveries of Ordovician sediments in three bores drilled by West Australian Petroleum Pty Ltd -- Goldwyer No.1, Thangoo No.1, and Thangoo No.1A. Three other bores -- Dampier Downs, Roebuck Bay, and Samphire Marsh -- have already yielded Ordovician fossils, but the Goldwyer and Thangoo sequences contain the only sub-surface Middle Ordovician fossils known in Australia, and provide the first instance of faunal similarity between any two bores that permits a tentative correlation. The higher levels in Goldwyer and Thangoo bores contain Middle Ordovician graptolites not previously recorded in northern Australia and trilobites new to Australia; one of the bores (Thangoo No.1A) also contains lower Ordovician (Arenigian) graptolites in its lower levels. Unlike Samphire Marsh No.1 Bore, the Goldwyer and Thangoo bores contain no Cambrian, and probably no Tremadocian (lowermost Ordovician).

Material. The samples examined are:

| | | |
|---|---|---|
| Goldwyer No.1 | - | Cores 1 to 15, 17 |
| Thangoo No.1 | - | Cores 1 to 4 |
| Thangoo No.1A | - | Cores 2 to 8 |

Some of the material from Goldwyer has already been reviewed in an informal note; additional material, not previously reported on, is considered here, and some of the earlier determinations of fossils have been revised.

Lithology and age. The Ordovician lithological succession in the subsidized bores Thangoo No.1 and No.1A is very similar to that previously established in Goldwyer No.1 Bore, and the Company geologists have used the same two rock units for all three bores -- "Thangoo Limestone" for

the lower part and "Goldwyer Shale" for the upper.

The "Thangoo Limestone" is dolomitic (probably dolomitized) and is characterized by the scarcity of fossils and their very fragmentary preservation. A bed of graptolitic black shale with associated shelly fossils occurs in Core 6 of Thangoo No.1A Bore but has not been found in the sequence penetrated by Goldwyer Bore. The age of the "Thangoo Limestone" is essentially Arenigian (lower Ordovician); possible exceptions are the lowermost sample of Goldwyer Bore, perhaps of late Tremadocian age, and the uppermost sample of Thangoo No.1A Bore, which may be early Middle Ordovician in age.

The "Goldwyer Shale" contains limestone beds. In its lower levels it is a graptolitic black shale which also contains many trilobites. Graptolites and shelly fossils range into the top of the sequence, which is, however, sparingly fossiliferous. The age of the "Goldwyer Shale" is Middle Ordovician.

Thicknesses of the formations (calculated from WAPET geologists' estimates of position of formation boundaries) are as follows:

| | "Thangoo Limestone" | "Goldwyer Shale" |
|---|---|---|
| Goldwyer No.1 | 1125 ft. | 752 ft. |
| Thangoo No.1 | not drilled through | 578 ft. |
| Thangoo No.1A | 1779 ft. | 695 ft. |

Structural relationships. Apart from a routine examination of the cores for stratigraphic and correlative purposes, this study has a particular object -- to test, by fossil evidence, the possibility of a disconformity between the "Thangoo Limestone" and the "Goldwyer Shale". No faunal evidence for a break between the two formations has been found : it seems more likely that the uppermost part of the "Thangoo Limestone" is conformable with the overlying "Goldwyer Shale" and that

if a break is present it is within the "Thangoo Limestone". The Goldwyer Shale" itself contains evidence for two successive invasions of trilobites that may for the present be considered exotic. The tectonic significance of these events cannot yet be evaluated, and it seems advisable to regard the "Goldwyer Shale" as a conformable sequence.

Stratigraphical nomenclature. As stated above, the names of two rock units are in use for the Ordovician sequence. The Company's usage is retained in this report, but the names are placed in quotes to indicate the doubtful validity of one and the informality of the other. The status of these names needs to be considered in the light of the palaeontological findings.

The name "Thangoo Limestone" is preoccupied by Thangoo Calcarenite (McWhae and others, 1958, p.30), given to an unfossiliferous sequence in Roebuck Bay No.1 Bore, which overlies the lower Ordovician Roebuck Dolomite with apparent conformity and is in turn overlain unconformably by the Permian Grant Formation. It is not clear whether "Thangoo Limestone" (Goldwyer and Thangoo bores) is an accidental homonym of Thangoo Calcarenite (Roebuck Bay bore) or whether identity of the two formations is claimed. The latter is hardly justified : by superposition the Thangoo Calcarenite should be no older than Middle Ordovician, though it is not necessarily even of Ordovician age.

A second problem -- that of the identity of the "Thangoo Limestone" in Goldwyer No.1 Bore with the sequence of the same name in Thangoo No.1A Bore -- cannot be solved on faunal evidence. The available fossils probably do not constitute a fair sample of the faunas, and it seems reasonable to assume that the sequences are the same until proved otherwise.

Finally, the admittedly meagre fossil evidence

suggests that a break is present within the "Thangoo Limestone", and hence it may be advisable to regard this sequence as two formations.

"Goldwyer Shale" (McWhae, pers. comm.) is a new, informal name. Its erection is justified on faunal as well as lithological grounds. Its fauna in Thangoo No.1 Bore is very similar to that in Goldwyer No.1 and is not known to occur elsewhere in Australia.

## PALAEONTOLOGY

### Goldwyer No. 1 Bore

Material. The Ordovician sequence in Goldwyer No.1 Bore is represented by samples from sixteen cores, two of which (Cores 3 and 13) are barren.

The depths of the samples are as follows:

"Goldwyer Shale" : Core 1 - 2867-76 feet
Core 2 - 2955-65 feet
Core 3 - 2965-74 feet
Core 4 - 2974-85 feet
Core 5 - 2985-94 feet
Core 6 - 2994-3002 feet
Core 7 - 3002-11 feet
Core 8 - 3191-3201 feet
Core 9 - 3201-15 feet
Core 10 - 3215-27 feet

"Thangoo Limestone":
Core 11 - 3555-61 feet
Core 12 - 3613-29 feet
Core 13 - 3993-4013 feet
Core 14 - 4013-25 feet
Core 15 - 4438-46 feet
Core 17 - 4568-78 feet.

Faunas. The distribution of identifiable fossils is shown in Table 1. Stratigraphically significant forms are articulate brachiopods, trilobites, and graptolites. Other forms -- sponge spicules, inarticulate brachiopods, molluscs, ostracods, and echinoderms -- are also present. With fourteen fossiliferous cores in a thickness of less than 2000 feet, Goldwyer No.1 Bore presents the most complete picture of any subsurface Ordovician section in Australia. The faunas, however, are small and, with few exceptions (Cores 8 to 10, in the lower part of the "Goldwyer Shale"), preservation is very fragmentary. Among the shelly fossils no species and few genera can be identified. Consequently the faunas can be analysed in their broader aspects only.

The articulate brachiopods provide evidence for two major faunal divisions in the sequence -- the lower characterized by orthoids and the upper by plectambonoids. The two divisions have no common fossils, and the faunal break occurs between Cores 12 and 14 -- within the "Thangoo Limestone" and not at the lithological boundary between "Thangoo Limestone" and "Goldwyer Shale". Orthids appear in the upper part of the plectambonoid sequence. This is, of course, the expected succession, familiar from central Australia, but not hitherto demonstrated in the Western Australian bores.

The fossils of the orthoid sequence, corresponding to the lower part of the "Thangoo Limestone" (Cores 14,15, and 17), are particularly badly preserved, and the accompanying table probably gives a very inadequate picture of the actual fauna of this part of the section. The genus of the orthoid is not determinable. Core 17 contains the unique specimen (a fragmentary crandidium) of a cheiruracean trilobite, which probably represents an undescribed genus. Core 15 is sparingly fossiliferous, but Core 14 contains a

variety of fossils -- sponge spicules, a gastropod, an unidentified asaphid trilobite, and two genera of ostracods. By contrast, Core 13, immediately overlying Core 14, is barren.

The plectambonoid sequence corresponds to the upper part of the "Thangoo Limestone" and the whole of the "Goldwyer Shale" (Cores 1 and 12), except that the black shale sequence (Cores 8 to 10) contains no articulate brachiopods. The best-preserved plectambonoids occur in Core 12 and show some resemblance to "Orthis" dichotomalis Tate of the Western MacDonnell Range. Fragmentary specimens in Core 11 may be conspecific. The genera in the higher levels of the "Goldwyer Shale", above Core 8, are not determinable.

In Cores 11 and 12 the plectambonoid brachiopods have no associated fossils, but above Core 11 orthid brachiopods, trilobites, and graptolites are present, as well as some undiagnostic forms. The asaphid trilobite Megistaspis ranges from Core 10 to the top of the section, as do the graptolites. Two subsidiary trilobite faunas are evident -- a lower fauna (Cores 8 to 10 ) with Triarthrus (c), Ampyx, Carolinites, and Goniotelus(?) (all rare), and an upper (Core 7) with Megistaspidella. Orthid brachiopods (gen. indet.) make their first appearance in Core 7 and continue until Core 2. Above Core 7 the section is sparingly fossiliferous, and Core 3 is barren.

Thomas (1960) has identified Amplexograptus cf. arctus in Core 1 and Amplexograptus sp. in Core 6. He also mentions the occurrence of A.cf perexcavatus at an unspecified depth. The fragmentary graptolites of the Triarthrus sequence (Cores 8 to 10) have not been determined.

Age. The "Thangoo Limestone" is lower Ordovician (essentially Arenigian) in age. The plectambonoid brachiopod in Core 12 (and perhaps also in Core 11) belongs to a group that in North America is dated as late Canadian and perhaps ranges into early Chazyan (old terminology), and a late Arenigian age

for this part of the section in Goldwyer bore seems the best approximation at present. Dating of the lower levels of the "Thangoo Limestone" is even less certain. Core 14 is Arenigian and not Tremadocian, but the fossils of Core 15 are undiagnostic. Core 17 therefore assumes considerable importance in dating the base of the Ordovician sequence. The cheiruracean trilobite in this sample is most probably Arenigian; nevertheless, trilobites of this group appear in the late Tremadocian, and thus, in the absence of associated fossils of diagnostic value, the age of this part of the section must be left open. Early Tremadocian and Cambrian, however, can be definitely excluded.

The graptolites date the "Goldwyer Shale" as Middle Ordovician, an age that is not inconsistent with that provided by the shelly fauna. In Norway, Megistaspidella is not known to range above the lower Llanvirnian (Zone 6, D.bifidus). The Goniotelus-like trilobite in Core 10 resembles a form from the early Middle Ordovician of Utah.

## Thangoo No.1 Bore

Material. Samples are available from four cores, distributed as follows:

"Goldwyer Shale" : Core 1 - 2852-59 feet
Core 2 - 2859-71 feet
Core 3 - 3147-55 feet

"Thangoo Limestone":
Core 4 - 3391-3401 feet

Faunas. The distribution of fossils is shown in Table 2. The fossils of Core 4 are undiagnostic. In the "Goldwyer Shale" most of the fossils occur in the lowest sample (Core 3), which contains fragments of a plectambonoid brachiopod and the trilobites Triarthrus, an undetermined asaphid, and a

new genus of Trinucleina. The sample also contains a varied assemblage of graptolites -- Didymograptus, Amplexograptus, Glyptograptus?, and Glossograptus?. Cores 1 and 2 are sparingly fossiliferous; inarticulate brachiopods, a machaeridian, the trilobite Megistaspis, an ostracod, and Amplexograptus are present.

Age. Core 4 can be dated by superposition only. The graptolites of the "Goldwyer Shale" are Middle Ordovician and the Triarthrus is probably the same species as that in Goldwyer bore, Cores 8 to 10. The family-reference of the new genus is at present uncertain; the trilobite shows characters intermediate between the Middle Ordovician forms Ampyxina and Endymionia.

## Thangoo No. 1A Bore

Material. The sequence is represented by seven cores, four of which (Cores 3, 5, 7 and 8) are unfossiliferous. The depths are as follows:

| | | |
|---|---|---|
| "Thangoo Limestone" | : | Core 2 - 3665-72 feet |
| | | Core 3 - 3906-17 feet |
| | | Core 4 - 4138-52 feet |
| | | Core 5 - 4393-4403 feet |
| | | Core 6 - 4645-57 feet |
| | | Core 7 - 4898-4908 feet |
| | | Core 8 - 5038-48 feet |

Faunas. Table 3 shows the distribution of identifiable fossils. Except for Core 6, the sequence is remarkable for the poor preservation of the fossils. Orthoid brachiopods occur in Core 6 and plectambonoids in Cores 2 and 4. The fauna of Core 6 is surprisingly varied and contains, in addition to some undiagnostic forms, a gastropod, two genera of nautiloids, the agnostid trilobite Trinodus, two genera of asaphids, and two genera of graptolites.

Age. Core 6, with a Tetragraptus of the quadribranchiatus group, is Arenigian. Core 4 is probably also Arenigian, but the age of Core 2 is uncertain. The plectambonoid in this sample is distinct from the forms in Cores 11 and 12 of Goldwyer Bore but bears some resemblance to the form in Core 3 of Thangoo No.1, which is Middle Ordovician in age. The fossils are too fragmentary, however, to draw any firm conclusions.

## CORRELATION

"Thangoo Limestone". On faunal evidence it is by no means certain that the "Thangoo Limestone" of Goldwyer No.1 Bore should properly be identified with the sequence of the same name in Thangoo No.1A Bore. The general sequence, as far as can be seen, is not dissimilar : in both bores beds with numerous (though fragmentary) fossils are overlain by unfossiliferous rocks, and these in turn are succeeded by beds with a monotonous fauna of plectambonoid brachiopods. Also, the time-span is roughly the same, although Core 2 of Thangoo No.1A Bore may be younger than Cores 11 and 12 of Goldwyer No.1 Bore.

On the other hand, the only common genus is the long-and wide-ranging gastropod Helicotoma, which without specific identity offers no hope of correlation; and, as indicated above (p. 9 ), the plectambonoids in the upper levels are not conspecific and may not even be congeneric.

Some of the differences may merely reflect poor preservation and accidents of collecting, and it is quite possible that Goldwyer and Thangoo Bores have penetrated parts of the same rock body (or bodies); but correlation between the various levels cannot be attempted.

Outside the Goldwyer-Thangoo area, lower Ordovician fossils have been identified in three other bores —

Roebuck Bay, Dampier Downs, and Samphire Marsh, Once again, the shelly fossils afford no basis for exact correlation. Roebuck Bay bore has yielded no larger fossils, and Dampier Downs bore contains a brachiopod of a group (subfamily Tritoechiinae) not known in any other bore. The upper part of the Ordovician sequence in Samphire Marsh bore (Cores 4 to 6) occupies roughly the same time-span as the "Thangoo Limestone", especially in Goldwyer bore, but no common genera can be identified. Resemblances in faunas may, of course, be obscured by differences in preservation : asaphid trilobites, for example, which are reasonably well-preserved in the Samphire Marsh sequence, are particularly fragmentary in the "Thangoo Limestone".

Two of the fossils of the "Thangoo Limestone" have opened a prospect of future correlation with Ordovician sections known in outcrop. The first of these is the agnostid Trinodus (Thangoo No.1A, Core 6), known also in the Prices Creek sequence. Specific identity is not attainable on the present material. The second significant fossil is a brachiopod in Core 12 of Goldwyer bore, whose resemblance to "Orthis" dichotomalis has already been noted (p.6 ). The Goldwyer material is rather fragmentary and probably immature, but future exploration may yield specimens suitable for specific identification.

"Goldwyer Shale". A tentative correlation of the "Goldwyer Shale" in Goldwyer No.1 Bore and Thangoo No.1 Bore is shown in Table 4. The formation was not cored in Thangoo No.1A Bore. Naturally, the correlation is surer in the lower levels (Cores 8 to 10 of Goldwyer Bore and Core 3 of Thangoo Bore), where the fossils are most abundant. Even here considerable variation in the faunas is evident : Triarthrus is common in both bores, but the accessory fossils mostly belong to different genera. Correlation of the upper levels is rather

speculative because of the scarcity of fossils. Core 1 of Goldwyer is provisionally correlated with Cores 1 and 2 of Thangoo No.1. The sequence represented by Cores 2 to 7 of Goldwyer bore cannot be matched in Thangoo No.1; this is the sequence with orthid brachiopods, which also contains the asaphid trilobite Megistaspidella at the base.

The fauna of the "Goldwyer Shale" is younger than the Ordovician faunas in all other Western Australian bores, and the trilobites, apart from the ubiquitous Ampyx and Carolinites, are generically distinct from those known in outcrop. Amplexograptus, too, has not previously been recorded in northern Australia.

Breaks. (1) From the palaeogeographic standpoint, the absence of Cambrian and early Tremadocian is important. Late Upper Cambrian is known on the surface in the Cambridge Gulf area and is strongly suspected in Samphire Marsh bore. The existence of Cambrian in the Prices Creek sequence is problematical.

(2) A marked faunal break occurs within the "Thangoo Limestone" between Cores 12 and 14 of Goldwyer No.1 Bore and between Cores 4 and 6 of Thangoo No.1A Bore. The break is dated as Arenigian.

(3) No fossil evidence for a break between the "Thangoo Limestone" and the "Goldwyer Shale" has been noted. The plectambonoid brachiopods are the only larger fossils present in both lithologies, and, as far as can be seen, they suggest that the sequence is conformable. The fossils are, of course, very fragmentary, and the resemblance between the brachiopods in Core 3 of Thangoo No.1 ("Goldwyer Shale") to those in Core 2 of Thangoo No.1A ("Thangoo Limestone") may be coincidental. Evidence from microfossils may shed light on this problem.

(4) The problem of breaks within the "Goldwyer Shale" is of the same sort as the preceding. As far as can be decided from the preliminary study of a completely undescribed fauna, the "Goldwyer Shale" and the top of the "Thangoo Limestone" together represent a sequence dominated by plectambonoid brachiopods and Megistaspis-like trilobites. Included in this sequence are two strange faunas -- a lower fauna with Triarthrus and an upper with Megistaspidella and orthid brachiopods. Both these trilobites are, from the Australian point of view, exotic: Triarthrus is known from Europe and North and South America, and Megistaspidella is restricted to northern Europe. The tectonic event that initiated their arrival in northern Australia need not, however, have been local, and it would be premature to postulate breaks in the Middle Ordovician sequence without confirmatory data from other sections.

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Table 1. Distribution of Ordovician fossils - GOLDWYER NO. 1 BORE

| Cores and uncored intervals \ Fossils | Sponge spicules | Inart. brach. gen. indet | Orthoid brach " " | orthid brach " " | plectambonoid br. " | cf. Helicotoma | Carolinites | Triarthrus | Megistaspis | Megistaspidella | asaphid tril. gen. indet. | Goniotelus? | cheiruraceantril. gen. indet. | Arpyx | tril. family indet. | "Bollia" | "Oepikella" | ostracod gen. indet. | echinoderm ossicles | dichograptid indet. | diplograptid indet. | Amplexograptus spp. | grapt. indet. | Thickness (feet) | Formation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. 2867-76 | | | | | | | | | | | | | | | | | | | | | | | | 9 | "Goldwyer shale" |
| Interval 2876-2955 | | | | | | | | | | | | | | | | | | | | | | | | 79 | |
| 2. 2955-65 | | | | | | | | | | | | | | | | | | | | | | | | 56 | |
| 3. 2965-74 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4. 2974-85 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5. 2985-94 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6. 2994-02 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7. 3002-11 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Interval 3011-3191 | | | | | | | | | | | | | | | | | | | | | | | | 180 | |
| 8. 3191-3201 | | | | | | | | | | | | | | | | | | | | | | | | 36 | |
| 9. 3201-15 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10. 3215-27 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Interval 3227-3555 | | | | | | | | | | | | | | | | | | | | | | | | 228 | |
| 11. 3555-61 | | | | | | | | | | | | | | | | | | | | | | | | 6 | "Thangoo limestone" |
| Interval 3561-3613 | | | | | | | | | | | | | | | | | | | | | | | | 52 | |
| 12. 3613-29 | | | | | | | | | | | | | | | | | | | | | | | | 16 | |
| Interval 3629-3995 | | | | | | | | | | | | | | | | | | | | | | | | 266 | |
| 13. 3995-13 | | | | | | | | | | | | | | | | | | | | | | | | 30 | |
| 14. 4013-25 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Interval 4025-4438 | | | | | | | | | | | | | | | | | | | | | | | | 413 | |
| 15. 4438-46 | | | | | | | | | | | | | | | | | | | | | | | | 8 | |
| Interval 4446-4568 | | | | | | | | | | | | | | | | | | | | | | | | 122 | |
| 17. 4568-78 | | ? | | | | | | | | | | | | | | | | | | | | | | 10 | |
| Interval 4578-4660 | | | | | | | | | | | | | | | | | | | | | | | | 82 | |
| 4660 | B A S E M E N T | | | | | | | | | | | | | | | | | | | | | | | | Basement |

Table 2. Distribution of Ordovician fossils - THANGOO NO.1 BORE

| Cores and uncored intervals \ Fossils | linguloid brach. | plectambonoid br | Plumulites | Triarthrus | Megistaspis | asaphid, gen. indet | Trinucleina n. gen. | "Primitia" | Amplexograptus | Didymograptus | Glossograptus ? | Glyptograptus ? | Thickness ( feet ) | Formation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. 2852-59 | | + | - | - | - | - | - | - | ? | - | - | - | 19 | "Goldwyer Shale" |
| 2. 2859-71 | | - | + | - | - | - | - | - | - | - | - | - | | |
| Interval 2871-3147 | - | - | - | - | - | - | - | - | - | - | - | - | 276 | |
| 3. 3147-55 | + | + | - | - | - | - | - | - | - | - | - | - | 8 | |
| Interval 3155-3391 | - | - | - | - | - | - | - | - | - | - | - | - | 236 | |
| 4. 3391-3401 | - | - | - | - | - | - | - | - | - | - | - | - | 10 | "Thangoo Limestone" |

Table 3. Distribution of Ordovician fossils. THANGOO NO.1A BORE

| Fossils / Cores and uncorded intervals | Sponge spicules | linguloid brach. | orthoid brach. | plectambonoid br. | cf. Helicotoma | nautiloids | Trinodus | Ptychopyge? | asaphid gen. indet | tril. family indet | echinoderm ossicles | Tetragraptus | Didymograptus | Thickness ( feet ) | Formation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2. 3665-72 | | | | | | | | | | | | | | 7 | " THANGOO LIMESTONE" |
| Interval 3672-3906 | | | | | | | | | | | | | | 234 | |
| 3. 3906-17 | | | | | | | | | | | | | | 11 | |
| Interval 3917-4138 | | | | | | | | | | | | | | 221 | |
| 4. 4138-52 | | | | | | | | | | | | | | 14 | |
| Interval 4152-4393 | | | | | | | | | | | | | | 241 | |
| 5. 4393-4403 | | | | | | | | | | | | | | 10 | |
| Interval 4403-4645 | | | | | | | | | | | | | | 242 | |
| 6. 4645-57 | | | | | | | | | | | | | | 12 | |
| Interval 4657-4898 | | | | | | | | | | | | | | 241 | |
| 7. 4898-4908 | | | | | | | | | | | | | | 10 | |
| Interval 4908-5038 | | | | | | | | | | | | | | 130 | |
| 8. 5038-48 | | | | | | | | | | | | | | 10 | |
| Interval 5048-5256 | | | | | | | | | | | | | | 256 | |
| 9. 5256-66 | Basement | | | | | | | | | | | | | | Basement |

TABLE 4

Tentative Correlation of Fossiliferous Horizons in the "Goldwyer Shale" - Goldwyer No. 1 and Thangoo No. 1 Bores.

Vertical Scale 100' = 1"