COMMONWEALTH OF AUSTRALIA

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BUREAU OF MINERAL RESOURCES
GEOLOGY AND GEOPHYSICS

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DEPOSITIONAL STRUCTURES IN CARNARVON BASIN W.A.

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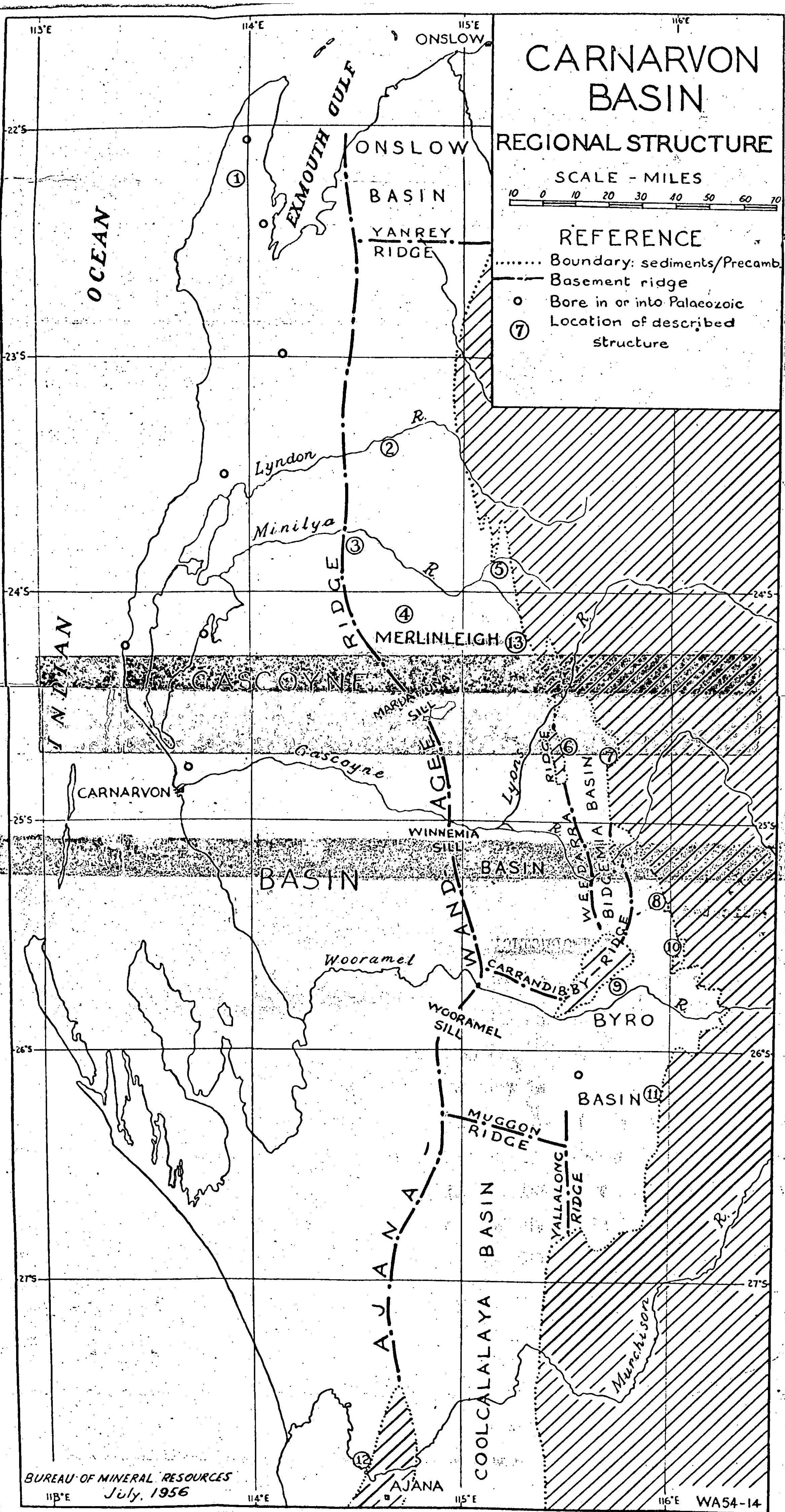
CARNARVON BASIN
REGIONAL STRUCTURE
SCALE - MILES
10 0 10 20 30 40 50 60 70
REFERENCE
Boundary: sediments/Precamb.
Basement ridge
Bore in or into Palaeozoic
Location of described structure
113°E
114°E
115°E
116°E
22°S
23°S
24°S
25°S
26°S
27°S
ONSLOW
EXMOUTH GULF
ONSLOW BASIN
YANREY RIDGE
INDIAN OCEAN
Lyndon R.
Minilya R.
RIDGE
MERLINLEIGH
GASCOYNE
MARDATHUNA SILL
Gascoyne
CARNARVON
Lyons R.
RIDGE
BASIN
WINNEMIA SILL
BASIN
BASIN
WANDAGEE
WEEDARRA
BIDGEMIA
CARRANDIBBY RIDGE
Wooramel
WOORAMEL SILL
BYRO
R.
BASIN
MUGGON RIDGE
YALLALONG RIDGE
COOLCALALAYA BASIN
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DEPOSITIONAL STRUCTURES IN THE CARNARVON BASIN, WESTERN AUSTRALIA

by M. A. Condon

ABSTRACT

In the Upper Palaeozoic sequence of the Carnarvon Basin of Western Australia, the major structure is controlled by the shape of the surface of the Precambrian basement on which the sediments were deposited. This surface has strong relief including asymmetrical ridges. The sediments were deposited mainly parallel to the gentler slopes and abutting the steeper slopes. Where the thickness of sediments is greater than the original relief plus contemporaneous sag, younger sediments abut the angle of rest slope of the older sediments deposited on the gentler slope of an asymmetrical ridge. This relationship is one kind of depositional unconformity. Criteria for recognizing the feature and for distinguishing it from a fault are given.

The likely effects of tangential stress on such structures are indicated.

INTRODUCTION

In the course of a regional geological and geophysical survey of the Carnarvon Basin of Western Australia (Fig. 1), my interpretation of the structural history of the basin changed, because of the weight of evidence, from the conventional tectonic to epeirogenic and depositional. In the Cape Range Anticline (Locality 1. Fig. 1), tangential stress in the sediments was regarded as incompetent to produce a fold of the required dimensions; possible modes of origin included differential compaction, deposition over pre-existing hills and vertical movement above a thrust wedge in the basement (Condon et al., 1953, p.34). At that time the thrust wedge origin was preferred. In the outcrop area of Palaeozoic sediments, contacts between Precambrian basement and Palaeozoic sediments were mapped as unconformities where they are gently dipping and as faults where they are steep. Contacts with stratigraphical discontinuity within the Palaeozoic

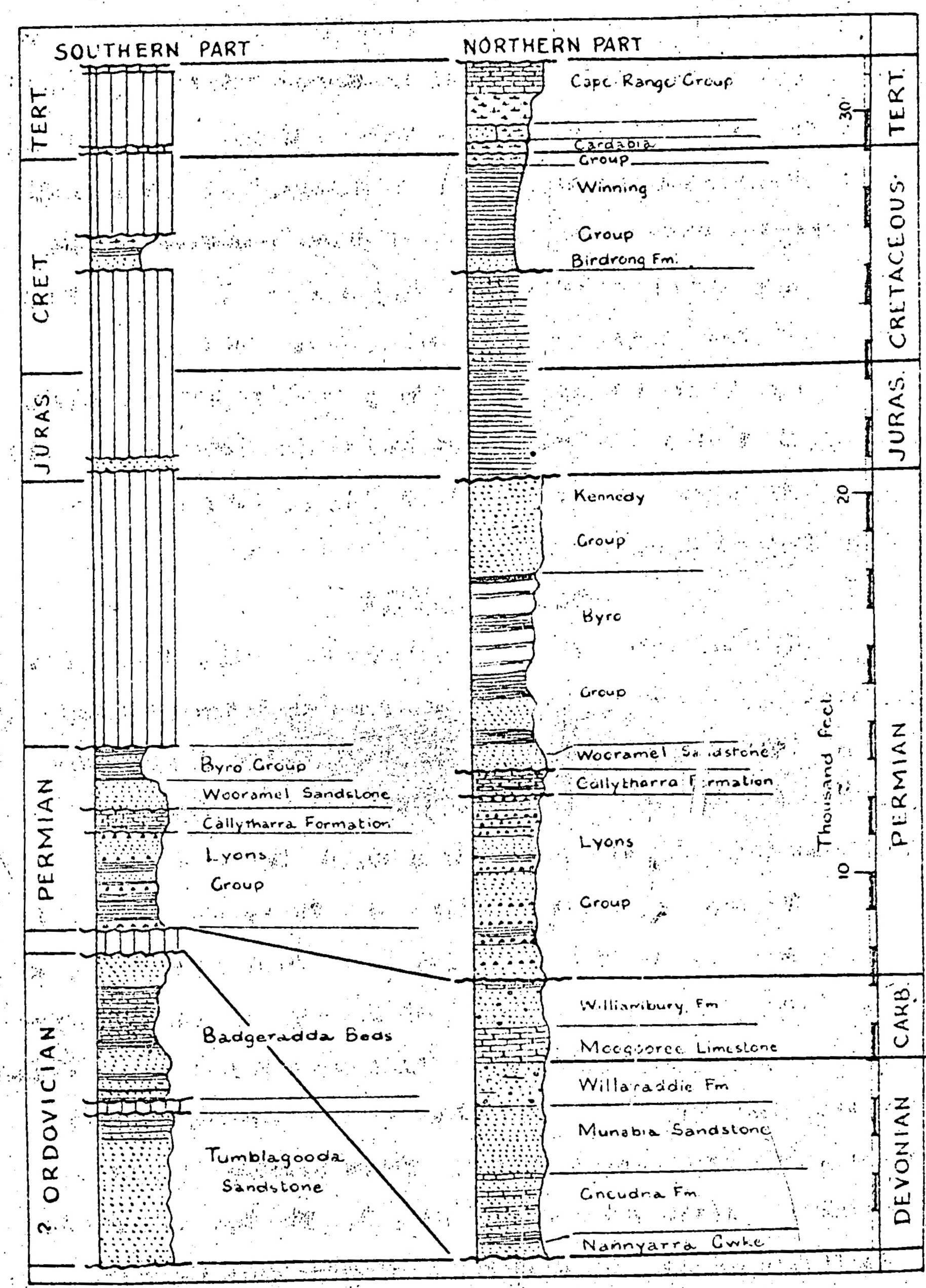

Fig. 2. Compiled stratigraphical columns

sequence were mapped as faults (Condon, 1954 b, 1955), although it was realized that their structure was anomalous. The possibility of upthrust blocks of basement carrying the sediments was considered to explain most, but not all, the anomalies. As the survey progressed, this explanation became untenable, and it was realized that all the major structures and most of the minor ones were depositional structures over a basement of marked relief. Several types of structures, rarely, if ever, reported in the literature have been studied and as they are likely to be of more than local interest they are described in some detail.

My thanks are due to the many colleagues who discussed these ideas with me and forced me to search for indubitable evidence of the features; in particular Dr. R. W. McWhae of West Australian Petroleum Company.

REGIONAL STRUCTURE

The Carnarvon Basin is a large epi-continental area of Palaeozoic and later sedimentation in which there is a maximum actual thickness of sediments of about 30,000 feet (based on drilling, seismic and gravity results). The maximum thicknesses of formations (Fig. 2) add up to about 40,000 feet.

The outcrop pattern, with older formations generally towards the east and younger formations towards the west, suggests a regional homocline, but drilling, and gravity and seismic surveys (Chamberlain, Dooley and Vale, 1954) show the structure to be much less simple. The main basin is broken up into several smaller basins separated by basement ridges. These basement ridges and the minor basins are shown and named in Fig. 1. The basins have downwarped during deposition so that the sediments were deposited mainly in shallow to moderately deep water.

Only on the north end of the "Carrandibby Ridge" and the south end of the "Weedarra Ridge" can anticlinal structure be demonstrated in the sediments overlying the ridges, although it is almost certainly developed over most of them.

The general structural pattern of the eastern basins is mainly north-south even where, in the north, the regional strike is north-north-west. The main structural features are relatively long narrow synclines bounded by unconformities.

In the "Gascoyne Basin" the only structures visible on the surface are the north-south anticlines in Tertiary and Cretaceous sediments near the coast (Condon et al, 1953; Condon, 1954-a; Condon, 1954-b; Condon et al, 1956). These anticlines are almost certainly depositional, and recent drilling in the Cape Range by West Australian Petroleum Ltd. indicates that the surface over which that structure is draped is probably quite shallow - possibly a surface eroded in the Eocene and older sediments. The Giralia Anticline on the other hand is almost certainly draped over a surface eroded in Permian sediments (Chamberlain et al, 1954, plate 3).

DEPOSITIONAL STRUCTURES

Depositional Dip

It is commonly assumed that sedimentary strata were originally horizontal, although it has been shown that sands deposit from quiet water with angles of rest from 33° to 43° (Draper, 1930, cited in Twenhofel, 1932, p.604), and that fine-grained sediments have deposited on present-day slopes as steep as 18° (Emery and Terry, 1956). Horizontal bedding is, rather, one limiting case; the maximum angle of rest of sediment is the other.

The dip of sedimentary strata as deposited is dependent on the slope of the floor; the type of sediment; the rate of supply of sediment; the nature and kinetic energy of the fluid environment; and the amount of re-working after initial deposition.

The slope of the floor determines the maximum possible initial dip; this applies even to foresets, the floors of which are the older foresets or the irregularity that started them.

In water, coarse-grained sediments have a steeper angle of rest than fine-grained; the range seems to be from about 45° for graded angular or subangular sand to almost horizontal for clay minerals. Heavy clay settles very slowly and traps large amounts of water so that the sediment as deposited tends to behave as a fluid. However, clay will settle and remain on slopes of up to 30° (Twenhofel, 1932, p.605) probably where there is free drainage from the clay. Sediments in the range of moisture between liquid limit and plastic limit (Puri, 1949, p.342) may move (in the manner of a mud flow) down slopes of any steepness and, by reduction of moisture content or lessening of slope, come to rest on those slopes.

The rate of supply of sediment affects the competence of the fluid environment to act on the sediment either before or after initial deposition.

Any movement of the fluid in which deposition is taking place lessens the angle of rest. On the other hand movement of the fluid slows or may even prevent the settling of the finer-grained particles (silt and clay).

In order for re-working to be effective the deposited sediment must be acted on by fluid sufficiently turbulent to re-disperse it. In standing water, the only places where this is likely are in the area of breaking waves and beneath a density current. In such a fluid environment the final depositional dip should be close to horizontal.

In the Carnarvon Basin, evidence of steep depositional dips is widespread. At the south end of Moogooree Station, near Howells Bore (Loc. 13 Fig.1) and also one mile west and three miles west-north-west of that bore, the basal sandstone of the Permian Lyons Group dips at 25° to 38°. The underlying Carboniferous and Devonian dips at 30° to 40°. At first it was thought that the main tilting was post-Permian; but in this same area the Lyons Group laps horizontally over the steeply-dipping Devonian, indicating that the Devonian had been tilted and eroded before the Lyons Group was deposited on the erosion surface which included flat areas and steep dip slopes. Six miles south-west of Arthur River Woolshed (Loc. 7), the unconformity between the Permian Lyons Group and the Precambrian is well exposed. The unconformity has a relief of 400 feet and includes slopes of about 30° on one side of asymmetrical valleys. The Lyons Group strata are parallel to the gentler slopes (with dips up to 22°) but abut or overlap on the steeper slopes, with dips, in the same direction as the slope, of only 5° to 10° (Fig. 3). Similar relationships on a bigger scale are seen $2\frac{1}{2}$ miles east of Coordewandy Homestead (Fig. 4).

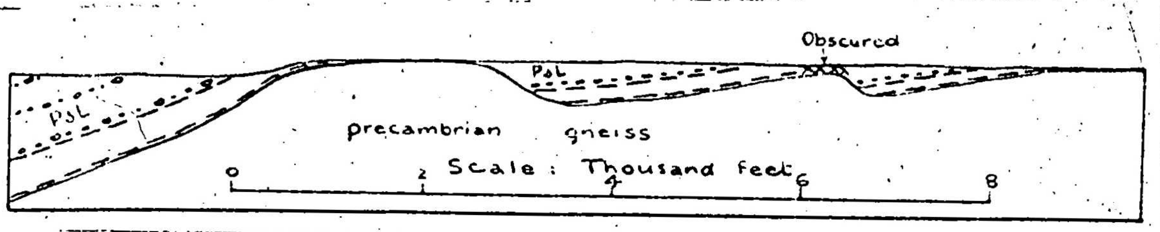

Figure 3. Section showing relationship between Permian Lyons Group and mature surface of Precambrian at Locality 7, Fig. 1.

Abutment unconformity

Where the slope of the floor is steeper than the angle of rest of the sediments, the strata will form at an angle to the floor. Where that slope is gentle, the common overlap unconformity develops but, where the slope is steep, an "abutment unconformity" develops. Any division between the two must be somewhat arbitrary, but if the angle between the younger strata and the surface of unconformity is more than about 10° it may be regarded as an abutment unconformity; where this angle is more than 30° there is no doubt. As the bedding tends to run up the unconformity, these angles refer to the persistent dip, not the dip of any minor turn-up near the unconformity.

The unconformities against the steep slopes shown in Figures 3 and 4 are abutment unconformities. The contrast between the Precambrian and Permian on the south-eastern side of Carrandibby Range is an abutment unconformity which is still regarded as a fault by some workers.

This feature, the "Madeline Unconformity" (Loc. 9) is over 40 miles long, and trends north-east. It is in contact with the Precambrian for 12 miles; in this length, the trace of the contact is straight in a general way but quite irregular in detail; the irregularities are sinuous, not angular, and are not merely the trace of the intersection of a plane with a dissected surface.

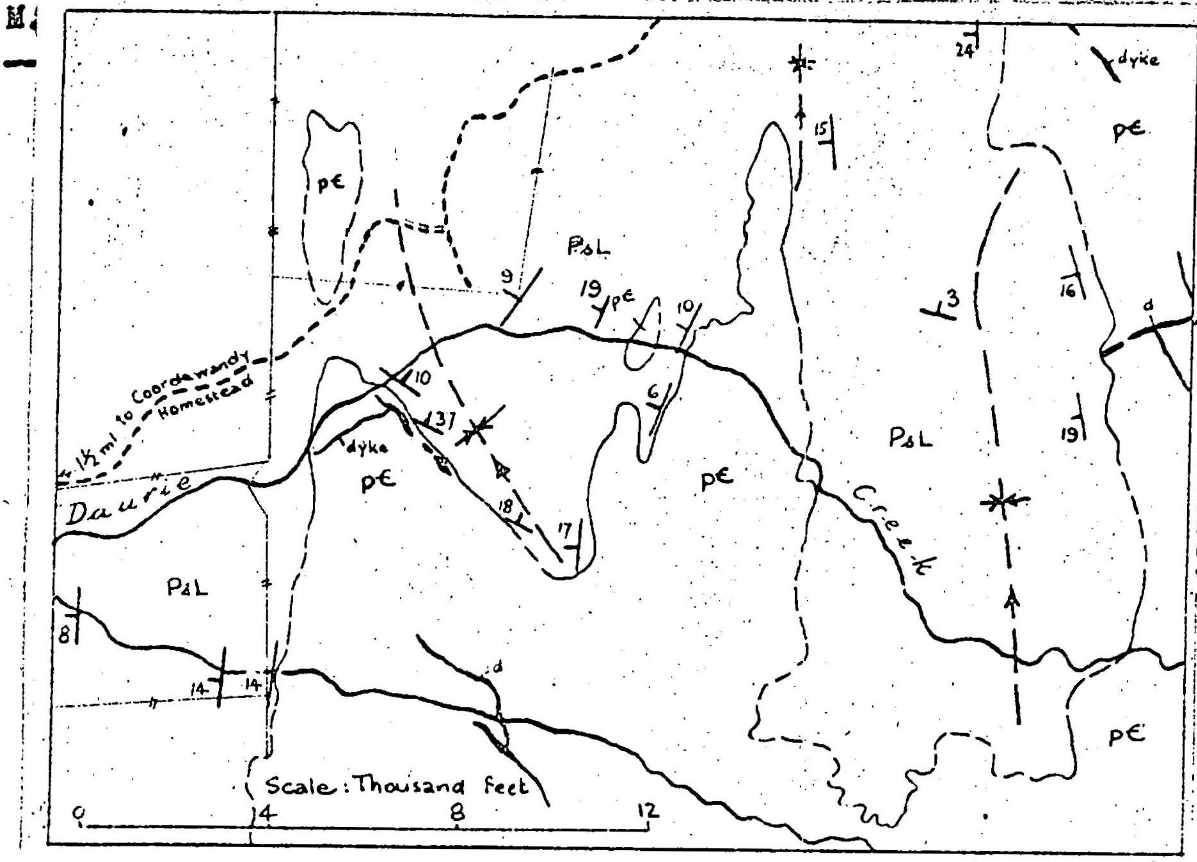

Figure 4. Map showing unconformity between Permian Lyons Group (PsL) and Precambrian schist (pЄ). Locality 10, Fig. 1.

The smaller re-entrants towards the Precambrian are up to 600 feet deep (in plan, from the line joining the adjoining salients). Larger sinuosities have an amplitude (in plan) of 1100 to 2700 feet. Measurements of the dip of the contact are few, between 30° and 42°. At the contact the strata are nearly parallel to the contact for a short distance but in less than 20 yards the dip of the strata flattens to about 15°. Further out the dip may gradually flatten, or reverse to form a syncline followed by an anticline. Observation of the unconformity in a good exposure three miles south-west of Mount Madeline showed that it dips at 30° to the south-east; this surface of the Precambrian, underlying the Permian, is underlain by a soil profile - weathered rock, subsoil, soil and terra rossa surface. At this place the overlying Permian strata are parallel to the unconformity for a short distance. No very steep contact has been seen along this line although steep dips (up to 67°) in the Permian sediments some distance from the contact suggest a steeper contact at shallow depth, in some places. Within a mile of the contact, the Permian is variously homoclinal (dipping east), synclinal or anticlinal. In at least one place, 1¾ mile south west of Mt. Madeline (Loc. 9), an anticlinal axis meets the contact at one of the salients in the trace. The trend of the "Madeline Unconformity" is close to the trend of the foliation in the Precambrian schist, as is the elongation of the range; drainage on the range is across the foliation but is probably superimposed.

Many similar features are shown by the contact between Precambrian and Permian, nine miles east of Lyons River Homestead (Loc. 6). This contact is 15 miles long and continues at either end as a Permian-Permian contact (older formations against younger). Along this contact the unconformity is not so clearly exposed, but the trace can be mapped and as there is reasonable relief along it (about 100 feet) the shape of the surface can be determined. A short section surveyed indicated a surface sloping to the east (under the sediments) at 30°. This surface may be seen by looking along the trace towards one of the high points along it. The structure in the Permian nearby is mainly synclinal with some small anticlines. The synclines are mainly basin-shaped.

The main characteristics of the abutment unconformity are; i. the unconformity dips at more than 10°, away from the older rocks; locally it may be very steep;

ii. at the contact, the younger sedimentary strata tend to run up the unconformity but, apart from this effect, there is a sharp discordance (more than 10°) between the dip of the unconformity and the dip of the overlying strata;

iii. along its length, the contact may pass into a normal overlap unconformity, into an "angle of rest" unconformity or into a fold;

iv. slumping (contortion and slumped blocks) is common, especially close to the contact;

v. fine-grained beds pinch out towards the unconformity.

The following characteristics are shared with normal overlap unconformities:

vi. the surface and trace are irregular;

vii. a soil or rubble of the older rock may be present at the contact;

viii. fragments of the older rock may be found in the younger sediments;

ix. the younger sediments may be found filling joint cracks and erosion channels in the older rocks;

x. synclines and anticlines of irregular shape may be developed in the younger sediments close to the contact;

xi. there may be minoe or? silicification, ferrugin-ization, slickensiding and transverse faulting caused by compaction or slump sliding of the sediments on the unconformity;

xii. all these features may be modified by subsequent tectonic activity (faulting, folding, intrusion, metamorphism).

Depositional Unconformity

Definition: A depositional unconformity is a surface, separating separteing younger from older strata with structural and stratigraphic discontinuity, which is formed by processes of sediment deposition.

Examples of this type of unconformity include the surface between a biohermal reef and later sediments, that between a submarine bank and later, flat-lying, sediments, that between a volcanic cone and later sediments, and the "angle of rest" unconformity. Unconformities formed by faulting or folding during sedimentation are partly of this type, as no erosion takes place at the unconformity.

The only type of depositional unconformity observed in the Carnarvon Basin is the "angle of rest" unconformity.

"ANGLE OF REST" UNCONFORMITY

Definition: An 2 angle of rest" unconformity is a surface, originating as an angle of rest slope in the older sediments, between younger and older strata, separating them with structural and stratigraphic discontinuity.

An angle of rest slope is the slope at which sediment will stand without lateral support.

Description: In the Carnarvon Basin, where "angle of rest" unconformities are well developed but generally not well dissected and exposed, they have the following characteristics:

i. In plan, there is a line separating stratigraphically different parts of the same major sedimentary sequence (Fig. 5). In the regional mapping, this was regarded at first as indubitable evidence of faulting; the stratigraphic break, within the Permian, is as much as 1000 feet.

ii. The trace of the unconformity is irregular, in places extremely so (Fig.5). The irregularity is sinuous, not angular. It was thought to be a result of minor cross-faulting but the extension of these cross trends into the adjoining strata is extremely rare.

iii. Unconformities in some places are roughly parallel but in a few places they form a dendritic pattern.

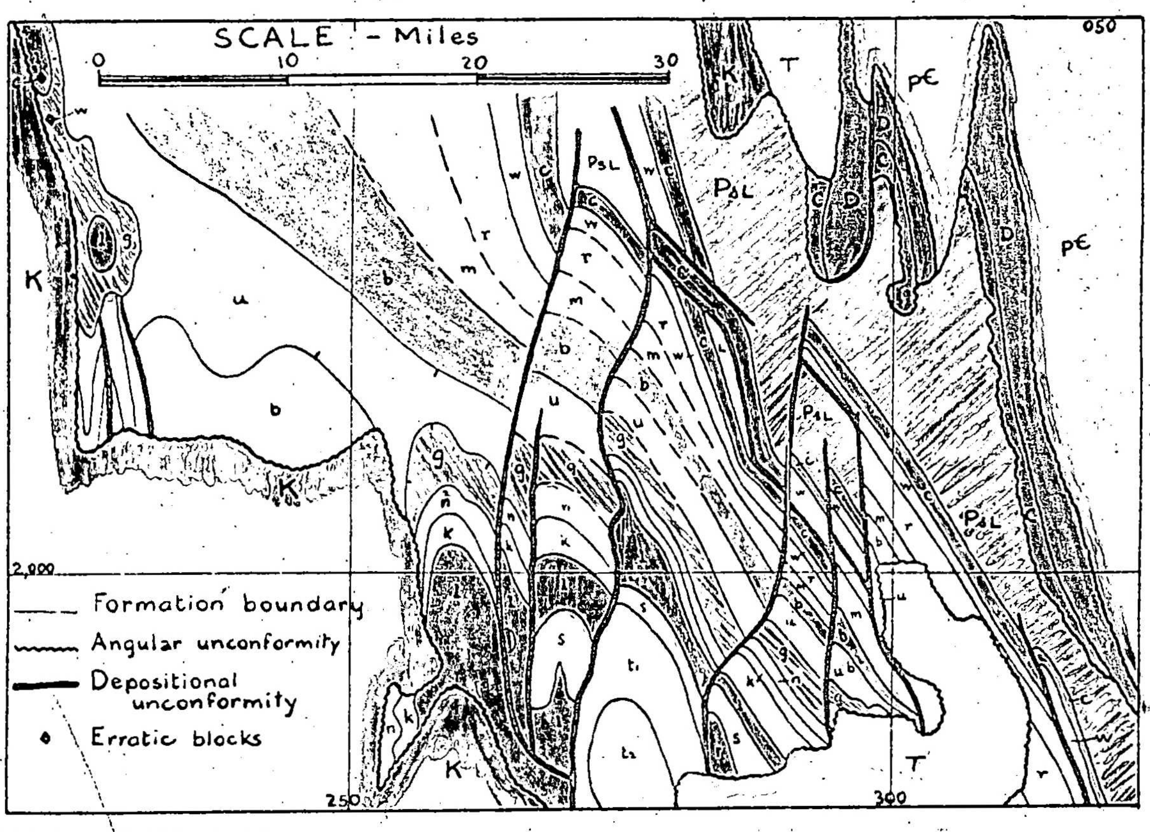

Figure 5. Plan of part of the Carnarvon Basin (Loc. 4, fig. 1) showing depositional unconformities. pC - Precambrian, D - Devonian, C - Carboniferous, PsL - Permian Lyons Group, Lower case letters - Permian formations, K - Cretaceous, T - Tertiary.

iv. Individual beds near the unconformity are ferruginized or silicified.

v. Commonly, but not invariably, the strata dip away from the unconformity, on either side (Fig. 5 & 6). Regionally the strata form shallow synclines between the unconformities.

vi. There are very few signs of tangential stress in the sediments (such as jointing, drag-folds, cleavage).

vii. In a few places, large blocks of older strata are found in younger strata on the younger side of the unconformity; examples include Wooramel Sandstone in Bulgadoo Shale, 22 chains east-south-east of Curdammuda Well, Minilya River, and limestone of Callytharra Formation, probably in Coolkilya Greywacke, two miles north of Curdamuda Well (Loc. 3).

viii. In the few places where the unconformity can be mapped in the vertical dimension, it dips at a low angle (about 30°) towards the younger side of the contact (Fig. 6).

ix. The thickness of formations is related to the position in the syncline. Adequate measured sections fully to demonstrate this are not available, but it is indicated by the regionally unusual thickness of some formations measured in the axial region, by variation of outcrop width of formations not related to dip variation, and by absence of part or the whole of some formations on the older side near the unconformity.

x. The syncline is commonly asymmetrical in both dip and length of flanks; the shorter, steeper flank is commonly very irregular in dip; the axial plane dips (towards the gentler flank) at a low angle roughly parallel to the unconformity (Fig.6) this, of course, is contrary to the relationship in a tectonic asymmetrical syncline where the axial plane dips towards the steeper flank.

xi. The unconformity may pass along its length into a monoclinal or anticlinal fold and disappear completely : in this these unconformities resemble faults.

xii. The "angle of rest" unconformity may pass along its length and at depth into an abutment unconformity.

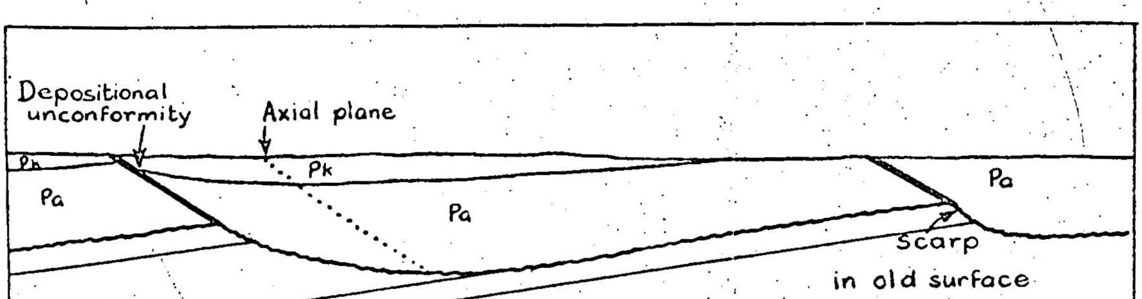

Figure 6. Diagrammatic section at natural scale of 4000 feet to one inch, showing typical geometry of angle of rest unconformity, and possibile nature of underlying rocks.

It will be seen from the above that the "angle of rest" unconformity has many features in common with an abutment unconformity; the main difference is in the nature of the underlying rocks and of the surface.

__Origin:__ The floor of the basin, consisting of hard Precambrian schist and gneiss, is known to have a topographic relief of at least 400 feet. This surface on the Precambrian rocks is commonly asymmetrical in profile, with a gentle western slope and a steep eastern scarp. Strata overlie the gentle slopes with bedding parallel to the unconformity, even where the slope is about 20°. Strata abut the scarp slopes, where they are steeper than about 30°.

The relationships at the top of the scarp have not been observed, but it is possible that, at the intersection of the top of a scarp with the upper part of a gentle slope, an angle of rest slope would develop in the sediments depositing on the gentle slope. Sediment falling on the scarp would slide down the scarp to the valley (or to a gentle slope in the same direction), thus tending to fill up the re-entrant between the scarp and the gentle slope relatively quickly.

When the original re-entrant is filled to the top of the scarp, deposition will continue against the angle of rest slope of the earlier deposited sediment. This contact is an "angle of rest" unconformity, and will persist until the infilling of the re-entrant eliminates the relief at the contact.

The angle of rest slope developed in a sequence of sediments of varying type will be the steepest possible in the range of sediments and conditions: if a sediment forming a low angle of rest is followed at any later time by one forming a relatively steeper slope, this later sediment will deposit on the gentler slope and build it up to its own angle of rest (Fig. 7). This applies also if the variation in angle of rest is produced by variation in kinetic energy of the water.

In the field, an "angle of rest" unconformity may be mistaken for a fault, because of the stratigraphic and structural discontinuity at the contact. Table 1 compares the criteria for recognizing a fault and an "angle of rest" unconformity and indicates how they may be distinguished. Movement may have taken place in the younger sediments, as they compacted; and evidence of this movement may lead the observer to regard the feature as a fault unless it is examined very carefully.

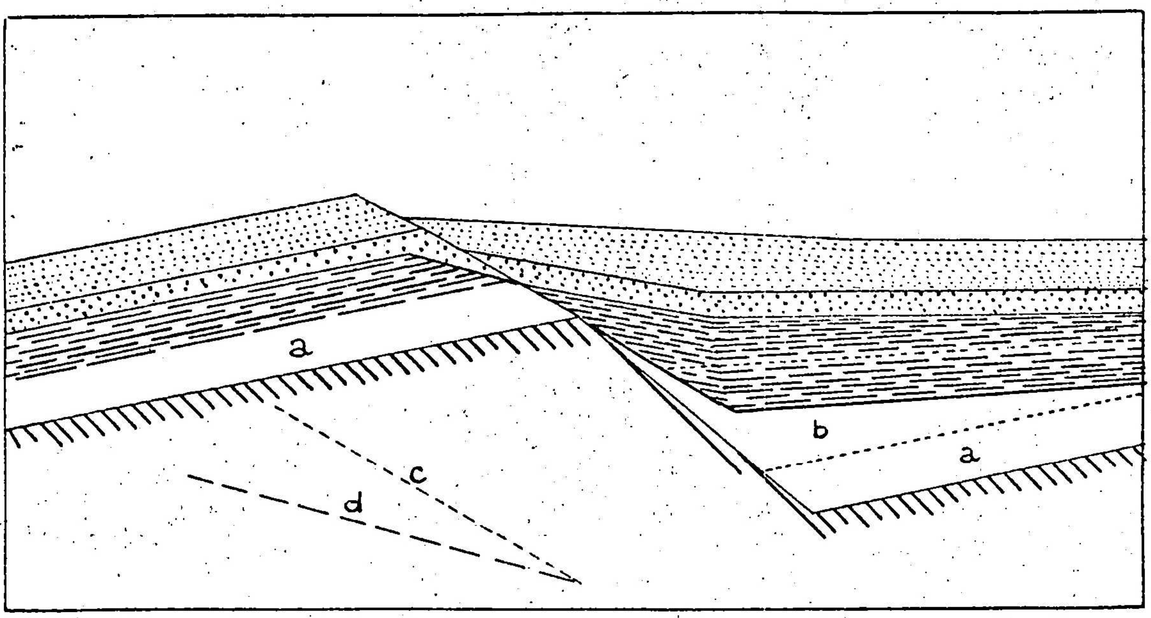

Figure 7. Diagrammatic section showing form of deposits from suspension in still water on sloping floor: a. Material deposited directly. b. Material moved from steep slope. c. Angle of rest of sand. d. Angle of rest of fine sediment.

Significance: The "angle of rest" unconformity has several very important implications in relation to petroleum accumulation. As it is an original structure, the possibilities of petroleum accumulation, in a sequence containing "angle of rest" unconformities, must be assessed with this in mind. The sediments deposited on the gentle slope are open at the up-dip end until covered by the filling of the re-entrant; as, during this period, they are still under water, beds are most unlikely to be sealed by the heavy fractions of petroleum; the main possibility of conserving oil generated there is in stratigraphic or structural traps developed during deposition. These traps are very likely to develop: the up-dip end of the gentle slope is in relatively shallow water; when the water is shallow enough to cause wave break, sediment will be cleaned at the up-dip end of the slope and moved down-slope and may form a lens sealed by later sediment (Fig. 8,a); minor irregularities in the original surface will be reflected in depositional ridge is above the edge of the scarp a depositional anticline may develop at the up-dip end of the gentle slope (Fig. 8,b). Traps may be formed in the younger sediments against the unconformity by pinchout, or by capping by contiguity of impermeable beds on either side of the unconformity. When the re-entrant is filled, the angle-of-rest unconformity passes up into a depositional anticline which offers the best conditions for entrapment of any oil formed in the sequence. Areas of drainage tend to be more restricted than in normally bedded sediments, but for the same reason there is the possibility of more widespread accumulations.

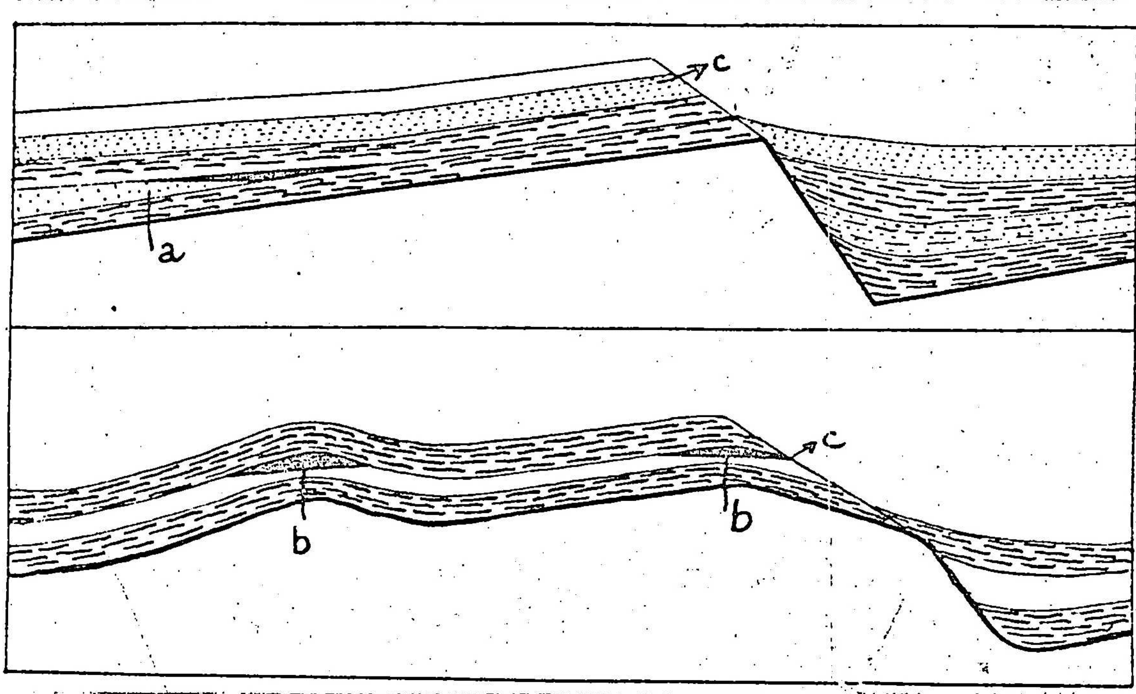

Figure 8. Diagrammatic sections showing possibilities of oil accumulation: a. stratigraphic trap. b. structural trap. c. No trap, oil escaping.

Interpretation: The stratigraphic position of the surface from which the "angle of rest" unconformity developed may be estimated if the general stratigraphic sequence, including angular and regional unconformities, is known.

Where the stratigraphic discontinuity is small, the originating surface will be shallow if the syncline in the younger sediments is narrow and the structural discontinuity is sharp; but deep if the syncline is wide and the structural discontinuity minor.

Where the stratigraphic discontinuity is large, the relief on the originating surface must be large also. From the evidence available in outcrop, and from two seismic sections in the Fitzroy Basin, the vertical depth to the floor of the re-entrant in the originating surface may be between one and two times the horizontal distance between the angle of rest unconformity and the axis of the syncline in the younger sediments. Knowledge of the sequence can then usually decide where the originating surface is likely to be. Scarps in cuesta-type topography rarely exceed 1000 feet in relief; resistant dykes in soft country rock may produce relief of more than 1000 feet, and fault or fault-line scarps may be several thousand feet high.

At the north end of the Kennedy Range (Fig. 5), the horizontal distances from contact to syncline fall into two groups, one from 500 to 1000 feet and the other from 8000 to 9000 feet. It seems likely that the first group is related to an unconformity below the Kennedy Group and the second to one below the Devonian. There is little difference in the stratigraphic discontinuities across these contacts, although the narrow synclines show slightly more structural discontinuity than the wider ones.

The conclusion that the basement forms the originating surface can commonly be checked by a gravity survey, which should show a positive gravity anomaly along a line two to four times the distance from contact to synclinal axis in the younger sediments and in the same direction. This seems to be so in the Wandagee Hill area on the absis of a single gravity traverse (Fig. 9).

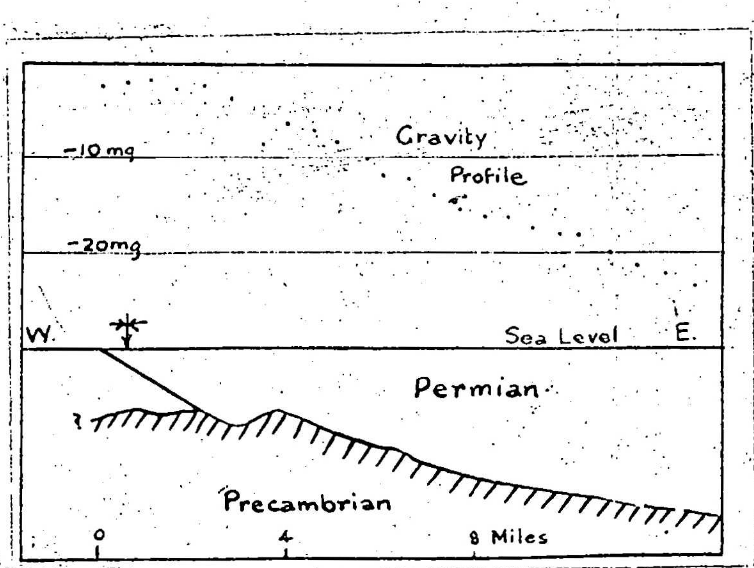

Figure 9. Gravity profile across Angle of Rest Unconformity, Wandagee Hill, showing probable Basement profile.

Depositional Anticlines

There are three groups of anticlines in the Carnarvon Basin probably formed by deposition over pre-existing hills. The first group comprises the relatively small generally dome-shaped anticlines in Palaeozoic sediments associated with basin-shaped synclines close to abutment and angle of rest unconformities. The second group comprise very large and smaller anticlines in Mesozoic and Tertiary sediments near the present coast. The third group, not so well established, but possibly as important as the second, consists of the anticlines formed in Palaeozoic sediments over the large ridges of Precambrian rock separating the minor basins.

EFFECT OF TANGENTIAL STRESS

Although there is no evidence in the Carnarvon Basin of the sediments having undergone tangential stress, it is of some interest to examine the possible effect of tangential stress of structures such as those described above.

Where a sequence with such structures is subjected to tangential stress initial structural irregularities and the unconformities provide very weak places at which movement would occur. Faulting and folding is likely to occur under much weaker stress then normally.

The location and direction of the initial faults and folds would be the same as those of the depositional structures, regardless of direction of the stress. In the very large depositional anticlines folds would develop at the monoclines on each flank and possibly at the crest: it is mechanically impossible to increase the amplitude of these large folds by compressional stress. The smaller folds would continue to fold and the anticlines would develop from them into the unfolded sediments at each end.

Faults would develop along the angle of rest unconformities and abutment unconformities, the younger sediments being thrust up over the older, initially. Thrust drag might develop. In the early stages, it would be possible to have indubitable evidence of thrust faulting in one direction, but stratigraphic "throw" in the other. The "anomalous" regional structure would remain, with some deepening of the synclines. Where the fault passed out into sediments not broken by an unconformity, the trend would be more directly controlled by the stress system, and would possibly be different from the trend of the faulted unconformity. The surface of unconformity would be modified towards a plane: marked change in direction would lead to the development of two planes near to the shear planes of the stress system.

Apart from the features on and near the faulted unconformity, the regional features would be largely unchanged and would allow the recognition of the original structure.

The structure of the synclines should tend towards that produced in normally bedded sediments, but only after severe compression would the depositional syncline be completely masked. Stratigraphic pinch-outs or original changes of dip would favour development of anticlines on the gently dipping flank of the synclines.

After severe folding and faulting, these original structures could be recognized by detailed isopach patterns - regular thinning towards the faults, thickening in the synclines; variations in lithology related to isopach features; thinning or absence of formations over anticlines; anomalous stratigraphic throw on thrust faults. The larger depositional synclines and anticlines may develop into synclinoria and anticlinoria - the depositional features will be related to these and not to the smaller, tectonic, folds; depositional structures will cause anomalous trends in the tectonic structures.

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TABLE 1.

CRITERIA FOR RECOGNIZING AND DISTINGUISHING FAULTS FROM "ANGLE OF REST" UNCONFORMITIES

FEATURE	FAULT	UNCONFORMITY
1. Stratigraphic discontinuity	Sequence and thickness (of the same part of succession) similar on either side.	Beds and formations may be different; thickness appreciably different on either side.
2. Trace of contact	Generally straight, or made up of straight parts; low-angle fault has trace produced by intersection of virtual plane and surface. Trends restricted to few directions in any area.	Irregular, sinuous, as well as showing effect of intersection of low-angle surface and land surface. Trends may be roughly parallel or dendritic.
3. Dip of neighbouring strata.	Regionally in any direction; near contact dip one way across contact.	Regionally dips away from contact on both sides. Near contact may dip across, but only in same direction as contact; commonly strata above contact roughly parallel to it strata below dip in opposite sense.
4. Structure of neighbouring strata	Small-radius bends, on one or both sides, with axis parallel to contact. Stress jointing on one or, more commonly, both sides. Drag folds may be present (parallel axes). Silica veining and slickensiding on both sides.	Large-radius syncline above contact; axis converges with contact, downwards. Jointing, in upper strata only, show no strain system. Slump contortion, only in upper strata (axes random). Silica veining and slickensiding only in upper strata.
5. Erratic blocks	Fault horses may occur along contact.	Erratic blocks of older sediments in younger strata on upper side of contact, near contact or well away from it.
6. Gravity profile.	Commonly shows gradient at or near trace of contact; relative gravity high in older strata.	Commonly shows no gradient at or near contact - gravity high in younger strata away from contact.