THE CAINOZOIC SUCCESSION OF MASLIN AND ALDINGA BAYS

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I. INTRODUCTION

1. Historical Review: The Cainozoic Succession which occurs in the cliffs to the north of Port Willunga as far almost as Ochre Point and the south as far as Snapper Point* was divided in 1878 by Tate (1) as follows:

" The Aldinga section admits of division into -

1. Lacustrine (?) clays. No fossils; 48 feet
2. Upper Series - Calciferous sandstones and impure limestones; with oyster banks; 22 feet.
3. Lower Series, consisting of beds ofa most diversified character - clays, limestone, and sands rapidly replacing one another in horizontal and vertical extension; not less than 80 feet."

In 1879, Tate divides the succession and this is shown in tabular form on page liii(2), whilst on page lviii(2) he gives the age of these divisions in concurrence with divisions of the Murravian (River Murray) beds. He correlates as follows:

Upper Murravian -	Upper Aldinga Series: Calciferous sandstones, impure limestones and oyster banks.	
Middle Murravian Lower Murravian	Polyzoal sand - rock, marls, sands and earthy limestones	Lower Aldinga Series
—	Glauconitic limestone	

On page lviii(2) Tate says: "The obviously higher antiquity of the fauna of the glauconitic limestones at Aldinga necessitates the separation of our Older Tertiaries into two distinct groups - the one referable to the Eocene, the other to the Miocene; and it may be well for the present to regard the Upper Murravian series as Upper Miocene, and the middle and lower portions as Lower Miocene, restricting the Eocene as indicated above."

The next paper of importance was written in 1896 by Tate and Dennant (4) who give some detailed descriptions of the Aldinga beds and descriptions of five vertical sections in the cliffs. The succession is discussed as two divisions only: "lower Eocene" beds and "upper Miocene" beds, the latter lying with angular unconformity above the "lower Eocene"beds.

Tate and Dennant have not made any attempt to group the beds listed under the descriptions of the vertical successions in a unified local sequence "because of the changing nature of the Eocene sediments." In his last paper Tate (5), 1899, subdivides the beds

* The name Snapper Point is used because (1) the terms "Snapper" and "Schnapper" are practically synonymous (2) confusion with Schnapper Point, commonly mentioned in discussions of Tertiary sediments in Victoria will be avoided.

at Aldinga into Miocene, Upper Eocene (upper part of Lower Aldingian Series), Middle Eocene (middle section of Lower Aldingian), and Lower Eocene (lower part of Lower Aldingian Series.) There is, however, no explanation as to which beds form the subdivisions. The name "Aldingian" as applied by Tate was amended to "Aldingan" by Hall and Pritchard (6) in 1902, who observed that the name had been wrongly applied to two distinct series which are in disconformable contact. In 1914, Chapman (8,9) placed the lower beds at Aldinga with his Miocene (Janjukian) localities and the Kalimnan which includes the upper Aldinga Beds is called the Lower Pliocene. Chapman and Singleton (10) in 1923 set out similar views to those of Chapman in greater detail and they regarded the bulk of the Tertiaries of south-eastern Australia as Janjukian and chiefly Lower Miocene in age. In the same year, Howchin (11) ~~proposed~~ stated that Pre-Miocene basal fresh-water beds are overlain by fossiliferous Miocene beds which extend from one third of a mile north of Blanche Point to a little south of Snapper Point. The former included the white sands overlying the "Cambrian quartzite bedrock" and the brown and greenish laminated sands occurring above the white sands; the latter commenced with a pink limestone five feet thick and very fossiliferous, overlain by a green white limestone highly glauconitic and also very fossiliferous, a dark colored banded argillaceous limestone and a yellow argillaceous and sandy bed passing in places to rock consisting of broken polyzoa. Howchin also notes that fossiliferous Tertiaries do not extend northwards beyond where the marine beds (Miocene) are truncated at the surface and that Pleistocene mottled clays rest directly on the basal fluviatile beds. From Blanche Point to Snapper Point the marine beds are overlain by Lower Pliocene beds which, in turn, are overlain by Pleistocene clays. Sir Edgeworth David, in the explanatory notes to his new geological map of Australia [(12) Table I] placed the lowest beds of the Aldinga section, formerly correlated with the Janjukian, in the Oligocene. Chapman and Crespin (13) subsequently regard Upper Oligocene and Lower Miocene as present in the lower Aldinga beds whilst the upper beds are divided into Kalimnan (Lower Pliocene) and Werrikooian with Marginopora vertebralis (Upper Pliocene).

The sands and plant bearing clays of the Maslin Bay sand quarry are regarded as Lower Oligocene by the above authors and also by Chapman (14) in another paper written in 1935. Singleton,(15) following a review of these earlier papers, made these tentative suggestions regarding the Cainozoic Succession at Aldinga Bay: the lower marine beds of Aldinga belong possibly to the Janjukian Stage, the lowest division of the Barwonian System which extends from the uppermost Oligocene to the base of the upper Miocene; the upper marine beds belong possibly to the Kalimnan Stage (Lower Pliocene); non-marine sands and "Pipe-clay"* with leaves, Maslin Bay, are regarded as Oligocene. The term Aldingan propsed by Hall and Pritchard (6) as a stage name was rejected by Singleton (15, p.24).

During 1946 a paper on the foraminifera and other micro-fossils from the Aldinga Bay area was written by Miss Crespin (16) Samples were taken from five localities and numbered 1 to 5. After examination of the micro-faunas from these samples, Miss Crespin says, "It is impossible to distinguish any stratigraphic difference in age of the faunas between samples 1 to 4 and 5 and it must be concluded that, based on the micro-faunas, the five samples should be referred to the same age, i.e. to the Longford substage of the Balcombian."

Samples 1 to 4 are from the beds which are later regarded as the Port Willunga Beds whilst Sample 5 is presumably from the South Maslin Glauconitic Limestone Formation or the immediately overlying Blanche Point North Transitional Marls being named by her as "Greenish glauconitic marl, Maslin Beach." As a result of my own observations on the faunal assemblages of these formations and in view of ~~the fact that Dr. Glaessner (19) has quoted~~ Parr's discovery of Hantkenina from the glauconitic marls (Blanche Point North Transitional Marls), it is now considered that Sample No. 5 could not be from beds younger than Upper Eocene, whilst Samples Nos. 1 to 4 are from beds which, pending

* The reason for placing "pipe-clay" in quotation marks is given later under the discussion of Formation 1: Port Noarlunga Sands.

further investigation of faunal assemblages from these and underlying beds, may prove to be Lower Miocene. In 1947 Miss Crespin (17) placed the Aldinga Pliocene with the Adelaidean Stage represented beneath the Adelaide Plains together with outcrops at Hallett Cove, Christies Beach and Port Noarlunga. "The foraminifera genera Marginopora, Sorites, Peneroplis and Valvulina form a characteristic assemblage, but the occurrence of zonal species of the Kalimnan Stage of Victoria indicates a Lower Pliocene age for the beds." Browne (18) as editor of David's "The Geology of the Commonwealth of Australia" describes an Oligocene lignitic series 280 feet thick with a southerly dip overlain by marine Barwonian limestones at Aldinga Bay. These beds, which have apparently been classified according to Singleton (see above, 15) are overlain by Lower Pliocene and possibly Middle Pliocene (18, see Table 25 facing p. 588).

Criticism of the attempts of authors prior to 1951 to classify the lower beds of the succession may be made along similar lines to that used above in the discussion of Miss Crespin's paper (16) following Parr's discovery of Hantkenina. As further evidence is made available from detailed faunal studies, it is probable that this succession will be subdivided into distinct stratigraphic units and used as a basis for local and regional correlations. Dr. Glaessner (19) in classifying three Foraminiferal Zones in the Tertiary of Australia points out: "To some extent previously named "Stages" lack time values and are actually Formations, i.e. purely lithological units", and that "it is not desirable to alter existing stratigraphic nomenclature without further field and laboratory work." In order to discuss these Foraminiferal Zones in connection with the beds at Maslin and Aldinga Bays, it is felt desirable to list the succession compiled by Miss N. Dolling of Adelaide University and used by Dr. Glaessner in his paper.

(H)	Polyzoal sandy marls (South of Aldinga Creek)		97 feet
(G)	Polyzoal sands and clays (North of Aldinga Creek		25 "
(F)	Red and green clays and pebble bands		6 "
(E)	Turritella clays		57 "
(D)	Turritella marls	about	30 "
(C)	Glauconitic and sandy marls	about	10 "
(B)	Glauconitic limestone		3 "
(A)	Polyzoal glauconitic sand	up to	5 "
			233 feet

The only Zone which can be correlated directly with the above sequence is the Hantkenina alabamensis Zone, Parr's specimen being taken from the basal parts of the glauconitic marls (C). According to Dr. Glaessner this zone is underlain by glauconitic quartz sand "which is generally unfossiliferous but contains bands and lenses with sponges, polyzoa and mollusca which have not yet been identified." Above this sand there is 2 to 5 feet of polyzoal glauconitic sand (A) and Hantkenina was found by Parr 6 feet above its top.

This Hantkenina bed at Maslin Bay is Upper Eocene being equivalent in age to the Brown's Creek and Hamilton Creek beds where Hantkenina is also found and age determination is supported by the occurrence of "Nonion" micrus and Uvigerina cf. selseyensis. The Turritella marls (D) are mentioned as the probably equivalents of the Anglesean whilst the most likely equivalents of the Janjukian are the Turritella clays (E). Beds (G), (H), equivalent to the beds of Miss Crespin (16) from which Samples 1 to 4 were taken, may be, based on the occurrence of Sherbornina, later regarded as a zone between the Victoriella plecte ("Janjukian") Zone and the Austrotrillina howchini (Lower Miocene) Zone when more evidence is available.

Professor Sir Douglas Mawson has done some field work to establish a sequence of the succession but has so far published neither detailed stratigraphic descriptions nor faunal lists.

Classification of this section into Stages and interregional correlation does not come within the scope of this thesis and the succession has been divided into lithological units which will serve as bases for further subdivision when the detailed study of the faunal assemblages has been completed.

2. Field Work and Scope: During January of this year, work on this project began with a Plane Table Survey of the coast-line from the sand quarry at a position 50 chains south-east of Ochre Point to Snapper Point, a distance of approximately four miles. Stations were marked at various intervals by flat-topped pegs and these were subsequently used as reference points in conducting the geological survey. Various topographical and other features are used for descriptive purposes in this thesis because later trips to the area have revealed that the pegs are being removed by erosive and other agencies. The survey was completed half-way through January and a map, scale 1 inch = 500 feet, was produced later in the year. The reference for heights given on the map is Tortachilla Trig Point, the height of which is given on Military Survey Map No. 820, Zone 6, Echunga, as 152 feet. This height is based on Mean Sea Level at Port Adelaide.

It was considered necessary to prepare a Mean-Sea-Level Datum at Port Willunga for two reasons: (1) to check with the Mean Sea Level at Port Adelaide, (2) the Trig Point was the only reference point available in the section, and determination of such a Datum Point would give a valuable check to heights established by the survey. Observations and readings made of tides at Port Willunga from the 24th to the 28th January, 1951, revealed that the times of tides as given in the South Australian Harbours Board Tide Tables were, within a matter of minutes, identical with the times of the equivalent tides at Port Willunga under certain specific conditions outlined hereunder:

(1) There must be no appreciable change in the thickness of beach sand during the period selected for observations,
(2) The sea must be flat and without surf when readings are made (any turbulence would result in the shifting of sand and provide difficulties in the measuring of the heights of tides.)
(3) Preferably there should be no breeze and high atmospheric pressure.

Similar conditions to these existed between the dates given above and a Datum Point was established on the westernmost of the remaining jetty piles. It was found that heights established by the Survey were correct to within one foot by this method, and that the height of a nail and notch at the base of the eighth pile west of the road was four feet to the nearest foot. This height was established for Mr. Thomas of the Zoology Department and will serve as a useful Datum Point for further work.

The geological examination of the beds was conducted from that time until the end of February and at various short intervals throughout the remainder of the year. Vertical sections were prepared at varying intervals, depending upon complexity, along the coast line. Heights were measured from fixed points by measuring tape and Abney Level and from the information thus obtained, a cross section has been drawn and is included with the map. Systematic sampling was conducted for foraminiferal research; samples were collected at short intervals over critical areas and at larger intervals when the succession was more obvious. Macroscopic fossil collections and important petrological samples were obtained and the exact position of their occurrence was noted.

A detailed study of all foraminifera has not been possible, but systematic sorting of the different species occurring in each sample into grid slides has been completed.* Some genera have been divided on morphological considerations into species by numbering and their ranges throughout the succession have been traced. Where possible, macroscopic fossils have been named and their ranges have also been traced. Chemical and microscopic analyses of some sediments have been conducted to determine their lithological nature.

The subdivision of this thesis into various sections has been based partly on the system used by Fleming in his paper on "Standard Sections of the Castlecliffian and Nukumaruan Stages in the New Zealand Pliocene." (23).

* These grid slides are in the possession of the Geology (Palaeontology) Department, University of Adelaide.

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II. GENERAL DESCRIPTION

1. Pre-Tertiary Basement: To the north of the sand quarry at Ochre Point there are steeply dipping Pre-Cambrian chocolate shales overlain by a greyish green grit with limonitic bands, a hard grey to reddish quartzite and consolidated to friable sandstones, the latter being somewhat obscured by recent deposits. They have a dip of approximately 50° in a direction 121° (True). From ~~By~~ observations made immediately to the north of the sand quarry, it is suggested ~~would seem~~ that the sandstones ~~grade into and~~ are probably the sourceof some, at least, of the quarry sands. ~~the sands in the quarry.~~ These beds, tentatively called Pre-Cambrian, are not, however, regarded as directly underlying the white sands. A clayey bed, locally known as pipe-clay, which does not show bedding is exposed in the pit used as a loading ramp adjacent to the elevator and loading construction, and in a small drain running westerly from the quarry below the bridge west of the buildings.

A measurement of the height of the base of the sands was made in a pit due east of the elevator and loader, but this pit has since been cemented in. The bed has a purplish stained appearance and shows Liesegang rings. Polished quartz pebbles and cobbles are occasionally found within this bed and small lenses of sandy material may been seen. One such cobble was taken from approximately 7 feet from the top of this bed and given a Sample number, A182. The unstratified and unsorted nature of this bed, together with the fact that occasional erratics are found, indicates strongly that this is a till. Since it is similar in appearance to the till at Hallett Cove, I have tentatively classed this bed as ?Permian This bed is 14 feet thick and is underlain by a fine sand at least 12 feet thick. These measurements were made in a well in the quarry to the west of the elevator and loader and are taken from ~~recorded in~~ Dr. K. R. Miles's report on the Noarlunga Sand Deposit. (22).

2. Cainozoic Succession: Gently dipping Pre-Pliocene Tertiary sediments overlain unconformably by almost horizontal Pliocene sands and limestones which are capped by approximately flat ?Pleistocene and Recent sediments are to bee seen for a greater part of the coast-line between the quarry and Snapper Point. The sands exposed in the sand quarry are regarded as the basal beds of the Cainozoic succession although age determination has not, as yet, been successfully accomplished, (Chapman's Lower Oligocene age (see page 3) is in conflict with later foraminiferal evidence). They are non-marine and overlain by sands which are predominantly brown and rich in limonite and quartz. These are regarded as separate formations although there is evidence of a transition between them. Howchin (11) regarded these two formations as a fresh water series, but entire and fragmentary remains of marine fossils, which are by no means abundant, have been found throughout the formation, which is now regarded as marine.

Highly fossiliferous polyzoal and glauconitic limestones are next in the succession above the sands, and there is a transition from these limestones to the overlying marls. The marls are divided, as a Group, into 3 Formations, the lowest being predominantly soft and showing a transition from the underlying glauconitic limestone, the middle formed of alternate hard bands and relatively softer beds and the upper clayey marls which, however, have one hard band towards the top. Immediately above the marls there is a distinct break in the succession and a thickness of 5½ feet of sandy clayey beds forms the second non-marine formation. The upper beds of the Pre-Pliocene succession are regarded as one formation although the composition of some beds varies from the predominantly polyzoal sandy nature of most; clay is present in varying degrees in most beds. The formation is marine and fossiliferous and in direct contrast to the underlying formation although there is evidence to suggest that the change from a non-marine to a marine environment may have been a more gradual process. This aspect is discussed in more detail under Conditions of Deposition.

Angular unconformity between Pliocene and Pre-Pliocene beds may be seen from approximately one-third of a mile north of Blanche Point to just north of Snapper Point. It is also seen in the southernmost quarry cutting where contact between the white sands and the overlying brown and green sands is truncated by almost horizontal sands, the significance of which is discussed under Aldinga Bay Limestones and Sands. This unconformity dips from a height of approximately 90 feet in the vicinity of the sand quarry to sea level just north of Snapper Point, (i.e. approximately 30 feet per mile).

The Pliocene-?Pleistocene contact is well defined from Blanche Point to just north of the huts at Aldinga Beach where an erosion surface is exposed on the uppermost limestone of the Pliocene beds. North of Blanche Point, however, the upper limestone bed is not continuous and the base of the ?Pleistocene occurs direcly above sands for most of the distance. Under such conditions the break between Pliocene and ?Pleistocene is not well defined and there appears to be an intermixing of the upper Pliocene sands with the basal beds of the ?Pleistocene deposits. This contact has a similar dip to the angular unconformity and from a height of approximately 100 feet to the north of the succession, it reaches sea level at Snapper Point as the erosion surface mentioned above.

3. Structure: In a section such as this where the dip rarely exceeds 5° and where, in most cases, the dip that is measured is only apparent dip, the determination of structure and calculation of the thicknesses of beds present considerable difficulties.

Dr. Miles has given descriptions in his report (22) of two bores, one to the east, the other south-east of the sand quarry. Little information of any importance in the determination of the dip of the base of the sands can be derived from these bore records, but by observations made in the cuttings adjacent to the elevator and loader it is suggested that the base has a slight dip towards the north-west. Measurements were made and were later disregarded because of the relatively small area covered by the outcrops, but due to the later discovery of the outcrop in the drain to the west where the height of the base of the sands was calculated, the suggested dip direction has been to some extent confirmed. Accurate determination of this dip will be possible should the floor of the quarry be cut below its present level, and the base of the sands reached in other parts of the quarry. This, however, is not likely to occur due to the fact that clay lenses occur towards the base of the sands and that the sands are required free from clay.

The dip of the base of the overlying brown and green sands is also difficult to determine because the contact between the two formations is evident only in ~~one or two~~ three places. Information from the bore records cannot be used because there is insufficient evidence to suggest where the actual contact occurs and the contact, although it occurs over a probable distance of approximately 20 chains, is masked by overlying Recent deposits. However, the contact has been revealed in the south of the quarry, where it has an ~~initial~~ dip (True) of $7\frac{1}{2}^{\circ}$, 201° (True), in a small stream course immediately south of the quarry, and also at the base of the southern wall of the Canyon at the westernmost extremities. By calculation of the heights above Mean Sea Level of the contacts at these exposures, approximately 88 feet at the sand quarry, 20 feet at the Canyon, and due to the fact that the brown sands are exposed down to a height of less than 50 feet on the small limonite-capped hill south of the quarry, it is estimated that the ~~initial~~ dip of $7\frac{1}{2}^{\circ}$ as seen in the sand quarry quickly flattens to a dip of not more than 2°. This estimation was made along the line of true dip.

The top of the brown sands is irregular and the dip has been calculated on a regional scale by estimation of the height at 3 points and using the method outlined in Lahee, p. 635 (20). The strike is approximately 162° True and the dip approximately 2°. Overlying the brown sands are polyzoal sands and limestone becoming glauconitic towards the top. There are transitional marls above the glauconitic limestone and these are overlain by the banded hard and soft marls which form Blanche Point. The dip of approximately 2° remains constant throughout these beds but there is a gradual change in the strike. The top of the glauconitic limestone strikes approximately 145° ~~-150°~~ whilst the banded marls have a true strike of 139°. Conformably above the banded marls are the soft marls which have, at their upper limits, an apparent dip of 1½° approximately in a direction 195°.

The freshwater Chinaman's Gully red sands and clays have, at the top, a dip of 2°-3° (200°True), the strike being 110° True. This was measured by Abney Level on a platform which is exposed just north of Aldinga Creek during winter months. Estimation of the dip of the overlying polyzoal beds from here south to where they pass below sea-level is impossible by the use of Lahee's method because the coastline may be regarded as almost straight. The only platform from which dip may be determined in a similar manner to the method used on top of the Chinaman's Gully fresh-water beds occurs just north of the prominent point approximately ½ a mile south of the remaining jetty piles at Port Willunga. The dip here is still 2° - 3° but the strike, which is approximately 063° (True) gives these beds a south to south-easterly dip. The reefs which occur in the vicinity of the polyzoal sandy beds show a similarly directed dip to this bed and confirm the south to south-easterly direction

The Dips of Pliocene and ?Pleistocene sediments have been discussed earlier and will not be dealt with under this section.

There are two series of minor faults, one just below Port Willunga township, the other approximately a quarter of a mile south of the piles of the former jetty. The greatest of these faults has a throw of only 9 feet, this being the displacement on the southern side of the downfaulted block (graben) below Port Willunga. The faulting occurred in

Pre-Pliocene times although there is evidence to suggest that in the southernmost series there was a slight displacement in Pliocene or Post-Pliocene times. This is indicated in a slight downthrow of the Pliocene beds between the two greater of the series of minor faults. All faults dip steeply to either the east or the west and the strike, as measured by prismatic compass, is North-South in the case of the larger, more prominent faults. Whilst there is no evidence of a continuance of these faults at Blanche Point, prominent fracture lines extend in a more or less north-south direction, i.e. in the general direction of the minor faulting.

4. Physiography: The coast-line from the sand quarry to Snapper Point consists principally of youthful cliffs cut in the sediments already briefly described. More resistant beds, such as the Pre-Cambrian quartzite at Ochre Point, the Blanche Point Banded Marls and the hard sandy limestone at the top of the Pliocene beds, form prominent points whilst less resistant beds have been eroded away to form embayments in the coastline in this section. The hard polyzoal and glauconitic limestones and harder bands in the Blanche Point marls, in the Blanche Point South soft marls and in the Port Willunga polyzoal beds form reefs, some of which are rich in marine life, from just north of Blanche Point at varying intervals to Snapper Point where the upper hard sandy Pliocene limestone forms an extensive reef. From observations made at low tide from on top of the cliffs at Snapper Point, this latter reef appears to be the ~~top~~ crest of a very slight anticline which plunges seaward.

The general succession is interrupted by the mouth of three creeks. The northernmost of these, about 500 yards south of the sand quarry is known locally as the Canyon, due, no doubt, to the fact that the walls of the cutting are almost vertical. The outlet to Bennett's Creek breaks the succession 500 yards south of the Canyon whilst just below Port Willunga, at the northern limits of the township, the Aldinga Creek enters the sea.

Whilst water flows from these creeks into the sea after heavy winter rains, the outlets are generally separated from the sea in the drier seasons of the year by sand. There is evidence to suggest that each of these creeks was of larger dimensions in Post-?Pleistocene ~~Pliocene to Recent~~ times and this is discussed in more detail under the heading of ?Pleistocene and Recent Deposits. Small streams traverse the section at Maslin Beach and between Blanche Point and Port Willunga. The cuttings formed by such streams are not generally important but Chinaman's Gully and two cuttings immediately north of it, formed by such streams, are important in that good exposures of the second non-marine formation are revealed.

Above the cliffs, the coastal section area is relatively flat undulating only where traversed by the creeks above-mentioned. A thin layer of kunkar travertine underlying Recent soils and deposits is almost continuous throughout this area and, apart from the undulations, it has a regional dip of only 1 in 200 feet from the sand quarry to Snapper Point. Generally the basal parts of the section may be regarded as wave-cut cliffs. However, the effects of other erosive agents may be seen in the upper parts of the section andwhere the basal parts of the section are composed of sands. Just south of the sand quarry the basal beds are composed of the brown sands and, although limonitic bands provide a certain amount of protection against erosion, small hilly slopes with moderately steep inclination have been formed between streams; such hillocks are capped with limonite. Between the Canyon and Bennett's Creek, these sands receive a certain amount of protection from the capping of Pliocene limestone but from Bennett's Creek to the Trig Point, this capping does not exist and the erosional effects of the small streams and their tributaries beginning in the overlying ?Pleistocene clays have produced rounded valleys with steep sides between protruding spurs. These valleys when they reach the sea resemble hanging valleys are suspended elevated above beach level by the rapid erosion of the lower beds by wave action. From the Trig Point to the southern limits almost of Maslin Bay and from Blanche Point to Chinaman's Gully, platforms have been formed above the hard upper layer of Pliocene limestone. The overlying ?Pleistocene clays are being eroded away and form a series of rounded protuberances with steep sides between stream courses. The erosion of the ?Pleistocene clays is occurring in a similar manner along the length of Blanche Point and from Chinaman's Gully to Snapper Point. Along these portions of the section, the lower beds are more resistant to the effects of waves and consequently, over a long period, they have become the protruding points mentioned at the beginning of this discussion of physiography. They thus become exposed to the full effects of wave action with the resultant production of almost vertical cliffs which are continuously being eroded away. It is because of this that such platforms as have been formed above the hard upper Pliocene limestone in those parts of the coastline described earlier as embayments, have not had the opportunity of being formed in these portions. The steep nature of most of the ?Pleistocene clay deposits is due to the thin protective layer of kunkar which underlies the Recent soils.

Sand dunes and banks occur at various intervals along the base of the section during the summer months and obscure certain beds in the succession. However, where such deposits are purely aeolian and not covered by vegetation, they will be removed together with a greater part of the beach sand by the high seas generally occurring during winter months. Sand hills and recent deposits covered with vegetation are present in the northern parts of Maslin Bay and to some extent between Blanche Point and Port Willunga.

Land-slides have occurred throughout the section with the result that, in some places, lower beds in the section have become obscured by ?Pleistocene clays, whilst in other places cliff faces have collapsed and produced the same effect. The fallen blocks, which occur amongst the scree at the base of such collapsed faces, have been used for the correlation and sampling of such beds in the section to which they can be proved identical, where such beds are inaccessible. A certain amount of obscurity as to the nature of beds in cliff faces has occurred as a result of surface weathering.

A small shallow cave exists near the south-eastern corner of Maslin Bay where sands underlying the polyzoal limestone have been eroded away. A deep cave has been tunnelled through the polyzoal and glauconitic limestones and overlying softer transitional marls along the northern side of Blanche Point and further west above a reef formed by the limestones, the soft transitional marls have been eroded away, leaving a large shallow cutting beneath the overlying banded marls. The only other caves occurring in the section have been tunnelled in the polyzoal beds below Port Willunga by fishermen.

Fresh to saline water has been observed emerging from above the glauconitic limestone reef in the large shallow cutting immediately north of Blanche Point and from the polyzoal beds in the vicinity of the first reef, locally known as "Spring Reef," south of the old Port Willunga jetty.

To the north-west of Blanche Point is a remnant of a former extension of the banded marls, which isknown as Gull Rock.

A Low Water Mean Line isincluded on the map to indicate those portions of the coastline which are generally inaccessible due to the sea. At times of lower than Mean Low Water tides, however, the reef just north of Blanche Point is exposed above sea level and it is possible to examine beds almost to Blanche Point.

TABLE I.

UNIT NO.		GROUP	FORMATION	LITHOLOGY	THICKNESS in feet
8			?Pleistocene and Recent Deposits	Mottled Red and Green clays and sands and Recent deposits	59 maximum
7			Aldinga Bay Limestones and Sands	Limestones and sands with some clays	18-20
Angular Unconformity					
6			Port Willunga Beds	Sandy, polyzoal and clayey cross-bedded sediments varying in composition and colour	$111\frac{1}{2}$
5			Chinaman's Gully Beds	Gravels, to silts with red, yellow, brown banded clayey beds - 2nd Non-Marine Beds	$5\frac{1}{2}$ maximum
4	C	Blanche Point Marls	Blanche Point South Soft Marls	Soft marls with one hard band and hard nodules	57
	B		Blanche Point Banded Marls	Alternate Hard and Soft bands, some of the former being siliceous	37
	A		Blanche Point North Transitional Marls	Limey glauconitic marls to marls	$7\frac{1}{2}$ maximum
3	B	South Maslin Limestones	South Maslin Glauconitic Limestone	Richly fossiliferous green glauconitic limestone	3 maximum
	A		South Maslin Polyzoal Limestone	Richly fossiliferous polyzoal sands and limestone	3-6
2			North Maslin Sands	Mainly brown limonitic quartz sands, green and purple in part	100-160 average
1			Port Noarlunga Sands	White gravels and sands with some clay lenses 1st Non-Marine Beds	64 approximate
					$388\frac{1}{2}$-$451\frac{1}{2}$

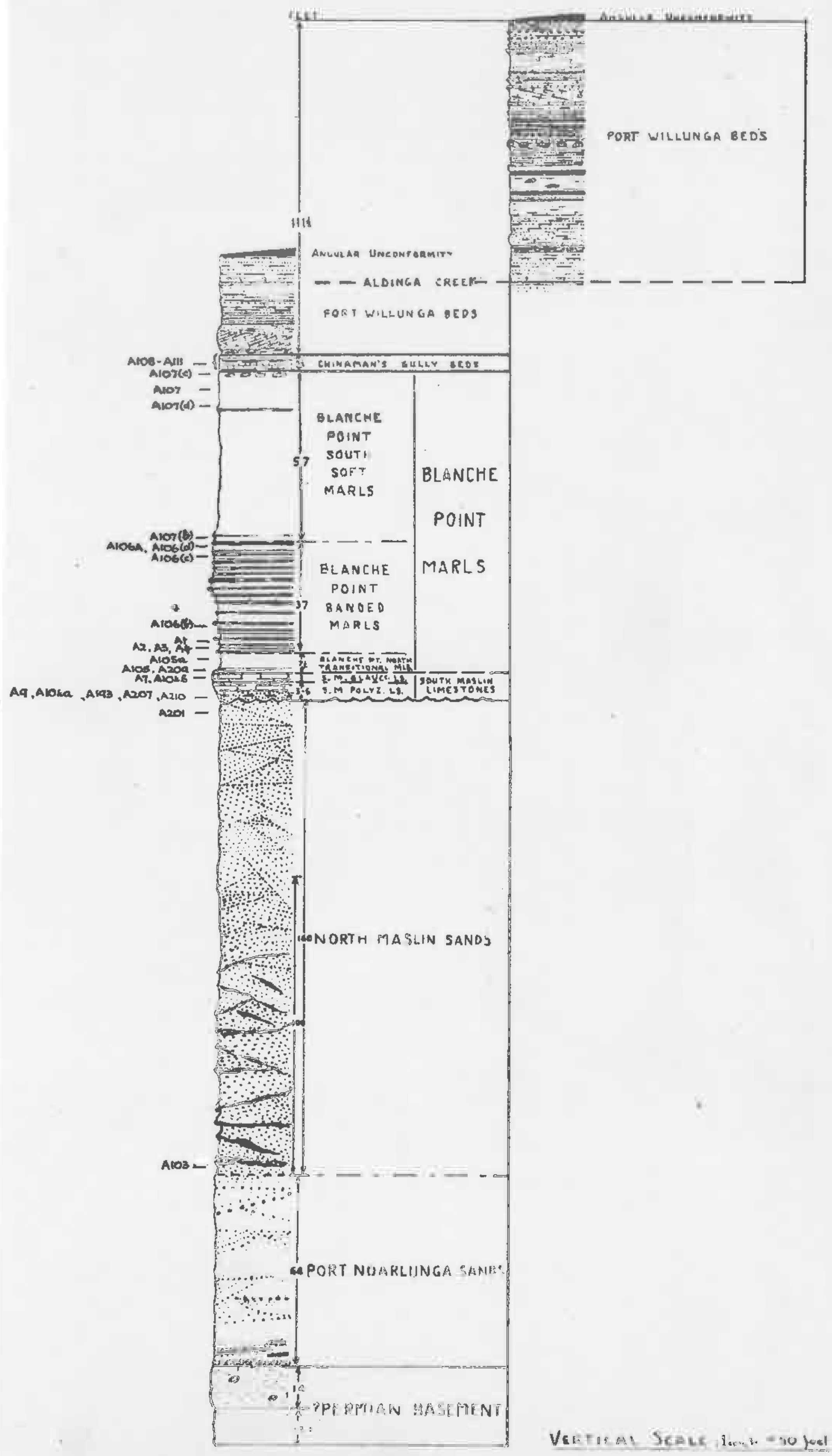


FIG. 1 COLUMN OF PRE-PLIOCENE BEDS.

III. STRATIGRAPHIC OBSERVATIONS

Under this heading it is intended to subdivide the succession into a number of lithological units and to name such units according to the Australian Code of Stratigraphic Nomenclature (25). No attempt has been made to give time and time-rock classification to the majority of these units because time has not permitted the full enquiry into the ranges of such foraminifera as may later prove to be important index fossils when studied in detail and correlated with those foraminifera which are known to have a limited time range.

Table I is included to illustrate the subdivision, lithology and thickness of the units which are discussed in detail hereunder. Fig. 1, facing, is a column of Pre-Pliocene formations.

Formation 1: Port Noarlunga Sands - First Non-Marine Beds.

Exposure: From the Noarlunga Sand Quarries Ltd. quarry situated approximately 50 chains south east of Ochre Point to the base of the southern wall of the Canyon at its western limits. Dr. Miles (22) mentions an exposure "at the mouth of a gully, just above the beach level" immediately south of the quarry, but this was not observed. However, the sands at their upper contact are exposed in the stream course just below the road leading into the quarry.

Lithology: Cross-bedded sands varying in grain size from pebbles to very fine sands with the coarsest particles at the base of individual beds. Fine silty clay bands and yellow clay lenses occur at a height of approximately 10 feet from the base; the former have the appearance of laminae which are somewhat flexible, the latter are sometimes nodular, and such clays occasionally yield fossilized plant remains. These are best seen in the northern parts of the quarry. However, to quote Dr. Miles (22): "The sand throughout the deposit is substantially free from organic material, and, for the most part, is sufficiently fine and free from clay substance to be used as ordinary building and concrete material without screening." The sands are predominantly white but variously colored bands and lenses occur more pronouncedly in the upper beds.

Flora: Chapman (14) describes some plant remains sent to him by Sir Douglas Mawson and for further reference the reader is advised to consult this paper. Such remains arenot as abundant as Chapman suggests in the "pipe-clay" which occurs towards the base of the sands. ("Pipe-clay" has been used in quotation marks because it is most probable that this clay is that which has been described as occurring at an approximate height of 10 feet from the base of this formation and is not the basement rock, known locally as pipe-clay.) Clays with fossilised plant remains have been seen east of the elevator in the gully which leads towards the "Flying-Fox". These should not be confused with the silty bed which contains lignitic material occurring at the top of the Pliocene sands (see under Formation 7: Remarks)

Contacts: The base of this formation is typified by a band of smooth polished quartz pebbles lying unconformably above the ?Permian till and is exposed in cuttings adjacent to and west of the loader and elevator. As exposed in the southern parts of the quarry just below the base of the Pliocene sands, a transition occurs between the upper parts of this formation and the overlying limonitic quartz sands which are green at the base.

Thickness: As already mentioned under the discussion of Structure, the true dip of the base of these beds is not determinable and true thickness cannot be measured. The height of the base as measured in the cutting(not now visible) east of the elevator and loader during the Plane Table Survey is 26 feet. Since the height of the base of the Pliocene would be approximately 90 feet (by estimation from measurements made to the south) in this vicinity, the thickness of this formation is given as approximately 64 feet.

Formation 2: North Maslin Sands

Exposure: This formation extends from the southern parts of the sand quarry to the small shallow cave in the south-east corner of Maslin Bay, a distance of almost 1½ miles.

Lithology: The sands consist predominantly of well-rounded grains of quartz and limonite loosely consolidated with a calcareous cement. The minerals occur to approximately the same extent in the sands but there are other constituents including small green clay pellets, pebbles of quartzite, etc., which occur in small amounts. Whilst these sands vary from a ~~pebble~~ gravel to a fine sand, they are predominantly coarse to very coarse. The color varies from mainly brown, due to the limonite, to green and light purple which colors apparently arise from staining of the calcareous cement. Cross-bedding occurs throughout the formation and pebble bands frequently form the base to successive beds. Thin leaves of limonite, often rich in quartz grains, form a capping to successive beds in the lower parts of the formation, and these, together with the pebble bands, emphasize the cross-bedding. Such limonite bands, as mentioned under Physiography, form a capping to the small hilly slopes south of the sand quarry. There is a brown earthy bed one foot thick which contains quartz pebbles 3 feet above the base of the formation. This is probably a bed of fresh-water origin occurring during the transition from terrestrial to marine environment.

Glauconite, as such, has not been observed in the sands, but it is believed, in view of the similarity in properties of some of the limonite grains to those of glauconite, that this mineral may have been originally deposited or formed. A sample of the "green-sand" overlying the "pipe-clay" and sands in the Maslin Bay quarry was also sent by Sir Douglas Mawson to Chapman (14) who ascribed the shape of many "glauconitic" casts to the infilling of foraminiferal tests, "whilst others are replacements of ovoid pellets variously ascribed to the excreta of worms, echinoderms or fishes." He also makes a pertinent suggestion: "These pellets are similar to those found in the glauconites and marls of Upper Oligocene age in the borings at Lakes Entrance Gippsland." Edwards, (21), in a discussion on the Glauconitic Sandstone of the Tertiary of East Gippsland, Victoria, describes the formation of glauconite from biotite and mentions, with illustrations, three pertinent facts outlined hereunder:

(1) faint traces of biotite cleavage are retained by glauconite,

(2) glauconite can develop a mammillated outline, and
(3) "As the gelatinous glauconite dried, it shrank, developing rounded edges and shrinkage cracks."

Further, the same author points out "... glauconite is an unstable mineral which readily alters to limonite or ferruginous clay if exposed to oxidising conditions, so that this is a normal change for glauconite to undergo." Some limonite grains exhibit the latter two, of the three propeties outlined above and since the change from glauconite to limonite under oxidising conditions is a normal one, the above statement that glauconite may originally have been deposited or formed is substantiated. To determine whether such alteration occurred during deposition or after deposition by diagenetic processes would be beyond the scope of this thesis, but it is thought that there has been ample opportunity for such alteration to have occurred.

Fauna: Fossil remains, although by no means plentiful, occur throughout the formation. Washings of samples from various horizons have revealed the presence of foraminifera, echinoid spines, sponge spicules and polyzoa. Sample A103 from the basal beds yielded Gyroidina? No. 2 and others (undet.), whilst casts of Polymorphinidae, similar to those found in the Polyzoal sands immediately above this formation, are common in the uppermost beds (Sample A201) exposed just above "Uncle Tom's Cabin" towards the south of Maslin Bay.

Mollusca: Lamellibranch tests, generally fragmentary, have been noted from various horizons, one of note occurring at beach level between the Trig Point and the first boat-shed to the south. Lima bassii (T.Woods), var. b (Tate), Barbatia sp. (Samples A188, A208 respectively) have been identified. Small gastropods, unidentified, have been collected and kept for reference.

Contacts: In the southern parts of the sand quarry, there is a sharp transition from the underlying Port Noarlunga Sands to a green sandy bed with white nodules which bed constitutes the base of this formation. The upper beds are overlain with unconformity by a polyzoal limestone which is also brown and unconsolidated at its base in places. The join of this unconformity with the angular unconformity above the Pre-Pliocene beds is not exposed but is thought to exist on the southern side of the spur immediately below the Trig Point. The upper contact, however, may be seen from just south of this spur to the south-east corner of Maslin Bay.

Average Thickness: 100 - 160 feet.

Method of Determination: Because of the fact that some of the heights used in the determination of true dips of the top and the bottom of this formation were calculated by interpolation, a series of diagrams and measurements allowing for possible slight discrepancies in such heights ~~were~~ was made. The resultant dips as used in the determination of thickness are as follows: Base of the formation - initial dip of $7\frac{1}{2}^{\circ}$ flattening to 1° to 2° (201°T) within 350 feet from where the base meets the base of the Pliocene, top of the formation - $1\frac{1}{2}^{\circ}$ to $2\frac{1}{2}^{\circ}$ (approximately 252°T). It was found that when a difference in height was used in allowing for possible slight discrepancies in the determination of the latter dip, the direction of dip was never more westerly than 252°T but could be more southerly with a reading of 227°T and estimations were also made using this figure as a lower limit.

Since the directions of dip of the top and the base differ, an intermediate position was chosen between the point where the top of the formation meets the base of the Pliocene and the position where it is estimated that the base flattens out, which is approximately at a height of 50 feet at the small hill immediately south of the sand quarry. The former point is at a height of 69 feet justsouth of the spur below the Trig Point. At the intermediate position half-way between the two described positions in a straight line, a line was drawn in the direction of the mean of the dip directions of the top and base, i.e. $226\frac{1}{2}^{\circ}$T in the first determination, 214°T in the second. Strike lines were drawn from the two positions to cut this intermediate line and the distance betwwen points of intersection gives the true distrance between the positions in which both the top and base would have the same dip direction.

The average maximum thickness was obtained in each case by taking the mean of the maximum dips of the top and base of the formation, i.e. $2\frac{1}{4}^{\circ}$, and applying this dip to both the top and the base. The average minimum thickness was likewise obtained.

Group 3: South Maslin Limestones

Formation 3A: South Maslin Polyzoal Limestone

Exposure: From just south of the spur below the Trig Point to the north side of Blanche Point where it is exposed from the beach to the small deep cave about 100 yards east of Blanche Point. The upper parts of the bed are exposed at low tides by an almost flat reef which extends from just west of the cave to just east of Blanche Point. This formation is not exposed south of Blanche Point.

Lithology: From the base upwards this formation consists of unconsolidated polyzoal sands rich in limonite grains grading into a hard polyzoal, richly fossiliferous limestone which becomes partly glauconitic towards the top. The limonite grains are less abundant in the upper parts and hence the color also grades from the base upwards from predominantly brown to pinkish white. In thin section quartz grains are seen to be present to almost the same extent as the limonite grains in the upper consolidated limestone. Sections of microfossils are plentiful and occur with the above-mentioned minerals in a richly calcareous matrix.

Fauna:

Foraminifera: Gyroidina ? No. 2, Casts of different species of Polymorphinidae similar to those occurring towards the top of the underlying sands; and others (undetermined) to be seen in Grid Slides Nos. A210, A9.

Brachiopoda: Terebratulina sp., Terebratulina lenticularis (Tate), Magadina sp., Magellania tateana (Tennison-Woods).

Lamellibranchia: Ostrea sp.

Cephalopoda: Aturia was obtained from approximately 3 feet above the base of this formation just above "Uncle Tom's Cabin." Sample No. A50

Echinoidea: Pseudechinus woodsii (Laube), Fibularia gregata (Tate), Australanthus longianus (Gregory), Echinolampas posterocrassus (Gregory), Eupatagus sp.(a).

Other fossils include a calcareous organism which may be an Alcyonarian Coral, a Comatulid Crinoid (undet.) Crinoid stems, many species of Polyzoa (see under formation 3B), Sponge spicules, Gastropod casts, Ostracodes and Shark's teeth (undet.)

These fossils occur in my Samples Nos. A104(a), A193, A207, A210 whilst grid slide No. A9 and the thin section No. A7 are from samples collected by Dr. Glaessner. A soft glauconitic pocket occurring towards the top of the hard consolidated polyzoal limestone was sampled and placed with sample No. A7 but fossils from here are included under Formation 3B because of the transition occurring between these two formations and secondly because of the glauconitic nature.

Contacts: The formation is underlain with unconformity by the North Maslin Sands and is overlain by the South Maslin Glauconitic Limestone. The change from Polyzoal to Glauconitic Limestone is transitional and the two formations are regarded as a Group.

Thickness: The maximum thickness of 6 feet is to be seen in the south-east corner of Maslin Bay where the basal polyzoal limonitic sands show their greatest development in a trough of the unconformity which is somewhat sinuous. These sands vary in thickness from 3 inches to 3 feet whilst the consolidated limestone above generally has a thickness of 3 feet, hence the thickness of the formation is given as 3 to 6 feet.

Formation 3B: South Maslin Glauconitic Limestone

Exposure: This formation is exposed over almost the same distance in Maslin Bay as the underlying polyzoal limestone. It may be seen from about 250 yards south of the Trig Point almost to Blanche Point where the lower parts from the top of the reef already mentioned under Formation 3A. Just east of the small deep cave 100 yards east of Blanche Point along the northern side, this formation forms the top of a small platform.

Lithology: This is in general a hard calcareous rock rich in glauconite, hence the predominant green colour. It is very fossiliferous and there are some small pockets of softer glauconitic material similar to those occurring in the upper parts of the underlying polyzoal limestone. There are some grains and pebbles of limonite and quartz in this rock also, and in some cases fossil tests which have not become infilled with glauconitic clay show a secondary formation of calcite in clear crystalline form.

Fauna:

Foraminifera: Uvigerina No. 1, Uvigerina No. 2, Uvigerina No. 3, U. No. 4, U. No. 5, U. No. 6, U. No. 7, Angulogerina No. 1, Angulogerina? No. 3, Anomalina No. 1, Astronion, Gyroidina No. 1, Gyroidina? No. 2, Nonion No. 5, Discorbis No. 1a, Discorbis? No. 2, Pullenia No. 1, Siphonina, Eponides?, Bulimina No. 1, Gumbelina No. 1, Bolivina No.17, B. No. 1, B. No. 2, B. No. 3, B. No. 6, Bolivina? No. 10, Bolivinita No. 1 and others to be seen in Grid Slide No. A7.

Polyzoa: Reticulipora transennata, Lichenopora sp., see also note at the end of this section.

Corals: Tate (1) lists Amphihelia zic-zac (Tennison-Woods) as occurring in the Glauconitic Limestone north of Blanche Point.

Brachiopoda: Terebratulina lenticularis (Tate), Magellania tateana (T.Woods), Victorithyris pectoralis (Tate), Victorithyris sufflata (Tate), Liothyrella tateana (Tennison-Woods) Aldingia furculifera (Tate), New species (1) old name Magellania insolita (Tate) and others (undet.)

Tate (30) named these additional brachiopoda from the Glauconitic Limestone north of Blanche Point: Terebratula vitreoides (Tennison-Woods), Terebratula aldingae (Tate), Magellania (?) fimbriata (Tate), Magellania (?) johnstoniana (Tate), Terebratella (?) pentagonalis (Tate), Magasella deformis (Tate), Rhynchonella squamosa (Hutton) and he named the following from the Glauconitic Limestone of Aldinga Bay: Terebratulina scoulari (Tate), Terebratulina davidsoni (Etheridge) and these also may belong to this formation.

Lamellibranchia: Notostrea tatei (Suter), Spondylus sp. Chlamys sp., Chlamys flindersi, Glycimeris sp.

Tate (32) names these fossils also: Notostrea lubra (Finlay), Anomia cymbula, Spondylus gaederopoides. In the same paper he lists others from the Glauconitic Limestone of Aldinga Bay and these are listed hereunder: Dimya sigillata, Chlamys aldingensis (Tate), Lentipecten cf. hochstetteri (Zittel), Hinnites corioensis, Lima bassii (Tennison-Woods) variety b (Tate), and in (31): Vulsella laevigata.

Echinoidea: Stereocidaris australiae (Duncan), Pseudechinus woodsii (Laube), Fibularia gregata (Tate), Australanthus longianus (Gregory), Eupatagus sp. (a).

Tate (53) - "Glauconitic Limestone, Aldinga Cliffs" - Salenia globosa (Tate), Cardiaster (?) tertiarius (Gregory), Cardiaster (?) latecordatus (Tate), Hemiaster planodeclivis (Gregory) - these may be additional to the above.

Other macrofossils include Worm tubes and microfossils include Lamellibranch shells and casts, Gastropod casts, Crinoid remains, Echinoid spines and Ostracodes. The reader is also referred to a paper by Miss Crespin (16) for a list of microfossils mainly Foraminifera and Polyzoa.

Macrofossils are generally listed under Sample No. A104(b) whilst Microfossils arefrom Sample A7 (Dr. Glaessner's collection). The reasons for placing this latter sample in this formation are given under Formation 3A.

Contacts: The transition from the underlying Polyzoal Limestone to this bed has already been discussed under Formation 3A. Marls which are highly glauconitic at the base overly the Glauconitic Limestone and there is once again some evidence of a transition between these two formations. Due to erosive agents and since the overlying marls are very much softer, the limestone protrudes from below them and the contact is generally well shown.

Thickness: By measurement is 3 feet maximum.

Group 4: Blanche Point Marls

Formation 4A: Blanche Point North Transitional Marls

Exposure: The formation is exposed from about 150 yards north of "Uncle Tom's Cabin" along Maslin Beach in the south-east corner of the bay to the north side of Blanche Point. Whilst this formation reaches almost to Blanche Point along the northern side, it is no longer exposed south of the Point. It has been eroded away above the reef just north and east of Blanche Point to form a large shallow cutting beneath the overlying banded marls (Formation 4B.)

Lithology: This is essentially a marly bed being dark grey at the base due to the numerous glauconitic grains, becoming lighter in color higher up, although still retaining a speckled appearance. An analysis of a sample from the middle parts of this formation revealed that the bed here contained 80% $CaCO_3$

with some insolubles, including quartz, Fe_2O_3 and clay. On petrological considerations, the sample would be classed as a Limey Marl, but this is not entirely satisfactory because this formation is rich throughout in microfossils which have calcareous tests. As mentioned above, the composition varies from the base where predominantly glauconitic to the upper richly calcareous parts, but it is considered that the formation may with confidence be called a marl.

The analytical method employed is set out hereunder for reference:

Weighed out accurately about .4 gms. of sample. Dissolved in 20 ccs. H_2O + 10 ccs. conc. HCl in beaker covered with watch glass. Allowed to stand until effervescence ceased and then brought slowly to the boil. Cooled. Filtered, using Whatman No. 2 paper. Insolubles determined by placing filter paper in crucible and heating over gauze mat until dry and then heating to red heat over porcelain triangle. Methyl Red indicator added to filtrate and NH_4OH added until neutral. Add 1 cc. HCl (dilute) and boiled. Added NH_4OH till neutral when $(Fe,Al)_2O_3$ precipitated. Filtered hot using Whatman No. 41 paper and determined insolubles in same manner as already described after washing with warm water and NH_4Cl solution (2% alkaline). Filtrate boiled and a solution of 2 gms. Ammonium oxalate in 30 ccs. H_2O added. Simmered gently for 2-3 minutes and allowed to stand overnight (3-4 hours is necessary.) Filtered all precipitate on to filter paper and washed with hot water containing a little NH_4OH. Transferred filter paper to beaker with 50 ccs. of water and added 10 ccs. conc. H_2SO_4. Heated to 70°C. and titrated with Standard .1N $KMnO_4$ solution.

1 cc. of .1N $KMnO_4$ $\equiv$ .0056 gms. $CaCO_3$
Titration reading in above analysis = 57.9 ccs.

$$57.9 \times .0056 = 0.32 \text{ gms.}$$

$$CaCO_3 = 80\%$$

Insolubles including ash weighed 0.08 gms.
$(Fe,Al)_2O_3$ ppt. + ash weighed 0.01 gms.

Insolubles have been kept in glass tubes but theweights given above will not be present as some of the insolubles were crushed andused for microscopic examination.

The marl is rich in microfossils throughout and macrofossils occur more abundantly towards the base which has been termed a "glauconitic marl" by some authors. At a height of 1½ feet there is a thin leaf of hard fossiliferous marl.

Fauna:

Foraminifera: Uvigerina No. 3, U. No. 4, U. No. 5, U. No. 6, U. No. 8, U. No. 9, Angulogerina (?) No. 2, Uvigerina No. 7, U. No. 11, Angulogerina No. 1, Angulogerina (?) No. 3, Uvigerina No. 10, Anomalina No. 1, Astronion, Gyroidina No. 1,

Gyroidina (?) No. 2, Nonion No. 5, Discorbis No. 1a, Discorbis No. 1b, Discorbis (?) No. 2, Discorbis No. 3, Pullenia No. 1, Pullenia No. 2, Siphonina, Notorotalia No. 1a, Bulimina No. 1, B. No. 3, Gumbelina No. 1, Bolivina No. 1, Bolivina No. 2, Bolivina No. 5, Bolivinopsis No. 2, Bolivinita No. 1 and others in Grid Slides A 105, A105a and from Sample A209.
It is from this formation that Hantkenina alabamensis was taken by Parr [see (19)].

Brachiopoda: Victorithyris pectoralis (Tate), ?V. sufflata (Tate), ~~New species (2) old name Magellania insolita (Tate)~~, ?Terebratella (?) pentagonalis (Tate), Aldingia sp. and others (undet.)

Lamellibranchia: Notostrea tatei (Suter), Notostrea lubra (Finlay.)

Other fossils to be seen amongst the microfossils include a small Gastropod, Polyzoa, Sponge spicules and Ostracodes. The reader is also referred to Miss Crespin's paper (16).

Contacts: ~~There is a marked break due to erosion~~ Between the underlying Glauconitic Limestone and this formation, ~~but~~ there is ~~some~~ evidence (i.e. the glauconitic rich basal beds and the fact that macrofossils similar to those in the underlying bed occur also towards the base of this formation) of a transition. The join of this contact with the base of the Pliocene is to be seen in a small stream course about 150 yards north of "Uncle Tom's Cabin." Overlying this formation is the first hard band of the Blanche Point Banded Marls.
Thickness: The maximum thickness, by measurement, is 7½ feet.
Remarks: 1. In view of Parr's above-mentioned discovery of Hantkenina and based on Dr. Glaessner's remarks (19), this formation may safely be assigned the Upper Eocene Age.
2. Sample A105 was taken from the base of the formation and A105(a) from 4 feet above the base in the vicinity of a fence which follows down over ?Pleistocene and Pliocene beds along the eastern limits of Maslin Bay, i.e. approximately 250 feet south of "Uncle Tom's Cabin." Sample A209 was collected from the base of the formation just west of the small shallow cave in the south-east corner of Maslin Bay.

Formation 4B: Blanche Point Banded Marls.

Exposure: From between "Uncle Tom's Cabin" and the fence mentioned under Remarks, Formation 4A, where the base of the first hard band meets the base of the Pliocene to just south of Blanche Point where the upper of the series of hard bands passes below sea-level. At this latter position the steep nature of the cliff-faces common throughout almost the entire distance of exposure of this formation along the coast line is lost and from here south to Chinaman's Gully, a change in the nature of the coast-line is noted. This feature has already been discussed under II 4, Physiography.

Lithology: The members of the formation are discussed hereunder with a list of measured thicknesses; samples are described under Remarks.

(5) Top: Soft clayey marls similar to the overlying Formation 4C with hard grey nodular bands three inches thick at heights of $\frac{3}{4}$, 3, $3\frac{3}{4}$ and $5\frac{1}{4}$ feet above the base. The dip ofthe banded marls was determined by Lahee's method (20) using the top of the band at $3\frac{3}{4}$ feet Thickness: $5\frac{1}{2}$ feet

(4) Grey marls with three hard bands at heights of 2, 4 and $5\frac{1}{2}$ feet above the base. Intervening softer bands are similar to the hard bands in composition but are not as consolidated. Thickness: 6 feet

(3) Soft yellow grey marls with four hard grey nodular bands and capped by a one-foot thick band of hard grey marl. Besides Turritella aldingae which is abundant throughout the formation, these beds are rich in Polyzoa. Thickness: 8 feet

(2) Rubbly marls generally light grey in color with irregular hard and some thin and nodular grey bands. Thickness: 12 feet

(1) Greenish grey and light grey marls, alike in appearance to the underlying Transitional Marls with a hard grey nodular band 2 feet up from the base and a hard light grey band 1 foot thick at the base. Thickness: $5\frac{1}{2}$ feet

37 feet

Analysis by the method described under Formation 4A revealed that the $CaCO_3$ content is 40% in the hard grey marls in member (4). The examination of insoluble residues revealed a large percentage of silica. This was expected since similar beds had already shown from microscopic examination of micro-fossils relatively large numbers of sponge spicules. Besides the abovementioned minerals, a thin section of Sample No. A1 revealed a green mineral (?Glauconite) as occasional grains and forming a part of the matrix. Cracks developed in these beds have a north-south directional trend and may be lines of weakness culminating in the minor faulting seen almost due south in the Port Willunga Beds.

Fauna:

Foraminifera:
From Sample No. A4: Gumbelina No. 1, Bolivina No. 1, Bolivina No. 2, B. No. 3, B. No. 7, B. No. 9, B.(?) No.10, Bolivinita No. 1, Uvigerina No. 5, Angulogerina (?) No. 2, Uvigerina No. 6, U. No. 8, U. No. 7, U. No. 11, Angulogerina No. 1, Anomalina No. 1, Astrononion, Gyroidina No. 1, Gyroidina (?) No. 2, Nonion No. 5, Discorbis No. 1a, Discorbis No. 1b, D. No. 3, Planorbulina, Siphonina and others to be seen in Grid Slides No. A4.

From Sample No. A3: Bulimina No. 1, B. No. 2, B. No. 3, Verneuilina (?) No. 1, Gumbelina No. 1, Bolivina No. 17, B. No. 1, B. No. 2, B. No. 4b, B. No. 8, B. No. 9, B. (?) No. 10, Bolivinita No. 1, Uvigerina No. 4, U. No. 6, U. No.8, Angulogerina (?) No. 2, Uvigerina No. 7, U. No. 11 Angulogerina No. 1, Angulogerina (?) NO. 3, Anomalina No.1, Astrononion, Gyroidina No. 1, Gyroidina (?) No. 2, Discor-bis No. 1a, D. No. 1b, D.(?) No. 2, D. No. 3, Pullenia No.2, Siphonina, Notorotalia No. 1a and others in Grid Slides No. A3.

From Sample No. A2: Bulimina No. 1, B. No. 3, Verneuilina (?) No. 1, Gumbelina No. 1, Bolivina No. 17, B. No. 1, B.(?) No. 10, Uvigerina No. 4, U. No. 5, U. No.8, Angulogerina No. 1, Angulogerina (?) No. 3, Astronion, Gyroidina No. 1, Nonion No. 5, Discorbis No. 1b, Discorbis (?) NO. 2, Pullenia No. 2 and others in Grid Slides No. A2.

From Sample No. A1: Angulogerina No. 1, A.(?) No. 3, Gyroidina No. 1, Pullenia No. 2 and others in Grid Slides No. A1.

From Sample No. A106A: Bulimina No. 2, B. No. 3, Gumbelina No. 1, Bolivina No. 1, Bolivinita No. 1, Uvigerina No. 4, U. No. 8, U. No. 12, U. No. 13, Anomalina No. 1, Astronion, Gyroidina (?) No. 2, Nonion No. 5, Discorbis No. 1b, D. No. 3, Pullenia No. 2, Sphaeroidina, Notorotalia No. 1b and others in Grid Slides No. 106A.

Samples Nos. A1 to A4 are from Dr. Glaessner's collection.

Brachiopoda: Some from Sample A3 (undet.)

Corals: Flabellum distinctum.
Tate (1) also records Amphihelia striata from limestone bands in clays at Blanche Point.

Lamellibranchia: ?Notostrea tatei (Finlay), Spondylus sp., Notostrea lubra (Finlay) not in situ but believed to be from the basal beds. A106 (d) - Propeamussium atkinsoni (Johnston); A106(c) - Chione multilamellata.
Tate (32) - "Turritella Limestone bands, Blanche Point": Spondylus gaederopoides (McCoy), Limopsis multiradiata, Barbatia dissimilis.

Gastropoda: Tenagodes adelaidensis (?), Lyria (?) sp., Turritella aldingae, and amongst the microfossils Vermicularia sp., Siliquaria sp. A106(d) - Trivia avellanoides

Tate (36): "Turritella bands, Blanche Point": Epitonium lampra (Tate).

Scaphopoda: Dentalium sp.

Cephalopoda: 2 species (undet.) probably of Nautilus. Some definite Nautilus sections noted in hard bands just south of Blanche Point.

Other fossils: include Crinoid stems, Sponge spicules, Echinoid spines and Ostracodes - these are to be seen among the microfossils. Sponge spicules are notably plentiful in the uppermost parts of this formation. An Otolith has been collected from member (5), Sample A106(d), and other fish remains include shark's teeth (undet.) and a vertebrae which was seen from a block which was not in situ.
Large worm burrows have been noted in harder bands lower in the formation.
Some additional fossils, mentioned by Tate in various publications, which could not be assigned to this formation because the locality given is not precise but which can be assigned to the Group have been listed at the conclusion of the List of Faunas of Formation 4C.

Contacts: The formation is underlain by the Blanche Point North Transitional Marls and overlain with conformity by the Blanche Point South Soft Marls, Formation 4C. The upper contact joins the base of the Pliocene almost directly above the small shallow cave in the south-east corner of Maslin Bay.

Thickness: By direct measurement 37 feet (see under Lithology.)

Remarks: Sample No. A106 consists of fossils taken generally from fallen blocksnorth of Blanche Point and represent the formation as a whole. Samples Nos. A106A and A106(d) are from hard and soft bands respectively of member (5) whilst A106(b) is from a hard band towards the top of member (2), and A106(c) is from the soft bands in member (4). Samples collected by Dr.

Glaessner and correlated with this formation are numbered A1, A2, A3 and A4, and of these, the first represents the basal 3 feet of member (2), the latter three cover member (1). A1 is described as "white porous glauconitic marl" 3 feet thick, A2 as "bedded Polyzoal marl" 3 feet thick, A3 as "soft glauconitic marl(lensing)" 6 inches thick and A4 as "hard Turritella marl" 2 feet thick. Dr. Glaessner (19) suggests that this formation is the probable equivalent of the "Anglesean" Stage.

Formation 4C: Blanche Point South Soft Marls.

Exposure: The base of this formation meets the base of the Pliocene almost above, approximately 100 feet west, the small shallow cave in the south-east corner of Maslin Bay. The top of the formation meets the Pliocene approximately 400 yards north of Chinaman's Gully and this may be seen in a stream course exposure. The top of the Marls is last observed just to the north of Aldinga Creek where it is decidedly blackish in colour and passes down below sea-level. This however is only to be seen when there is little or no sand cover.

Lithology: The formation is essentially a brownish to greenish grey marl generally soft and clayey (more so towards the base,) with some hard grey nodules dispersed irregularly throughout. There is a hard grey-black band which forms a reef due west of Chinaman's Gully at a height of approximately 45 feet and a thin nodular band 1½ feet from the base. The uppermost bed is a dark greenish grey color and very fossiliferous, being rich in Limopsis ~~insolita~~ chapmani (Singleton) and Turritella aldingae, the latter, however, being common throughout the formation.

A sample from the topmost Limopsis bed, A107(c), was examined for Foraminifera which were found to be very small comparatively and not numerous. The bed is extremely rich in glauconite which occurs as green molluscan pellets. Another characteristic feature of the upper beds of this formation are the white marly nodules which are sometimes of quite large dimensions. They appear to be non-fossiliferous and may possibly represent the relics of an erosional surface which existed prior to the deposition of the overlying non-marine sediments. The Blanche Point Marls are generally grey in colour throughout, some horizons being darker than others and this may be due partly to the presence of organic matter.

Analysis of Sample No. A107 revealed 47.5% $CaCO_3$, together with clay and some silica which are left as insolubles.

Fauna:

Foraminifera: Sample No. A107(b): Bulimina No. 3, Gumbelina No. 1, Bolivina No. 1, B. No. 2, B. No. 4(c), ?B. No. 8, B. No. 6, B. No. 9, B.(?) No. 10, Uvigerina No. 5, U. No. 8, U. No. 7, Angulogerina (?) No. 3, Anomalina No. 1, Astronion, Gyroidina (?) No. 2, Discorbis No. 1b, Pullenia No. 2, Sphaeroidina and others (undet.)

Sample No. A107: Bulimina No. 3, Gumbelina No. 1, Bolivina No. 1, B. No. 2, B. No. 9, B. No. 11, Uvigerina No. 8, Angulogerina No. 1, Uvigerina No. 12, Astronion, Gyroidina (?) No. 2, Nonion No. 5, Discorbis No. 1a, D. No. 1b, Pullenia No. 2, Sphaeroidina and others (undet.)

Brachiopoda: Victorithyris sufflata (Tate) and others (undet.)

Lamellibranchia: Limopsis ~~insolita~~ chapmani (Singleton), Dimya sigillata, Lentipecten sp., Lentipecten cf. hochstetteri (Zittel), ~~Parv~~Propeamussium atkinsoni (Johnston), Anomia cf. cymbula (Tate), Cardium sp. and others (undet.) A107(b) - Chione cainozoica, Arca equidens; A107(b) Chione multilamellata.
Tate and Dennant (4) list this additional species: Chione cainozoica.

Gastropoda: Turritella sp. (b), Turritella aldingae, "Murex" sp., Ancilla ligata (Tate), Natica sp., Voluta pagodoides, Trivia avellanoides (Tate) and Vermicularia sp. and Turritella tips occur among the microfossils.

Tate (4) Lampusia tortirostris.

Scaphopoda: Species of Dentalium (undet.)

Other fossils: to be seen in Samples A107, A107(b) include Sponge spicules and Ostracodes.

The fossils listed hereunder are given by Tate in the references given and are additional to those already listed in the three Formations which form Group 4. Whilst they cannot be restricted to any one of the Formations, they are confined to this Group.

Corals: Tate (1) Trochocyathus heterocostatus (Tennison-

Woods), Notocyathus tateanus (Tennison-Woods), Notocyathus aldingensis (Tennison-Woods), Cyathosmilia laticostata (Tennison-Woods), Cyathosmilia tennicostata (Tennison-Woods), Bistylia adherens (Tennison Woods), Conosmilia contorta (Tennison-Woods), Flabellum distinctum (Tennison-Woods) all from "Clays at Blanche Point."

Brachiopoda: Tate (30): Terebratulina triangularis (Tate) from "Blanche Point Marls."

Lamellibranchia: Tate (32): Crassatella corrugata, Dimya sigillata, Anomia cymbula, Nucula semistriata, Nuculana huttoni (Tennison-Woods), Nuculana apiculata (Tate) "Turritella clays, Blanche Point"; Nuculana leptorhyncha (Tate), "Turritella Marls, Aldinga Bay"; Limarca angustifrons "Turritella beds, Blanche Point"; Tate (31): Limea multiradiata, "Turritella marls, Aldinga Bay"; Tate and Dennant (4): Nuculana planiuscula (Tate), Arca equidens, Cardita latissima, Meretrix tenuis, "Upper Turritella banks, Blanche Point"; Tate (33): Chione multilamellata, Myodora lamellata, Corbula pixidata, "Turritella clays, Blanche Point."

Gastropoda: Tate (34): Murex calvus, Murex manubriatus, Murex bifrons, Chicoreus adelaidensis (Tate), Phyllonotus sublaevis (Tate), Ocinebra prionotus (Tate), O. tridentatus (Tate), Trophon torquatus, T. hypsellus, Lampusia oligostirus (Tate), Fusus cochleatus, F. incompositus, F. aldingensis, Latirus aldingensis (Tate), L. apicilirata (Tate), L. actinostephes (Tate), Plesiotriton varicosus (Tate); Tate (35): Voluta cribrosa, Cancellaria (s.g. Biretopsis) ptychotropis (Tate), Cancellaria turriculata; all the above "Turritella clays, Blanche Point"; Tate (38): Natica hamiltonensis, Thylacodes adelaidensis, "Turritella beds, Aldinga"; Mesalia stylacris, "Turritella banks, Blanche Point"; Tate (35): Mitra citharelloides (Tate), "Turritella Marls, Blanche Point"; Tate (38): Cypraedia clathrata, "Eocene Marls, Blanche Point"; Tate and Dennant (4): Erato pyrulata, Natica aldingensis, "Turritella banks (Upper), Blanche Point."

Scaphopoda: Tate (33): Dentalium mantelli (Zittel), D. subfissura (Tate), "Turritella clays, Blanche Point."

Pteropoda: Tate (33): Styliola annulata (Tate), "Turritella clays, Blanche Point."

Contacts: The base of the formation is underlain by the topmost hard band of the alternate hard and soft bands of marl which form Formation 4B whilst immediately aboveare the basal beds of the second non-marine beds, i.e. laminated green, brown and yellow clays with white nodules.

Method of Determination of Thickness: A line was drawn connecting 3 points which lay in a straight line and at these points the heights of the top of this formation were obtained by direct measurement or by estimation from measured heights of the top of the Chinaman's Gully Beds.

This line was produced to cross the line of true dip of

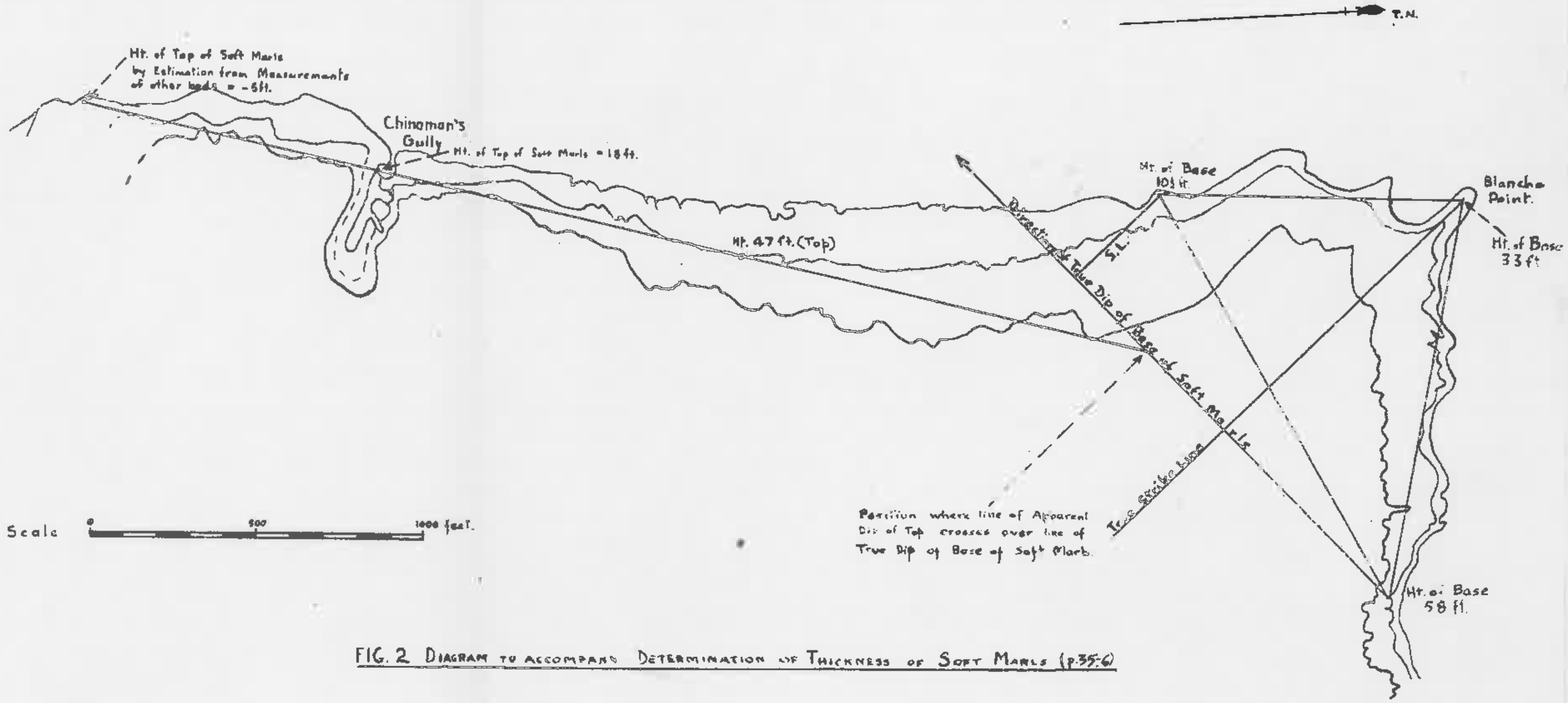


FIG. 2 Diagram to accompany Determination of Thickness of Soft Marls (p.35-6)

the base of the formation (i.e. the top of the Banded Marls.) At the position where the lines crossed, the height of the base could be determined from the known heights used in the determination of dip, and the height of the top was determined by the use of ratios from the known heights. The difference in these two readings gave the vertical thickness = 57 feet. The mean of the apparent dip of the top and the true dip of the base of the formation was determined and the actual thickness (i.e. perpendicular) was calculated. Due to the fact that the angle is so small, there is no significant difference in the vertical and perpendicular thicknesses. Figure 2 is included to illustrate this method.

Thickness: 57 feet

Remarks: Sample No. A107 consists of fossils obtained from an exposure of this formation just north of Chinaman's Gully. Specimens from fallen blocks north of Blanche Point are labelled A107(a), whilst the base of this formation is represented by A107(b), which was obtained from above the landslide in the south-east corner of Maslin Bay. Sample No. A107(c) is from the top Limposis bed and A107(d) is from the hard consolidated grey marl band at a height of 45 feet from the base. The two latter localities are between Chinaman's Gully and Aldinga Creek. This formation may possibly be equivalent to the "Janjukian" Stage, according to Dr. Glaessner (19).

Formation 5: Chinaman's Gully Beds
Second Non-Marine Formation

Exposure: These beds meet the base of the Pliocene, the base at 370 yards, the top at approximately 290 yards, north of Chinaman's Gully, but except where exposed in stream courses, they are generally obscured by Recent deposits in this vicinity. The best exposure is in Chinaman's Gully, whilst they are also well shown in two small stream cuttings just to the north. They are generally to be seen in part from Chinaman's Gully to Aldinga Creek but not south of the latter locality.

Lithology: Because these beds are easily measured and have some variation in composition they have been listed hereunder in tabulated form with Sample Numbers and thicknesses:

Lithology	Sample No.	Thickness
Top		
Yellow to brown becoming red laminated dayey to gritty bed, limonitic in part and containing nodules of blue-grey and green sandy clays which show Liesegang Rings - this bed is in parts cross-bedded.	A111	11"
Blué-grey silt with parallel bands of coarser sands	A110	8"
Red laminated sandy to clayey bed) Thin band of bluish grey silt) Yellow laminated sandy bed) Greenish yellow silt band)	A110	1' 8"
Interbedded coarse and very fine to medium sands varying in color from greenish yellow to white and blue-grey with a hard white sandstone leaf at the base and some white sandy nodules just above the base	A109	1' 1"
Laminated green, brown and yellow clays with white sandy nodules	A108	1' 0"
Base		5' 4"

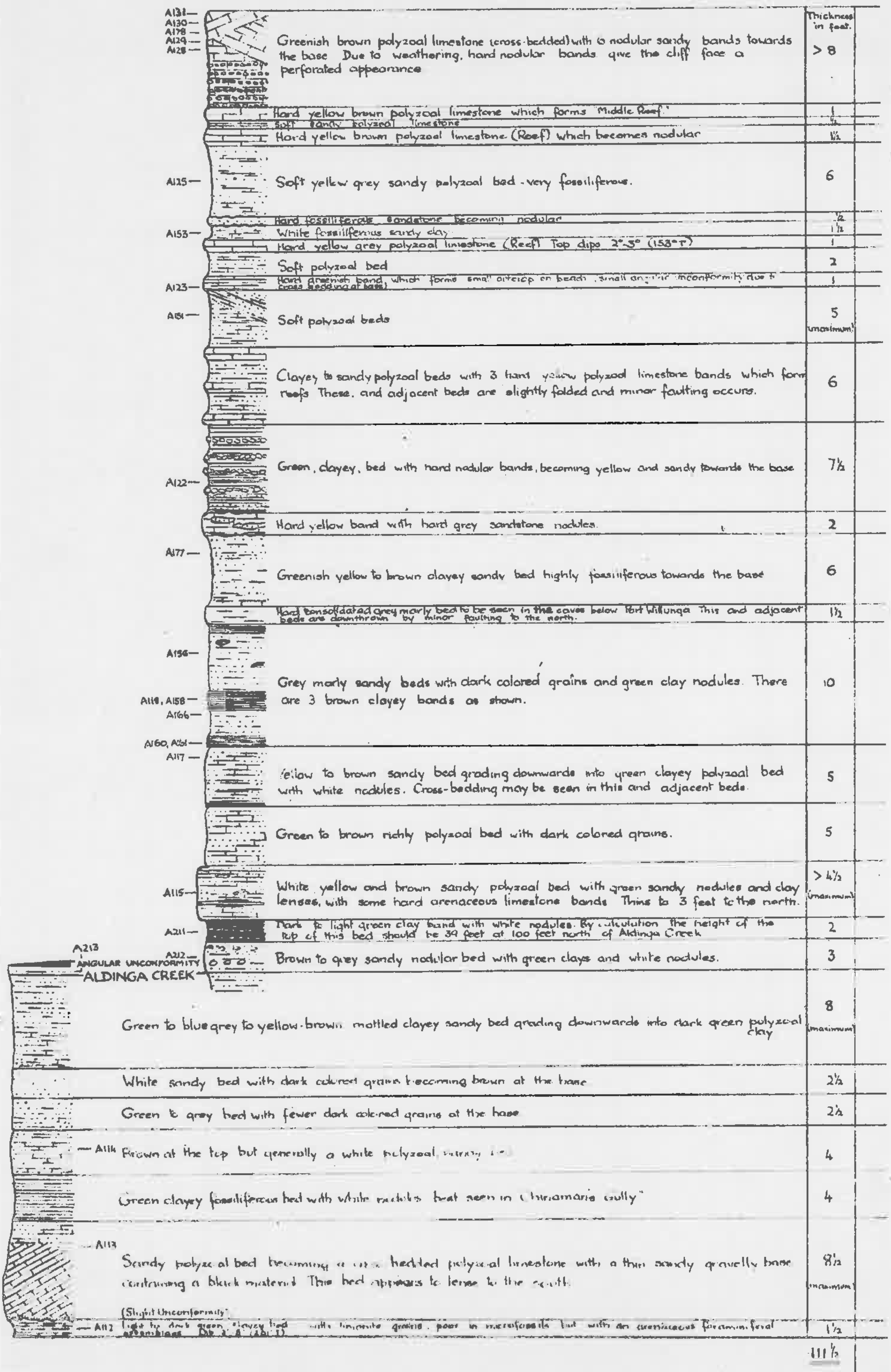
In samples of the coarser constituents examined quartz was seen to be the predominant mineral but there were other dark grains (undet.) and some muscovite. Clay, sometimes with iron oxides, and silts form the very fine constituents of these beds.

Fauna: Some foraminiferal tests were obtained from sample No. A109, but these are thought to have been derived from the underlying soft marls being left as remanie fossils during erosion under a terrestrial environment.

Contacts: This bed overlies the Blanche Point South Soft Marls and, at the base, shows a marked contrast to the highly fossiliferous grey marls which are fairly abundant in white nodules at the upper limits. A green bed with a maximum thickness of 1½ feet overlies the formation and whilst the break as shown by the change in color is quite evident, the microfossil assemblage, as discussed under Formation 6, indicates a distinct change in the environment.

Thickness: By measurement 5½ feet maximum.

FIG. 3. THE PORT WILLUNGA BEDS.



Formation 6: Port Willunga Beds

Exposure: The northernmost limit of this formation is somewhat obscured by Recent terrestrial and aeolian deposits. The top of the lowest member of the formation meets the Pliocene basal unconformity approximately 270 yards north of Chinaman's Gully. This is exposed in the bed of a small stream course and by estimation, taking into consideration the apparent dip of the beds [approximately $1\frac{1}{2}^{o}$ (120 feet/mile) 200^{o}T] and of the unconformity (approximately 0^{o} in the vicinity) the northernmost limit is 280 to 290 yards north of Chinaman's Gully. The southernmost limit occurs where the base of the Pliocene dips below the sand at an approximate distrance of 1,000 yards south of the remaining jetty piles at Port Willunga. This distance is based on the level of the beach sand during February, 1951, and will be subject to variation.

Lithology: Due to the variable nature of the members of the formation, a column has been drawn, Fig. 3 , showing such variation, sample horizons and thicknesses. The minor faulting discussed earlier, the thinning of certain beds, cross-bedding and the effects of a relatively deeper Aldinga Creek in post-Pleistocene times have all created some difficulties in the correlation of beds and measurements of thickness. The formation as a lithological unit could be classed as an arenaceous polyzoal limestone with argillaceous bands.

Fauna:

Foraminifera: Sample No. A112 - a distinctive assemblage of arenaceous types which have not been identified.
A113: Anomalina (?) No. 2, Sherbornina (?), Sphaeroidina and others (undet.)
A114: Verneuilina (?) No. 1, Verneuilina (?) NO.2, Gumbelina No. 1, Bolivina No. 2, B. No. 12, B. No. 4(a), B. No. 13, Uvigerina No. 4, U. No. 6, U. No. 8, Angulogerina No. 1, Astrononion, Gyroidina No. 1, Gyroidina (?) No. 2, Nonion No. 5, Discorbis No. 1b, D. No. 3, Planorbulina, Sherbornina (?), Sphaeroidina and others (undet.)
A131: Verneuilina (?) No. 1, Bolivina No. 14, Angulogerina No. 1, Anomalina (?) No. 2, Gyroidina (?) No. 2, Planorbulina, Sherbornina (?) and others.

The following have been separated from A212: Uvigerina No. 8, Angulogerina No. 1, Bolivina No. 16, B. No. 4(a), B. No. 13, B. No. 15, and these from A115: Angulogerina No. 1, Verneuilina (?) No. 2, Bolivina No. 13, B. No.14, Bolivinopsis No. 1, but separation of other types was not possible due to lack of time.

Corals: A151: Graphularia senescens.

Polyzoa: A129,A151: Cellepora cf. verruculata.

Brachiopoda: A113: Magellania garibaldiana (Davidson); A114: Stethothyris (?) insolita (Tate), ?Magellania tateana (Tate); A177 Victorithyris sufflata (Tate) and others (undet.) from A122, A177, A156, A125, A151.

Lamellibranchia: A113: Pecten cf. consobrinus (Tate); A114: Ostrea arenicola, Chlamys asperrimus asperrimus; A161: Chlamys asperrimus asperrimus; A177: Pinna sp.(a); A123: Spondylus sp; A125: Pecten eyrei; A128: Ostrea arenicola; A178: Dimya dissimilis.

Gastropoda: A113, A114: Vermicularia sp. in microfossils; A156,A118: Turritella sp. (a), ?Mitra sp.; A151: Cirsotrema mariae (Tate).

Echinoidea: A113: Duncaniaster australiae (Duncan), Nucleolites sp., Linthia compressa (Duncan); A114: Pseudechinus woodsii (Laube), Duncaniaster australiae (Duncan), Eupatagus sp.(c); A117, A161: Stereocidaris australiae (Duncan); A177: Prionocidaris scoparia (Chapman and Cudmore), Stereocidaris australiae (Duncan); A151: Prionocidaris scoparia (Chapman and Cudmore), Goniocidaris prunispinosa (Chapman and Cudmore), Duncaniaster australiae (Duncan), Scutellina patella (Tate), Linthia compressa (Duncan); A153: Prionocidaris scoparia (Chapman and Cudmore); A128: Fibularia gregata (Tate), Eupatagus sp. (d); A178: Stereocidaris australiae (Duncan) Pseudechinus woodsii (Laube), Fibularia gregata (Tate), Eupatagus sp. (b).

Asteroidea: A177, A128 and A178: Pentagonaster sp.

Crustacea: A113: abundant Cirripedia.

Pisces: A161: Tooth of Odontaspis contortidens
A161, A177: Teeth of Odontaspis attenuata.

Other fossils include worm tubes (A151), and microfossil samples contain Polyzoa, Ostracodes, Sponge spicules, Echinoid spines, Crinoid stem remains.

Hereunder are some additional fossils mentioned by Tate in various publications:

Brachiopoda: Tate (30): Magellania furcata (Tate) -"rather rare in the Polyzoal calciferous sands forming the lower part of the seacliffs immediately south of Port Willunga Jetty", Magellania sufflata (Tate) - same locality, Magasella woodsiana (Tate) - "yellow calciferous sands, Aldinga Bay."

Lamellibranchia: Tate (32): Pecten peroni - "polyzoal limestone, Aldinga Bay."

Echinoidea: Tate (53) - Eupatagus decipiens (Tate) -

"calciferous sandstone ... south side Port Willunga Jetty," Lovenia forbesi (Tennison-Woods) - "calciferous sandstone, Eocene, Aldinga,"

Tate and Dennant (4) list also these Echinoderms - Antedon sp., Maretia anomola (Duncan) from "calciferous sand rock with hard concreted portions at top and siliceous bands at bottom," Port Willunga Jetty, Lower Beds. The reader is also referred to a paper by Miss Crespin (16) for a list of microfossils, mainly Foraminifera and Polyzoa, which come from her Samples Nos. 1 to 4.

Contacts: The formation is underlain by the second non-marine formation as described under Formation 5. The upper contact of these Port Willunga Beds is not revealed in this succession.
Thickness: By measurement 111½ feet.

Formation 7: Aldinga Bay Limestones and Sands

Exposure: Sands and limestones with sands all regarded as Pliocene in age extend continuously from north of Ochre Point to south of Snapper Point.
Lithology: This formation consists predominantly of white and yellow sands and arenaceous limestones with occasional lenses of clayey sands. For the purpose of this discussion, the Pliocene formation will be considered in 3 divisions numbered 1 to 3.

1. From the north of this succession to 120 yards south ofthe spur below the Trig Point, the formation consists mainly of unfossiliferous yellow and white sands. A typical section of these beds may be seen at the sand quarry where a basal white, brown, yellow and red mottled friable sandstone band is overlain by white and yellow sands showing some banding. (Sample A186). In the upper parts of this section there is a yellow, hard limonitic (in part) sandy band, the thickness of the formation being 10½ feet. The only fossiliferous arenaceous limestone occurring in this division of the succession is a capping over the small hill between the Canyon and Bennett's Creek. This bed is hard, white with some yellow staining and travertinous in appearance (Sample A175). It is slightly fossiliferous, 4 feet thick and overlying 6 feet of yellow sands (Sample A176.)
2. This division extends from 120 yards south of the spur

below the Trig Point to the north side of Blanche Point. A typical section is described from above "Uncle Tom's Cabin": Yellow sands (Sample A200) 9 feet thick are overlain by a green clayey sandy bed (A199c) grading into a dark grey, green to brown clay (A199b) 4½ feet thick and the section is capped by white sandy limestone(A199a) 5½ feet thick. This upper limestone is slightly fossiliferous and towards the north of this division it is slightly pebbly; the underlying 12 feet of sands in this position also contain pebbly bands.

The top of the upper hard limestone forms an intermediate platform between beach level and the top of the cliffs. This hard band, however, does not seem to extend to the base of the (?)Pleistocene clays in the northern parts of this division, where grey to white pebbly sands (Sample A197) pass upwards into yellow sandy clays (A196) and yellow clays (A195). This is exposed in a small stream course and the clays here pass directly upwards into a grey mottled bed (A194) which grades up into red ?Pleistocene beds. The formation as described (i.e. above "Uncle Tom's Cabin") is the same in the southern limits of this division. There are, however, calcareous nodules in the basal parts here, which are similar in appearance to some which occur at the base of the Pliocene along the north side of Blanche Point. A feature of interest is the so-called "sandstone dyke" which occurs on the path from "Uncle Tom's Cabin" to the top of the ?Pleistocene. This is a "dyke" in appearance only, and not in the true sense of the word, formed by the lower sands of the formation which have filled in a crack in the underlying Pre-Pliocene beds and become cemented to form a sandstone.

3. The third division may be seen from Blanche Point to south of Snapper Point almost to the huts at Aldinga Beach. Generally the beds are as follows: Basal beds of highly fossiliferous yellow sands overlain by white sands with irregular bands and lenses of calcareous sandstone and arenaceous limestone are capped by 5 feet of white to grey arenaceous limestone with sandy lenses, the whole being approximately 18 to 20 feet thick.

The section is generally fossiliferous, more so at the base and in the irregular bands where mostly casts only are to be found. Some fossils are to be found in the white sands and fossil impressions and casts are to be seen with some occasional fossils in the upper hard white limestone. In places a greenish sandy clayey bed, best seen in Chinaman's Gully, underlies this upper hard white limestone and there is evidence to suggest that there is an unconformity below this latter bed. A typical section may be seen along the road leading to the jetty at Port Willunga and this is described hereunder:

Top - White fossiliferous arenaceous limestone	5' 0"
Yellow to white mottled sand	2' 0"
Hard calcareous sandstone with some fossils	1' 8"
White sand	1' 0"
Hard calcareous sandstone with fossils	1' 0"
White sand	1' 0"
Hard arenaceous richly fossiliferous limestone	2' 0"
White fossiliferous sand	9"
Yellow sand with hard sandstone leaf	2"
White sand	8"
Hard arenaceous fossiliferous limestone	1' 6"
Yellow to white mottled sands, richly fossiliferous	9"
Hard fossiliferous nodular limestone	6"
	18' 0"

~~Nodules~~ Boulders of Pre-Pliocene formations are occasionally found at the base of the Pliocene beds and white chalky nodules are also found in the colored beds immediately underlying the topmost arenaceous limestone. The top of this formation is exposed between Snapper Point and the huts at Aldinga Bay as an erosion surface.

Fauna:

Foraminifera: Elphidium species are prominent amongst the Rotaliidea but these types have not been separated. Marginopora vertebralis is common in the hard limestone bands. See Samples A163, A165.

Lamellibranchia: Ostrea arenicola, Spondylus spondyloides (Tate), Pecten consobrinus, Chlamys asperrimus anti-australia, Tellina lata, Dosinia (Kereia) greyi (Zittel,) Pinna sp. (b), Spisula variabilis (Tate).

Tate (32) lists these additional types: Placunanomia ione, Pecten palmipes, Amussium lucens, Pinna semicostata, glycimeris convexus (Tate) - "imperfect specimens", Trigonia acuticostata - "casts probably of this species", Cardita trigonalis: Tate (33): Lucina arsea, L. nuciformis L. fabuloides, Loripes simulans, Lepton planuisculum, Glycimeris orbita; Tate (5): Cucullaea corioensis, Crassatella oblonga; Tate (31): Pecten subbifrons, Limatula jeffreysiana; Basedow (42): Meretrix sphericula - "large imperfect cast referable to this species."

Gastropoda: Casts of Potamides sp. Cerithium sp. Phasianella sp., Terebra sp. Cassis sp., ?Architectonica sp. Bulinella sp., and casts and external moulds of Haliotis sp. have been seen.

Tate (34) lists these additional fossils: Trophon anceps, Lampusia sexcostatus (Tate), Cominella subfilicea, Latirus approximans (Tate); Tate (35): Ancilla orycta (Tate), Terebra mitrellaeformis, Terebra crassa, casts of Cassis textilis; Tate (38): Natica subvarians, Capulus danieli; Tate (39): Rhinoclavis subcalvatus (Tate).

Scaphopoda: Cadulus acuminatus - Tate (33).

Echinoidea: Peronella platymodes (Tate), large species (undet.)

Crustacea: Crab claws are common.

Other fossils as seen in microfossils include Ostracodes. Polyzoa, Brachiopod and Molluscan remains, Sponge spicules and some species of Foraminifera found in Pliocene sands at Maslin Bay come from underlying Pre-Pliocene formations. Sample No. A200 from the yellow basal sands above "Uncle Tom's Cabin" shows small pieces of wood. The occurrence of lignitic material at the top of this formation is discussed under Remarks.

Whilst casts of fossils are common in the lower beds of the formation, fossils are also plentiful and, in particular, Ostrea arenicola, Spondylus spondyloides, Pecten consobrinus, and Chlamys asperrimus antiaustralis are abundant, hence these beds are sometimes referred to as "Oyster Banks."

Contacts: The formation overlies the Pre-Pliocene formations with angular unconformity and is overlain by the ?Pleistocene beds. Where the ?Pleistocene beds directly overlie sands, the upper contact is not always well defined.

Thickness: The maximum thickness by measurement varies from 18 to 20 feet.

Remarks: This formation could possibly be divided into 3 members, viz: (a) Non-marine sands, (b) First Marine beds and (c) Second Marine Limestone, but it has not been possible to verify this hypothesis by research work because of lack of time*. However, the subdivision is based on these pertinent facts: (a) the Sands from north

* See Figure 4.

of Ochre Point to north of Blanche Point are unfossiliferous, they are capped by limonite (?lateritic) to the north and just below the Trig Point they have pebble and gravel bands. Such properties suggest a terrestrial environment. In addition to these may be quoted the occurrence of a silty bed containing lignitic material at the top of Pliocene sands at the sand quarry. It underlies a brown limonitic bed and dark brown green clays which may be Pliocene or ?Pleistocene in age, and overlies a consolidated sandy bed highly perforated by roots. In view of available facts i.e. the limonitic capping to these sands further south, the clay occurring above the sands above "Uncle Tom's Cabin" and pieces of wood from this locality, the lignite band is tentatively classed as Pliocene.

(b) The first marine series includes the lower sands, sandstones and limestones described under Division 3. These are highly fossiliferous and in contrast to the non-marine beds described under (a) above. The sandy clayey bed at the top of these beds may possibly be equivalent to the clays at the top of the non-marine beds above "Uncle Tom's Cabin." Any transition from a non-marine to a marine environment will be seen along the north side of Blanche Point but these beds are inaccessible.

(c) The upper limestone described under Divisions 2 and 3 of Lithology appears to overlie the basal non-marine and marine sands with unconformity. It appears to be approximately uniform in lithological nature and, although assumptions can only be made in general on casts of fossils, the faunal assemblage seems to differ at least in part from the assemblage of the first non-marine beds. The outlier of Pliocene limestone occurring between Bennett's Creek and the Canyon is tentatively placed with this member. It has the same travertinous appearance and is only poorly fossiliferous, casts only having been seen.

The correlation of the Pliocene beds is shown in Figure 4 .

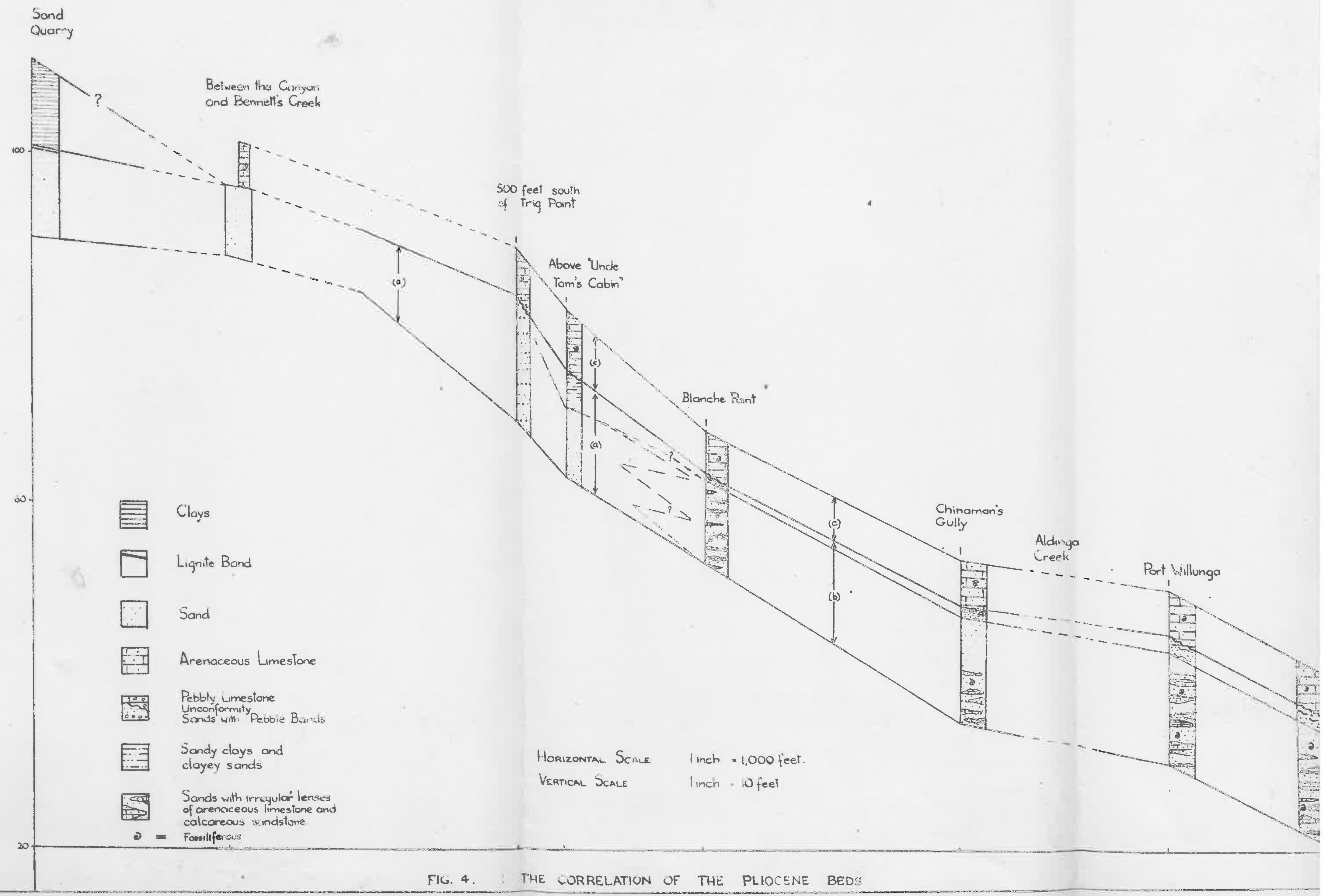


FIG. 4. THE CORRELATION OF THE PLIOCENE BEDS

Unit No. 8: ?Pleistocene and Recent Deposits.

The ?Pleistocene beds are exposed from north of Ochre Point to south of Snapper Point and consist predominantly of red mottled sandy clays overlain by green sandy clays. Boulder and gravel beds were noted in the red beds at Ochre Point but generally the composition of the beds is as described above. South of Blanche Point the lower red beds have been covered by the overlying green beds and are no longer visible. A thickness of 10 feet of brown to green clays underlie the red beds in the northern parts of the succession but it is not certain whether these beds belong to the Pliocene non-marine member or ?Pleistocene. The maximum thickness of the ?Pleistocene beds as measured between the Trig Point and "Uncle Tom's Cabin" is 59 feet, of which the red beds form 39 feet. From Blanche Point to Chinaman's Gully, these beds gradually become thinner but from Port Willunga to Snapper Point they again approach the maximum thickness, and at Snapper Point are approximately 55 feet thick. These beds cannot on available evidence be classed as definite Pleistocene and until further work has been done they are called tentatively ?Pleistocene.

Recent deposits include a thin layer of kunkar, which, in general, is continuous and overlying the ?Pleistocene beds. However, it does overlie other beds as mentioned hereunder in the discussion of the creeks. A thin layer of topsoil is seen in parts of the section, whilst also included under Recent deposits are the aeolian and other deposits which, particularly in the embayments, obscure some parts of the lower beds in the coastal section. The three creeks which traverse the coastal section at the Canyon, Bennett's Creek and Aldinga Creek are believed to have been much deeper at some time between the completion of deposition of the ?Pleistocene beds and Recent times. At the Canyon, in the northern wall, the ?Pleistocene beds are no longer divisible into 2 divisions and seem to have been reworked. The Port Noarlunga and North Maslin sands exposed in the southern wall have likewise, in part, been resorted to form a bed of pebbles and coarse white sand overlain by a conglomeratic deposit with pebbles of limonite and quartzite in sand beds. This formation is in complete contrast to the exposure at the westernmost portions of the southern wall, where the Port Noarlunga Sands are exposed beneath a thickness of approximately 30 feet of North Maslin sands in an unaltered condition. The northern wall shows only the resorted ?Pleistocene beds, and these are overlain by Recent sands which extend to the top of the small hill immediately north, where only small outliers of the kunkar remain above Pliocene and ?Pleistocene deposits. Silicified roots are to be seen in some abundance in these sands.

At Bennett's Creek the ?Pleistocene beds are not to be seen within 150 yards either north or south, and Recent sands and deposits form gradual inclinations on both sides. Just south of Bennett's Creek, the North Maslin sands have been cemented to form a hard rock at the surface. Just north and south of Aldinga Creek the old creek bed may be seen cutting the section. The overlying ?Pleistocene beds have been removed and the thin kunkar layer directly overlies both Pliocene and Pre-Pliocene beds, and in the south it may be seen resting above the fluvial deposits of the former creek. The Pre-Pliocene beds appear to fold downwards beneath these deposits, and this can be accounted for by a slumping of the upper incompetent beds when lower beds have collapsed due to erosional forces. An erosional surface, similar to the type seen south of Snapper Point, was observed just north of Port Willunga at beach level above the fluvial sediments, which are predominantly dark in color and contain pebbles of kunkar which exhibit bedding. Evidences of a submergence of the present coast-line in comparatively Recent times exist in the form of terraces in the vicinity of Bennett's Creek. These consist of boulder and pebble beds which occur above the present beach level associated with deposits of Recent types of shells, including Turbo undulata and the common limpet (Cellana tramoserica.)

On the other hand, these may be storm beaches and such shell deposits may have been formed by wandering tribes of aboriginals who have been known to pass through this vicinity and who leave such remains at their squats. Definite emergence of the coast-line, however, seems probable in view of the stream profiles earlier discussed. Certain terms such as "raised sea-beaches" have been purposely avoided in this discussion and definite conclusions regarding changes in sea-level have not been formed in view of the fact that it has not been possible to carry out the detailed studies as required by Fairbridge and Gill (24).

IV. CONDITIONS OF DEPOSITION

The Port Noarlunga sand deposit is probably a deltaic deposit, the sands being derived from adjacent Pre-Cambrian quartz rich sediments. Gravel and coarse sediments are usually not common in deltaic deposits except where streams flow into a sea or lake directly from uplands under which conditions gravel may become a considerable part of the sediments. Clay bands with and without plant remains and cross-laminations are also suggestive of deltaic deposits under these conditions. The quartz boulders and pebbles at the base of the sands are probably derived from two sources, the more angular being from adjacent Pre-Cambrian uplands and left as relics of an original piedmont deposit, whilst highly polished pebbles have probably been accumulated by the resorting of the underlying ?Permian beds, the till being removed by distributaries to possibly form "bottomset"* beds. Determination of "subaerial" and "subaqueous" "topset" and "foreset" beds has not been possible in view of the relatively small size of this deposit as compared with the large areas usually covered by deltaic deposits, and because it has only been possible to examine this exposure more or less as a vertical section.

There is evidence to suggest that there is a transition between the non-marine sands and the overlying North Maslin

* The terms used in the discussion of deltaic deposits on pages 47-49 and such statements as are made in support of a deltaic environment are taken from Twenhofel "Principles of Sedimentation" 2nd Edition, 1950, pp. 102-118. Such terms and statements have been included in quotation marks.

sands. As already mentioned, there is a brown bed with quartz pebbles 3 feet above the base of the latter, and this is considered as being deposited by terrestrial agents. Twenhofel in his discussion of "sediments of the foreset slope" says: "Certain chemical sediments, such as glauconite, may also form" and in view of the cross-bedding which is in part similar to that exhibited by the Port Noarlunga sands, it is suggested that these beds are closely associated with the deltaic environment. The units formed in the brown sands are however generally more lenticular than those in the white sands. The cross-laminations of the North Maslin sands are produced mainly under a marine environment in contrast to those of the sand quarry deposit. Twenhofel also makes this pertinent statement: "Foreset beds owe their deposition to stream and marine agencies with the former dominating adjacent to areas of distributary currents and the latter over intermediate areas." It has already been proposed that some of the limonitic grains have been formed by the alteration of glauconite, but it is not within the scope of this paper to discuss the formation of the latter mineral, although it seems quite logical to assume in view of available evidence that it was originally formed and deposited in this "foreset" environment. The limonitic bands exposed in cross-laminations are not regarded as of the same origin as the grains formed by alteration of glauconite. They form the capping to units in the lower parts of this formation, and are probably the result of precipitations of colloidal clay and iron oxide, ".....and there may also be much precipitation of colloids of iron oxide and slica where fresh and salt waters mingle." This would also explain their somewhat laminated nature. Mudcracks with the intervening limonite being sometimes curved concavely upwards or peculiarly coiled could be formed in this near-shore environment. Only some of the limonite grains can be accounted for by the alteration of glauconite and the remainder may be attributed to a similar precipitation from colloids, followed by dispersal amongst quartz sands by weak wave or current action. Iron oxides derived from the chocolate shales underlying the Pre-Cambrian quartzites etc. at Ochre Cove could be the source of much of this limonite. At the furthest limits of this formation from the sand quarry, the sands are predominantly limonitic and the limonitic capping is no longer observed. The mingling of fresh and salt waters would be less marked at this distance from the landmass, and the percentage of grains formed from glauconite would be greater in deeper neritic seas. Macrofossils are found mainly in lenses of a light green to purple color and these may be part of the "foreset" environment (Twenhofel states that "Shell matter should be more or less abundant over foreset bottoms, particularly between distributary currents,....").

Erosion occurred before the next group of beds was formed, and a disconformity separates the North Maslin sands and the South Maslin limestones. The latter are richly fossiliferous and are rich at the base in limonite grains derived from the underlying formation, and Polyzoa. The biofacies, mainly benthonic with some planktonic forms, is indicative of a shallow water environment. These are autochthonous limestones which generally have little or no clastic detritus and it is suggested that they were formed in clear water with little wave action. Above the less consolidated limonitic, Polyzoal sands they become very hard, although there are softer pockets of glauconitic clay in the upper parts. Sedentary organisms may have played a major part in the formation of these beds, in which case the limestones could be regarded as a biostrome formation. Whilst little is known about the formation of glauconite, it would seem from the transition of the purely polyzoal limestone to glauconitic limestone that it can be formed gradually without materially changing environmental conditions. However, there must be the addition of material from which such glauconite can be formed, and in the absence of biotite flakes, a commonly suggested source of glauconite, and in view of the composition of the directly overlying marls, it is contended that a certain amount of clay probably in colloidal form has been deposited at the same time as the upper parts of the biostrome were being formed.

As the amount of clay deposited became greater, a new sediment was formed, which was also quite rich in $CaCO_3$, a fair percentage of this being contributed by the tests of micro-organisms, mainly Foraminifera. There is a transition, therefore, from the South Maslin glauconitic limestone to a glauconitic and limey marl, the basal formation of the Blanche Point Marls. Above the transitional marls are hard and soft bands of calcareous, and in part siliceous sediments which are essentially marls in composition. Silica is contributed in the main by sponge spicules, which become comparatively abundant. The sponges which predominated are of the tetractinellid and monactinellid rather than hexactinellid type, and these are generally more common in shallow warmer waters. The tests of Turritella aldingae are plentiful in these and the overlying soft marls, and their abundance is marked in the upper banded marls, where they may be seen deposited at random. One would have expected a set pattern of arrangement for these tests had there been any distinct movement of water. Further evidence for suggesting calm waters is given by the flat nature of exposed surfaces as seen south of Blanche Point, and also by the discovery of paired Lamellibranch valves and an Echinoid with some spines still attached. There seems to be little change in the conditions of deposition from the earlier deposition of the Polyzoal limestone to the final stages of deposition of the Blanche Point Marls, the marine environmental conditions of relatively shallow clear waters, with little movement persisting throughout. Parr, as mentioned by Dr. Glaessner (19) found that "all the beds at Port Willunga and Maslin Bay were laid down in much shallower water than the Brown's Creek and Hamilton Creek beds... In all of the samples I have looked at there is an almost complete absence of pelagic forms and species of the Polymorphinidae are very common." However, the height of sea level relative to the base level of deposition may have become slightly greater during the deposition of the Limopsis bed at the top of the Soft Marls.

Here Foraminifera are not abundant and are relatively very small, whilst large numbers of Limopsis are found with Chione, some Turritella and other molluscs, the pellets of such being abundant. This distinctive biofacies found only in this horizon is thought to represent a different environment.

Following the marine phase, there are beds which have been deposited under a terrestrial environment. An erosion surface may have existed as previously explained by the presence of white nodules at the top of the marls and the second non-marine series is generally unfossiliferous, such fossils as are found being few in number and probably derived from the underlying formation, i.e. remanie fossils. This formation, the Chinaman's Gully Beds, is variously colored from grey-blue silts to red and brown clayey gritty beds, it is in part cross-bedded and shows Liesegang rings. These deposits also resemble a small deltaic deposit formed under arid conditions, the last mentioned property being caused by diffusion within the beds at a later date. This formation is only 5 feet thick and overlain by the Port Willunga Beds. The base of these latter beds consists of a green bed 1½ feet thick, rich in arenaceous Foraminifera and with some limonitic grains. The faunalassemblage is peculiar and may possibly represent a brackish water facies. The environment thereafter is again marine and whilst the faunal assemblage and the nature of the sediments indicate shallow water conditions, there is evidence to suggest that these deposits were more affected by wave and current action, due to the fact that the tops of beds seem to be frequently levelled by erosion. Cross-bedding is common, Polyzoal remains being commonly prominent in cross-bedded sediments. Foraminifera are mainly shallow water types, and some types such as Planorbulina appear to be adapted to attachment, being characterised by flat or concave surfaces.

The beds described above belong to the Pre-Pliocene formations and have a slight dip generally less than 3^{o} in directions, which although variable are, with the exception of the base of the Port Noarlunga Sands Limited quarry, confined to a south-west to south-east direction. These beds, originally horizontal, have been tilted by the tectonic movements of late Miocene age.

Pliocene beds have been discussed in some detail, and the conditions of deposition with reasons for the assumptions made are mentioned under Formation 7: Aldinga Bay Limestones and Sands - Remarks. Member (a) consists of lignitic silts, sands and clays deposited under a terrestrial environment, member (b) sands with hard lenses are richly fossiliferous towards the base; these are regarded as Oyster banks by Tate and others, and have been formed under a marine shallow water environment: member (c) is a fossiliferous marine limestone, and indicates that shallow seas extended over this succession at least as far north as the Canyon towards the end of the Tertiary Period. The ?Pleistocene beds are widespread, and whilst they have been obviously deposited under a terrestrial environment, little more can be said concerning conditions of deposition until they have been studied in more detail.

V. STRATIGRAPHIC RELATIONS

1. Some Palaeontological Observations: Some detailed work has been commenced in the study of the Foraminifera from various horizons and some macrofossils have been named, and their ranges throughout the succession noted, but it will not be

TABLE III

SERIES	STAGE		ZONE	SOUTH EASTERN VICTORIA	WESTERN VICTORIA		SOUTH AUSTRALIA: R. MURRAY	SOUTH AUSTRALIA: ADELAIDE
PLIOCENE	UPPER				Werrikooian		Werrikooian ?	(Missing)
	LOWER			Kalimnan			"Upper Murravian"	Dry Creek Sands "Upper Aldingan"
MIOCENE	UPPER	FONTIAN, SARMATIAN	(Not Zoned)	"Mitchellian" and "Cheltenhamian"	(MISSING)			
	MIDDLE	TORTONIAN, HELVETIAN		"Bairnsdalian"	UNCONFORMITY			
	LOWER	BURDIGALIAN	*Austrotrillina howchini*	"Batesfordian" and "Balcombian"		Heytesbury formation	"Middle Murravian"	*Austrotrillina* Beds; Polyzoal Beds of Aldinga Bay
		AQUITANIAN	?*Sherbornina*	"Longfordian"			"Lower Murravian" ?	Red Sands
		CHATTIAN	*Victoriella plecte*	"Janjukian"				*Turritella* Clays and Marls of Aldinga Bay
OLIGOCENE		RUPELIAN	(Not Zoned)	"Anglesean" and Equivalents		Latrobe formation	Lignitic Sands	
		LATTORFIAN						
EOCENE	UPPER		*Hantkenina alabamensis*		Brown's Creek Glauconitic Beds	Wangerrip formation		Glauconitic Marls with *Hantkenina*
	MIDDLE							Glauconite Sand
	LOWER							

possible to draw any conclusions until more work has been done. Hantkenina alabamensis and the significance of its discovery in the basal beds of the Blanche Point North Transitional Marls has already been discussed. Whilst this species has not been found in the samples examined by the author, certain species of the Family Buliminidae seem to be ~~somewhat~~ restricted more particularly in the lower beds, whilst certain Rotalids may after more detailed examination prove to be limited to certain beds. As an example of the latter, Sherbornina (?) is confined to the limits of the Port Willunga Beds. Certain macrofossils have ranges which appear to be ~~somewhat~~ restricted and some of these have been listed in Table II, page 54 .

Fossils not listed in the table but which may prove to be important include: (1) Notostrea lubra, which has been found mainly in fallen blocks, but is probably restricted to the Blanche Point North Transitional Marls and the basal members of the overlying Banded Marls: (2) The Cephalopod Aturia, one only found by Dr. Glaessner 3 feet above the base of the South Maslin Polyzoal Limestone, has not been found elsewhere, but Nautilus remains seem to be common in the Banded Marls; (3) Marginopora vertebralis is found in the marine Pliocene beds, more so in the upper limestone, member (c). An occurrence of interest is in the cross-bedded Polyzoal limestone at the base of the Port Willunga Beds, sample No. A113, where there is an abundance of Barnacle remains, which do not appear elsewhere in the succession.

2. Lithological Considerations: The table which appears in Dr. Glaessner's article (19) has been included in this thesis, Table III, and using the Hantkenina alabamensis Zone as a basis, the division of the Tertiary succession of Aldinga and Maslin Bays is discussed briefly hereunder.

The "Glauconitic Marls with Hantkenina"* are equivalent to my Blanche Point North Transitional Marls Formation, and the beds which underlie this formation are older than Upper Eocene.

* See bottom of p.55.

TABLE II.

Fossils	Group No. 3: Formation A	3: B	4: A	4: B (Members 1-3)	4: B (Members 4-5)	4: C	6	7 (b)	7 (c)	Remarks
Echinolampas posterocrassus	x									Echinoids see p. 25, 26.
Australanthus longianus	x	x								
Eupatagus sp. (a)	x	x								
Chlamys flindersi		x								Lamelli-branchs see p. 26, 29, 32.
Notostrea tatei		x	x	?						
Spondylus sp.				x						
Turritella aldingae				x	x	x				Gastropod see p. 32, 34.
Flabellum distinctum					x					Coral see p. 32.
Lentipecten sp.						x				Lamelli-branchs see p. 34.
Lentipecten cf. hochstetteri						x				
Probeamussium ~~Parvamussium~~ atkinsoni					x	x				
Limopsis ~~insolita~~ chapmani						x				
Ancilla ligata						x				Gastropods see p. 34.
Voluta pagodoides						x				
Trivia avellanoides					x	x				
Pecten eyrei							x			Lamelli-branchs see p. 39, 42.
Pecten cf. consobrinus							x			
Chlamys asperrimus asperrimus							x			
Ostrea arenicola							x	x		
Duncaniaster australiae							x			Echinoids see p. 39.
Linthia compressa							x			
Graphularia senescens							x			Coral see p. 39.
Spondylus spondyloides								x		Lamelli-branchs see p. 42.
Pecten consobrinus								x		
Chlamys asperrimus antiaustralis								x		
Spisula variabilis								?	x	
Peronella platymodes								x		Echinoid see p. 43.

Although the Port Noarlunga Sands are a non-marine formation there is evidence of a transition between them and the overlying North Maslin Sands. Since these latter beds appear to have been eroded before deposition of the overlying South Maslin Limestones, it is suggested that if the North Maslin Sands are to be regarded as Lower Eocene, then the Port Noarlunga Sands must be regarded as basal Tertiary. The South Maslin Limestones pass with transition upwards into the Blanche Point North Transitional Marls and are therefore probably Middle and/or Upper Eocene in age. Conformably above the Transitional Marls are the Blanche Point Banded Marls ("Turritella Marls") and the Blanche Point South Soft Marls ("Turritella Clays of Aldinga Bay").

The former, Dr. Glaessner suggests, are probable equivalents of the "Anglesean" and the latter may be referable to the "Janjukian." In view of the conformable nature of these Formations, these suggestions seem to be justified and will probably be verified as Foraminiferal research proceeds. The Chinaman's Gully Beds ("Red Sands") have been mentioned as possibly overlying an erosional surface, and because there appears to be a transition between them and the overlying Port Willunga Beds ("Polyzoal Beds of Aldinga Bay"), it is suggested that they should be regarded as closer to the ?Sherbornina Zone than to the underlying Marls.

Sherbornina (?) occurs in abundance in both the upper and lower beds of the Port Willunga Beds, and can be placed with certainty when the true position of the ?Sherbornina Zone is established.

The division of the Aldinga Bay Limestones and Sands ("Upper Aldingan") which lie with angular unconformity over the formations discussed into members has already been discussed. Dr. Glaessner places this formation with the "Upper Murravian" in the Lower

* The names used by Dr. Glaessner in the Table are placed in quotation marks to distinguish them from names used by the author.

Pliocene (Kalimnan) and whether the above-mentioned subdivision is justified will not be revealed until all possibilities have been studied in greater detail. Likewise the age of the ?Pleistocene and Recent deposits will remain in doubt until further research work has been completed.

VI. SUMMARY

After a brief review of various attempts to classify the Cainozoic succession of Aldinga and Maslin Bays, which together with a description of Field Work and Scope and Acknowledgements form the Introduction, the General Description of the Pre-Tertiary Basement, Cainozoic Succession, Structure and Physiography is given. Under the section on Stratigraphic Observations, the Succession is divided into 8 units, with appropriate subdivisions, and these are discussed in detail, with descriptions of Exposure, Lithology, Fauna, Contacts and Thickness. These units are listed under Table I, and although they are lithological units, the separation of them has necessitated some consideration being given to the faunal assemblages which they contain.

After a consideration of the conditions of Deposition, the Stratigraphic Relations are reviewed, with both palaeontological and lithological observations.

Whilst careful analysis of the ranges of all fossils has not been completed, it seems likely that major breaks in lithology will closely approximate the more prominent changes which are expected to emanate from such analysis.

This thesis is submitted with the hope that it will form a basis for the establishment of a standard section of Cainozoic beds, and that it may be used in both local and regional correlations.

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Scaphopoda: see also (31)

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(50) Cotton, B. C., and Ludbrook, N.H., 1938. "Recent and Fossil Species of the Scaphopod genus Dentalium in South Australia", Ibid., 62 (2), pp. 217-228.

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Plants: see (14)

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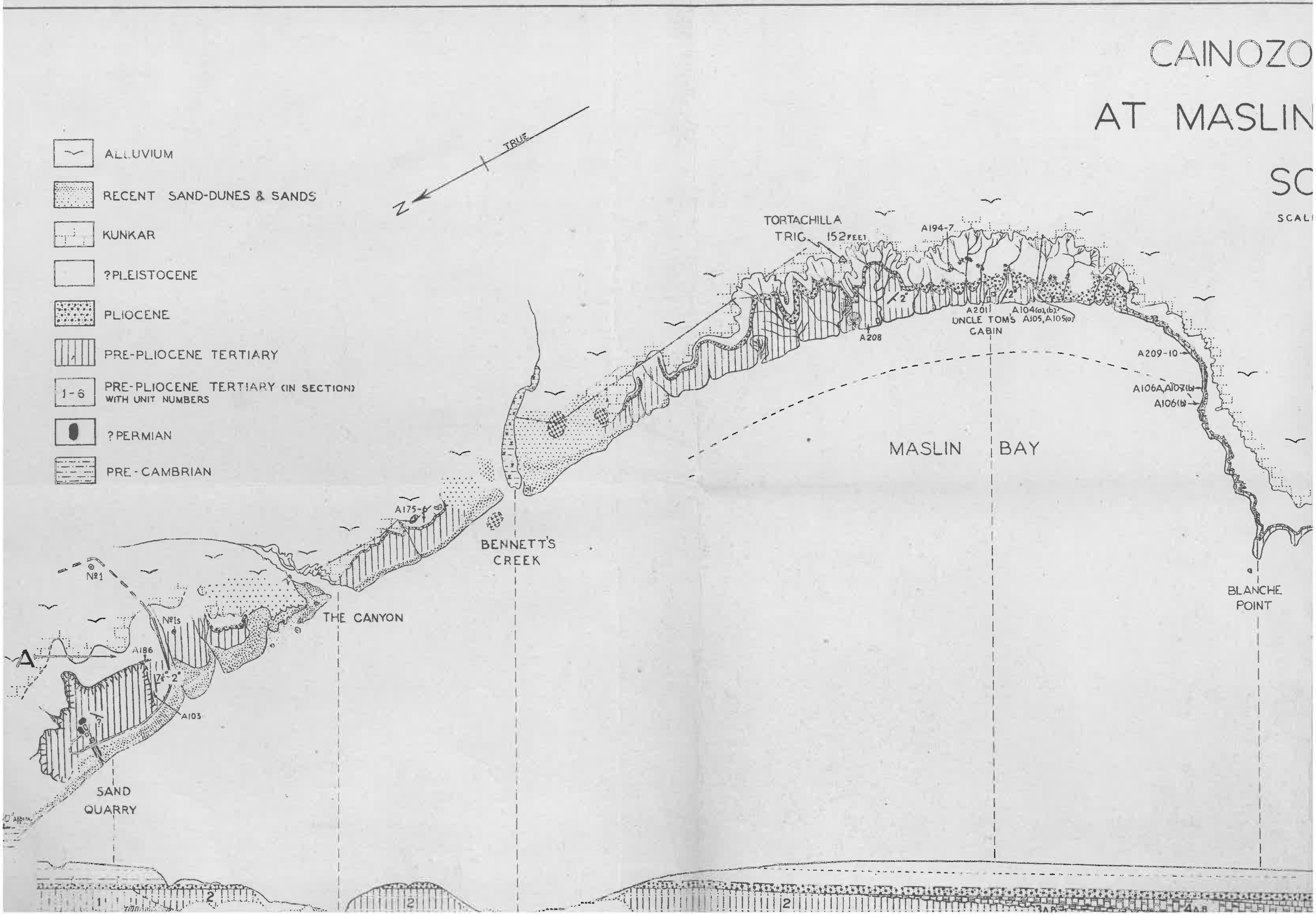
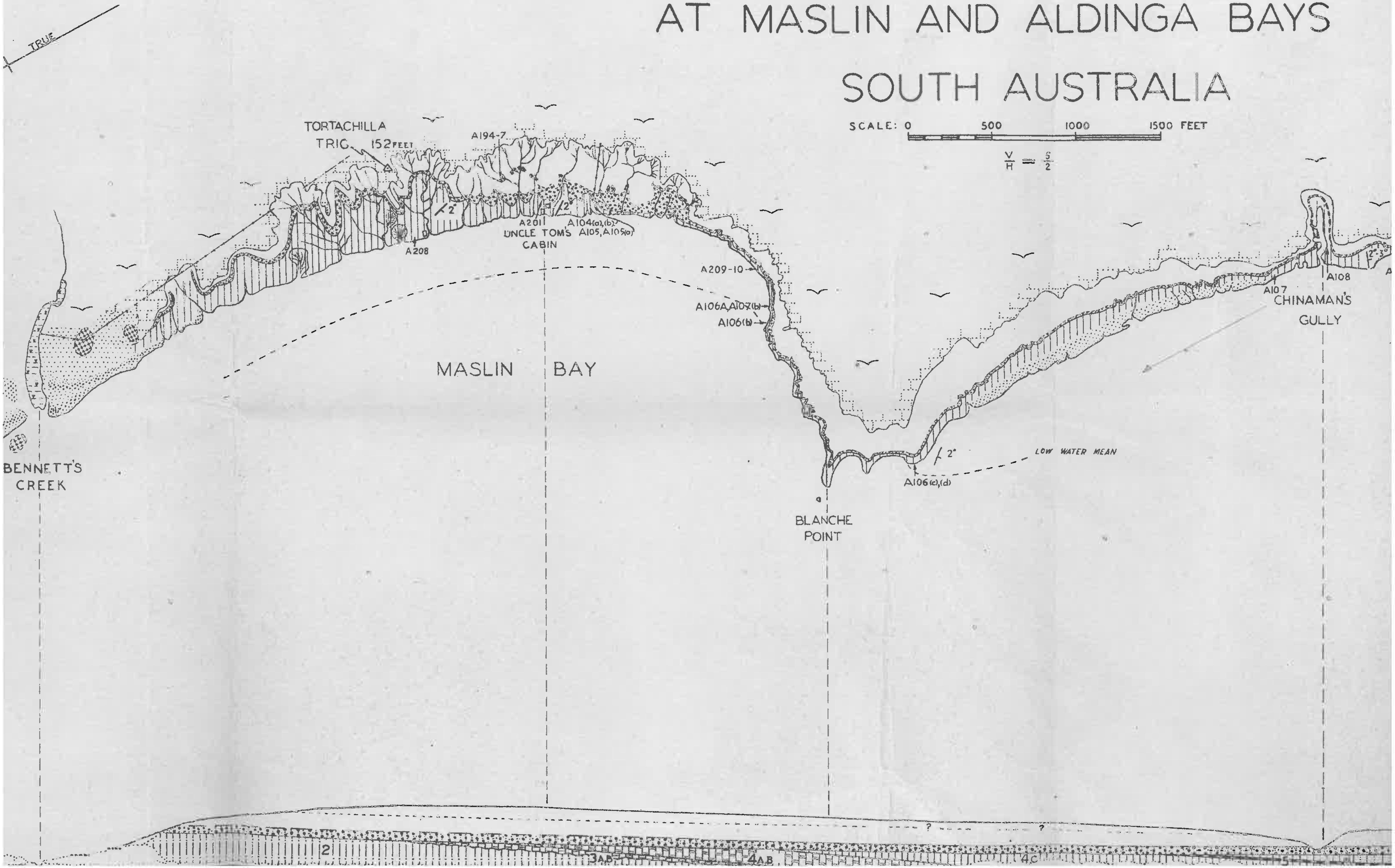
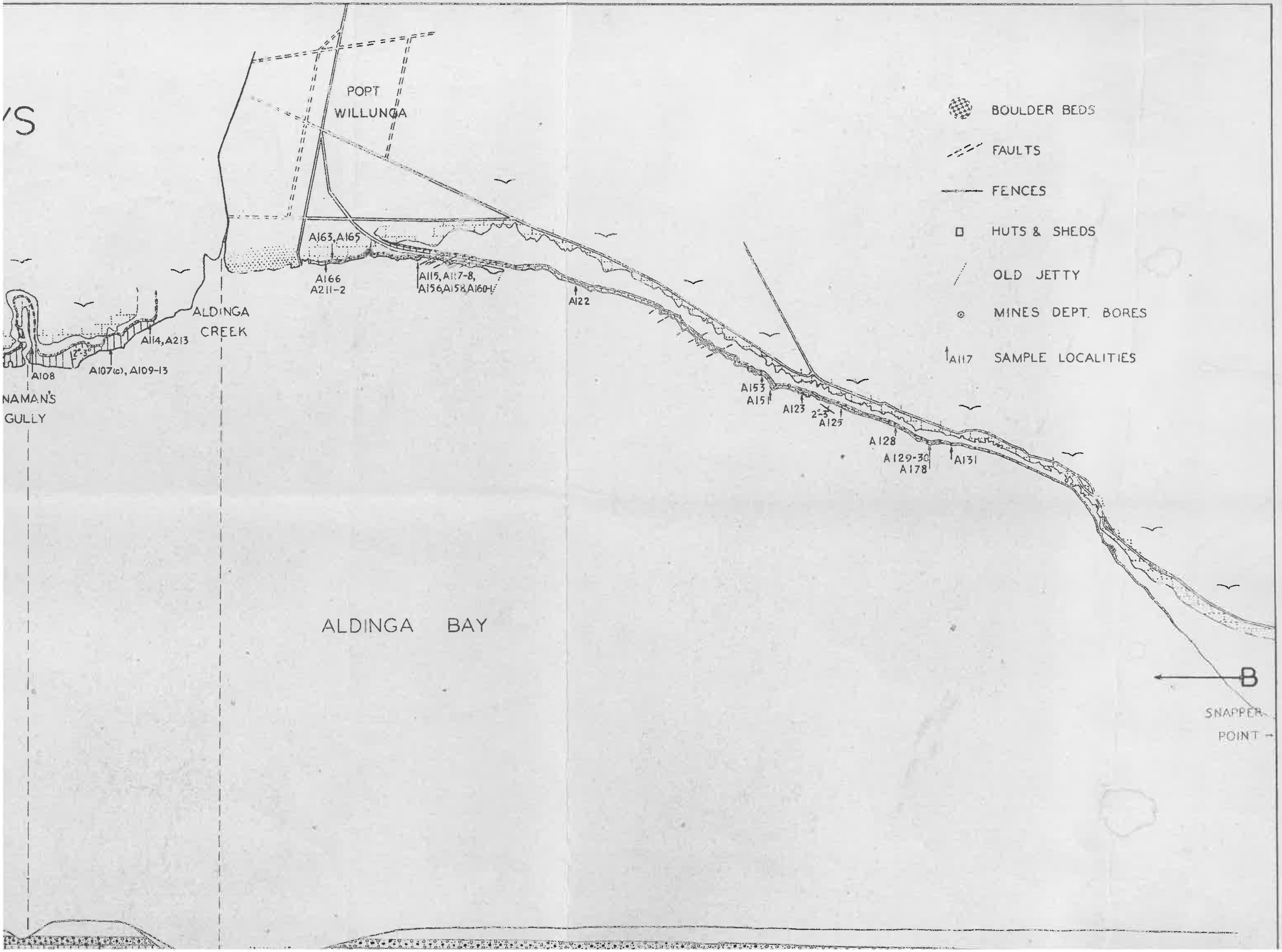

CAINOZO
AT MASLIN
SC
SCAL
ALLUVIUM
RECENT SAND-DUNES & SANDS
KUNKAR
?PLEISTOCENE
PLIOCENE
PRE-PLIOCENE TERTIARY
1-6
PRE-PLIOCENE TERTIARY (IN SECTION) WITH UNIT NUMBERS
?PERMIAN
PRE-CAMBRIAN
TRUE
N
TORTACHILLA
TRIG. 152 FEET
A194-7
A208
A201
A104(a),(b)
UNCLE TOM'S
A105,A105(a)
CABIN
A209-10
A106A,A107(b)
A106(b)
MASLIN BAY
A175-6
BENNETT'S
CREEK
BLANCHE
POINT
№1
№1s
THE CANYON
A186
A
A103
SAND
QUARRY

CAINOZOIC SUCCESSION AT MASLIN AND ALDINGA BAYS SOUTH AUSTRALIA





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BOULDER BEDS
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MINES DEPT. BORES
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A211-2
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A156, A158, A160-1
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A114, A213
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A128
A129-30
A178
A131
ALDINGA BAY
B
SNAPPER
POINT