DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

REPT.BK.NO. 87/43

PETROLOGICAL EXAMINATION OF QUATERNARY COASTAL SEDIMENTS FROM WESTERN SOUTH AUSTRALIA BETWEEN HEAD OF THE BIGHT AND SHERINGA LAGOON

GEOLOGICAL SURVEY

by

M.G. FARRAND

and

A.P. BELPERIO
REGIONAL GEOLOGY

FEBRUARY, 1987

DME.454/82

CONTENTS

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

REPT.BK.NO. 87/43
DME. NO. 454/82
DISK NO. 38

SADME Pet. Rept. 11/84
1:100 000 Sheets 5135, 5334, 5433,
5533, 5633, 5831, 5830, 5930.

PETROLOGICAL EXAMINATION OF QUATERNARY COASTAL SEDIMENTS FROM WESTERN SOUTH AUSTRALIA BETWEEN HEAD OF THE BIGHT AND SHERINGA LAGOON

ABSTRACT

Forty nine specimens of calcareous sediments from the Bridgewater, Glanville and St Kilda Formations collected along the west coast of Eyre Peninsula were examined in thin section. Factors such as the extent of recrystallisation and the ratio of calcium and magnesium in framework and matrix material are assessed as indicators of relative age. Four of the samples were analysed by XRD to check mineralogical interpretations and two samples were analysed for sylvite content. It is concluded that some lithological and pedological features may be misleading and that field relationships are a more reliable indicator of age.

INTRODUCTION

An investigation in hand specimen and thin section was made of forty nine coastal sediment samples, mainly of Late Pleistocene and Holocene age. The specimens were mostly lithified and partially lithified calcarenites and shelly calcarenites that have undergone varying degrees of calcretization. They were collected from coastal environments between Sheringa Lagoon, south of Elliston, and Head of the Bight in the far west of South Australia (Figures 1-4). Most specimens are from the Bridgewater or Glanville Formations, but a few are of Holocene age or are reworked lithoclasts from Holocene strata. One Tertiary specimen is included.

The specimens had been impregnated with an epoxy resin and treated with a dye, alizarin red. The uptake of the resin varied widely as there were great differences in the porosity of the sediments. The dye distinguishes calcite from other carbonates but the relationship between calcium content and the intensity of

the red colouration of the carbonate is only reliable if care has been taken to standardise the conditions of preparing the dye and treating the sample. In theory, non ferroan and ferroan calcite and argonite stain pink to red-brown, whilst dolomite remains largely unstained.

Attention has been paid to evidence of grain alteration, cementation and calcretization, particularly to the number and intensity of episodes of dissolution and precipitation of carbonate. Calcretization is a pedogenic, diagenetic process that alters the original sedimentary characteristics and produces overprinting textures and fabrics, including grain calcitization and micritization, caliche peloids, pisoids and microids, calcrete nodules and laminar carbonate crusts. Calcitization is the conversion of aragonite to calcite. Micritization is the process of grain diminution and degradation that destroys a primary skeletal structure. Petrological terminology follows Bathurst (1975) and Tucker (1981), and caliche (calcrete) terminology follows Peryt (1983) and Esteban & Klappa (1983). In addition, the mineralogy of four samples was analysed by X-ray diffractometry and results are presented as whole rock, normalised, peak height ratios. Two samples (5633 RS 40A, 40B) were analyzed for potassium and sodium contents. Identification of molluscs is based on Ludbrook (1984).

PETROGRAPHY

Specimen 5135 RS 6A, TS C42539
Locality Yalata Swamp
Rock name Calcarenite: Upper Bridgewater Formation
Field relationship Outcrop (S91)
Hand specimen

The specimen is a moderately sorted, medium grained, calcarenite. A light brown, laminated crust envelops the outside of the specimen (case hardening) and is up to 5 mm thick. The matrix consists of creamy white micritic carbonate and the granular component consists mainly of fragments of skeletal carbonate, generally brown in colour, about 0.5 mm to 1.0 mm across. Rhizoliths are evident and a lichen community is developed on the exposed surface.

Thin section

Main features

The specimen is composed predominantly of skeletal fragments, mostly with micritic rinds, and minor silicate grains in a matrix of micritic carbonate. The rock is matrix-supported but layers of micrite between grains are sometimes very thin. A rhizolith structure within the specimen is distinguished by its colour (darker brown) and by floating texture and corroded grains. The granular component is similar to that of the remaining specimen. Grain dissolution is obvious in the poorly laminated micrite crust. This laminated crust may be due to the endolithic lichen, though this sample lacks any diagnostic structure.

Grains

The granular component is moderately well-sorted and consists of a wide variety of clasts. The most abundant forms are light brown clasts of calcareous red algae showing good preservation of cellular structure (?Goniolithon, Lithothamnium, Jania), mostly micrite-walled miliolid and rotaliid foraminifera, more coarsely crystalline molluscan fragments, and echinoid fragments showing uniaxial extinction. The algal and bivalve fragments are generally well rounded but many of the forams are virtually unabraded, although some are recrystallised. Thin micrite rinds are ubiquitous around most clastic grains. The rinds are generally in sharp contact with the enveloped grain, and are thus accretionary and due to caliche processes rather than to marine endolithic algae (which are also present). A few aggregate grains are present, as are some dark brown, structureless caliche peloids. Angular to rounded quartz grains are common and some show marginal embayment. Other constituents present as a few grains include bryozoa, echinoid spines, single carbonate grains, some as zoned crystals, microcline, oolitic forms with up to seven concentric layers, and amorphous silica.

The carbonate which is clear enough for a stain from alizarin red to be seen varies betwen colourless to medium pink. Single crystals often appear to be dolomitic while the majority of shell fragments appear to contain substantial

magnesium. However, the validity of this type of compositional determination depends on the reproducibility of the staining procedure and is an unknown factor.

Matrix

The matrix is a substantial component of the rock and consists of fine, micritic carbonate. It is unstained by alizarin red but round the laminated crust and within the rhizomorph it is stained brown, probably by iron oxide. A deeply stained rim round the margin of the rhizomorph appears to be in the host rock suggesting a cavity that later filled with carbonate sand. Amorphous, fine organic material is disseminated throughout the matrix.

The majority of grains are matrix supported and only a few are in contact at one or more points. Most grains are coated with a brown micritic rind, the thickness of which varies from grain to grain. This carbonate is quite distinct from the matrix and was probably acquired when the grains were loose.

Cement

For the sediment as a whole, the matrix is the cement. There is no evidence of a second form of lithification. However, some individual grains, particularly chambered foraminifera, include a coarser grained, sparry carbonate as a complete or partial filling of open cavities. This may have been a post-lithification process.

Dissolution processes

Individual grains show only rare evidence of chemical corrosion as opposed to abrasional rounding. In the rock as a whole a few small, irregular cavities remain and are probably the product of post-lithification dissolution, possibly by meteoric water. The rhizomorph structure is an early feature as it is filled by material identical to that of the rest of the sediment.

Petrogenetic affinity

The sediment is lithified and the major part of the clastic component consists of skeletal material that has suffered little alteration. Only one significant episode of cementation appears to have taken place although minor differences in the abrasion and recrystallisation of some clasts suggests that some of the detritus may have been recycled from earlier deposits.

The microscopic evidence of calcretization is the thin coating of micritic, iron-stained, laminated carbonate on the surface of the sample, the coated grains (microids and pisoids) and partial micritization of some skeletal clasts. It seems likely that the sediment has undergone only one major cycle of pedogenesis, in agreement with its deduced Late Pleistocene age. The abundance of micritic matrix suggests deposition in a mixed back-barrier environment rather than subaerial deposition as a dune.

Specimen 5135 RS 6B, TS42540
Locality Yalata Swamp
Rock Name Calcarenite: Upper Bridgewater Formation
Field relationship Outcrop (S91 duplicate)
Hand specimen

This specimen was collected adjacent to specimen 6A, and has a more substantial coating of laminated micrite. The outermost zone is leached of the dominant brown stain. Intersecting joints have provided access for solutions which have modified the lithology. The marginal micrite is evidence of incipient calcretization.

Thin section
Main features

The lithology of specimen 6B is essentially similar to that of 6A but post-lithification processes of calcretization, dissolution and replacement in a pedogenic environment have played a proportionately more important role in this duplicate specimen.

Grains, matrix and cement

There is no significant difference in the major rock-forming components in the two specimens from locality 6. The difference lies in the degree of lithification and calcretization. The samples were collected less than one metre apart.

The greater influence of caliche processes is evident in four respects; the deposition of a thick surface layer of laminated micrite, embayment and rounding of grains within a more abundant matrix, the greater penetration of the sediment by oxidised iron and the frequent occurrence of irregular cavities within the specimen, with substantial removal of matrix between surrounding grains.

The surface coating of the specimen is layered partly by variation in the density of iron staining, including an outer zone from which iron has been leached completely, and partly by the inclusion in some bands of granular material. Grains are predominantly of quartz but a few carbonates are also present and include both staining and non-staining types. Irregular patches and layers of iron-stained faunal hyphae of endolithic lichen also accentuate the banding. The clasts are finer grained than those of the main lithology and are separated by substantial areas of micritic matrix. Vague outlines of granular shapes within the matrix, embayments and rounded outlines of the visible grains, together with the predominance of quartz, suggest that the micrite has been emplaced as much by corrosion of detrital material as by direct precipitation.

The processes of embayment and rounding of detrital grains and of producing a more expanded matrix extend from the layered surface coating into the main mass of the calcarenite, as does the oxidised iron stain. Brown stains of oxidised iron have penetrated most completely the micrite coatings surrounding most clastic grains.

Dissolution Processes

Solution cavities are a few grains across, of irregular shape and widely distributed. They are frequently the centre of a wide area in which enough matrix has been dissolved to create interstitial cavities but not enough to release the grains

completely. As in specimen 6A, a few cavities remain inside chambered foraminifera but these are the result of incomplete filling rather than the dissolution of existing matrix carbonate.

Petrogenetic affinity

The specimen is a Pleistocene calcarenite in which incipient calcretization and micritization have affected the fabric to a greater extent than they did in specimen 6A. As with 6A, only one major cycle of sedimentation, lithification, and dissolution appears to be involved.

Specimen 5135 RS 12, TS C42541

Locality Yalata Swamp

Rock name Calcarenite: Upper Bridgewater Formation

Field Relationship: Incipient nodular calcrete layer below 1.40 m of Holocene gypsarenite (VC93).

Hand specimen

The specimen consists of a pale, poorly sorted and fine grained carbonate which is weakly banded and has a weakly defined granular structure. Two areas of this lithology are separated by a flat, slightly darker band in which pale yellow brown grains are more sharply defined.

Thin section

Main features

The banded structure of the specimen is formed by two lithologies. The pale, more massive type consists of poorly-crystalline clotted micrite with a patchy, irregular structure which includes a few unaltered quartz and carbonate grains and frequent faint traces of former carbonate grains now completely replaced. Corroded quartz grains and floating texture are also characteristic.

The darker band is composed largely of quartz, carbonate and feldspar grains with less micritic matrix. The grains for the most part are strongly abraded but a few unbroken forams are preserved. Most carbonate and some quartz grains have a well developed accretionary micrite rind (microids) and in many cases the original skeleton is now unrecognisable.

In the transitional lithologies on each side of the darker band a few corroded grains, in which quartzose compositions predominate, remain in a matrix of micrite studded with partly replaced carbonate grains.

Grains

The granular component of the darker band is distinct in four respects from the calcarenite sampled as specimens RS 6A and 6B. The silicate fraction is much more abundant and contains a substantial proportion of feldspar. The carbonate component has stained more deeply with alizarin red and, if the staining technique is reproducible, presumably is a low-magnesian calcite. This may be due to a stronger recrystallisation since organic structures are less pronounced and the abundance of single crystal fragments is higher. Thirdly, the grains, both silicate and carbonate, are finer grained and more strongly rounded than in specimens RS 6A and 6B, apart from a few unbroken forams. Fourthly, accretionary micritic rinds (caliche microids) dominate over skeletal debris micritised by endolithic algae.

In bands in which the grains are scattered or very sparse both the silicate and carbonate fragments are embayed and smoothed. It is possible that most of the rounding of clasts may be chemical rather than physical. Little internal detail remains visible in the carbonate fragments which have been largely merged with the micritic matrix and it may be assumed that recrystallisation has been severe.

Matrix

The layers with more abundant matrix consist of a complex of clotted micrite which represents grain dissolution, illuviation of carbonate and ongoing calcretization. Different patches are distinguished by variation in crystallinity and staining. Some patches are outlined by a concentration of oxide staining, others by meandering and irregular bands of slightly coarser and more translucent carbonate. The material displays few or no consistent optical properties and may be largely amorphous. It is only lightly stained or unstained with alizarin red dye and may be a calcium-poor dolomite if the staining is consistent.

Faint traces of former carbonate grains are still visible and unaltered grains of both silicate and a red-stained carbonate become more abundant adjacent to the highly granular band.

The latter band is matrix-poor although it is still matrix-supported. If the rounding of the grains is partly due to chemical corrosion the band may originally have been clast-supported, with the thin matrix layers interposed later by replacement.

Circular, millimetre-sized rhizoliths are partially infilled with micrite matrix and have a high concentration of disseminated, amorphous organic matter around their circumference.

Cement

There is no cement apart from the micrite of the matrix, although there may be several generations of the latter. The micritic filling of one foram chamber is quite unstained and must be relatively pure dolomite.

Dissolution processes

The poorly crystalline micrite matrix results from a complex interplay of grain alteration, dissolution, disaggregation and illuvation in a pedogenic (caliche) horizon. Specific dissolution events cannot be separately recognised.

Petrogenetic affinity

Both the nature of the clastic fraction and the extent of post-depositional alteration are significantly different in specimens RS 6 and 12, although the samples are only 400 metres apart. The concentration of silicate clasts may be the result of greater dissolution and removal of interstitial and granular carbonate.

The changes apparent in specimen 12 may be considered a simple progression in degree of calcretization from those observed to have taken place in specimens 6B and 6A.

Specimen 5334 RS 8, TS C42542

Locality Fowlers Bay

Rock Type Muddy calcarenite: Glanville Formation

Field Relationship Outcrop (S96), sampled below calcrete cap

Hand specimen

The sediment is largely poorly sorted and medium grained and contains large specimens of entire and often articulated bivalves (Katelysia rhytiphora, Anadara trapezia) and the scallop Chlamys (Equichlamys) bifrons in what must be very close to their life positions. The bivalves retain much of their original ornamentation on valves which remain attached and have clearly been only minimally abraded. The sediment itself is highly porous and friable and consists of grains, mainly of carbonate, in a fine, muddy matrix. Root-mouldic porosity is evident. Most of the sediment dissolves in hydrochloric acid but there is a small residue of quartz grains stained a pale brown and fine, iron-stained clay particles.

Thin section

Main features

Major features are related to the large fossils and to variations in cementation. High porosity appears to be a result of only partial cementation and incipient calcretization, and post-lithification dissolution. Sediment protected by the almost complete closure of the two valves of a bivalve fossil is lighter in colour than the main part of the sediment and is porous due to the scarcity of interstitial matrix. Outside the protected environment the sediment is darker brown and contains many pore spaces greater in diameter than the average grain size.

Other structures distinguishable by variations in colour and porosity, are incipient caliche nodule development, and root moulds.

Grains

Most of the grains are skeletal carbonate, but some quartz is present together with a few grains of plagioclase, microcline, chlorite and muscovite. The grains are well rounded and substantial recrystallisation has obscured diagnostic features of much of the carbonate detritus. Where detail of the organic

fragments is visible the organisms present are coralline algae, bivalves, gastropods, echinoids, foraminifera (including Marginopora vertebralis) and bryozoa. Inorganic carbonate detritus such as accretionary microids are present, but are less common than peloids (micritized former skeletal grains).

Grains may be from several sources and with varying histories of deposition and remobilisation. Many are heavily stained with limonitic oxide and their response to the alizarin red dye is obscured. In grains without iron staining the dye is strongly absorbed and a high calcium content is indicated.

The bivalve fossil seen in section retains an external ornament of spines or thin ridges which has been preserved without appreciable damage, although boring algae have micritized one section of the outer valve.

Matrix

The matrix varies greatly both in abundance and in colour. In some places the sediment consists essentially of micrite with scattered remnants of grains embedded in it. In these areas the micrite is heavily stained with limonite. At the other extreme the sediment is framework-supported with only a little interstitial matrix. This has resulted from differential illuviation and incipient caliche nodule development. Where the colour of the matrix is not obscured it can be seen not to have absorbed the alizarin red dye and on this evidence may be essentially dolomitic. After dissolution in HCl the matrix is seen to contain a little clay. Much of the matrix has been removed by intergranular solutions.

Cement

The matrix again dominates over cement. The only other deposition within the sediment consists of a coarse, sparry carbonate of non-staining composition which is seen in a few chambers of occasional foraminiferal tests.

Dissolution processes

As noted already, porosity is enhanced by dissolution of interstitial matrix in parts of the specimen and by dissolution of both matrix and grains in other parts. Even within those areas marked by strong iron staining in which intergranular solutions have played a significant role, the role has varied between deposition of micrite by replacement of framework and matrix alike and a similar wholesale dissolution of both framework and matrix. The most abundant and coarsest pore system occurs within the same area as the major development of matrix at the expense of framework grains and resembles alveolar texture resulting from millimetre-sized rhizomorphs.

Petrogenetic affinity

The most prominent features distinguishing this specimen from the others examined are the presence of large fossils which have been very little disturbed since they were living organisms. The environment of deposition from field criteria is quite clearly an intertidal flat.

Specimen 5334 RS 9, TS C42543

Locality Fowlers Bay

Rock name Intraclastic calcilutite: St Kilda Formation

Field Relationship Modern supratidal carbonate crust (S98A).

Hand specimen

The specimen is a flat slab of indurated, intraclastic carbonate mudstone with a porous structure and a surficial carbonate crust. Some of the cavities are root tubes and others are solution tubes. Weakly defined bands sub-prallel to the surface represent bedding traces. A diffuse pattern of dark markings on one surface may be composed of manganese oxide.

XRD peak height ratios

Quartz (4%), aragonite (62%), Calcite (17%), high magnesium calcite (17%).

Thin section

Main features

The rock is an intraclastic, poorly sorted sandy mudstone with a wide distribution of diffuse granular shapes and remnant fragments of carbonate and quartz. Much of the material is now massive or with nondescript textures.

Grains

Fine to medium grained corroded remnants of quartz, carbonate, chlorite and mica are assumed to be relics of the former framework of the sediment. Frequent fine platy slivers of calcitic echinoid fragments, with a high birefringence, are preferentially preserved within the matrix. Some carbonate grains are recognisable as fragments of foraminifera, bivalves, echinoids and coralline algae. The poorly-defined peloids are largely of secondary origin. Carbonate grains in which it is possible to see the staining from alazarin red generally show a strong colour but many grains are stained by oxide.

Matrix

Despite the light colour of the hand specimen, the matrix is seen in thin section to be quite heavily impregnated with fine organic residues and limonitic staining. Superimposed on this is a patchy uptake of the red colouration from the alizarin dye, uptake being greater within diffuse peloids. This matrix is assumed to be largely aragonite.

Cement

Matrix and cement are again the same. The only other material which could be referred to as a cement in the sense that it is introduced to the rock as a solution and precipitated in open spaces is manganese oxide. This has been noted as a deposit on a joint face of the hand specimen. In thin section it is visible as a filling of a few small pore spaces and as the latest layer deposited on the internal walls of one of the large tube-shaped cavities. A pendulous, acicular ?aragonite cement is present on the top wall of one cavity.

Dissolution processes

The passage of solutions through the sediment is marked by dissolution as well as precipitation and the substantial porosity of the specimen is probably the result of dissolution. Some of the tubular cavities have been formed by the roots of plants and others by burrowing organisms. There is evidence of gas expansion within the cavities, resulting from summertime heating, further affecting the sediment.

Petrogenetic affinity

The specimen, from field evidence, is quite clearly a Recent deposit, despite the complexity of cementation and alteration. The abundance of aragonite is consistent with lithification in a supratidal environment.

Specimen 5334 RS 10, TS C42544

Locality Fowlers Bay

Rock name Calcarenite: St Kilda Formation

Field Relationship Cemented crust on thin aeolian capping on supratidal flat (S98B).

Hand specimen

The specimen is weakly cemented and the sand grains appear to adhere only at their points of contact, whilst in other parts a white micritic cement fills the interstitial spaces between the yellowish grains, creating a variably but generally very porous rock. Root-mouldic porosity is evident.

XRD peak height ratios

Quartz (5%), aragonite (7%), calcite (38%), low magnesian calcite (48%), high magnesian calcite (2%).

Thin section

Main feature

The major physical variations through the specimen are in the intergranular relationships and the presence or absence of an intergranular cement. In the thin section most of the grains are loosely packed and often in mutual contact at only one to three

points in the plane of section. Since the nodule was coherent even before impregnation with epoxy resin, the grains must adhere at their points of contact. At high magnification, a multiple generation fringe cement of calcite and low magnesian calcite is seen to coat most grains and seal the gap between the grains in contact. At one end of the section a diffuse area is cemented by isopachous, fibrous aragonite which partially fills the intergranular spaces. An incipient crust is evident at the surface of the specimen.

Apart from these differences, the sediment is uniform, without bedding on the scale of the specimen and with well sorted grain size.

Grains

The grains are dominantly skeletal carbonate with foraminifera (Elphidium, Peneroplis, Discorbis and Triloculina spp.) and coralline algae the most abundant forms represented. Bryozoa, mollusc and echinoid debris are other types of skeletal remains. Other carbonate fragments are pelletoids, ooliths and nondescript debris. Minor silicate grains include quartz, microcline, orthoclase, plagioclase, garnet, biotite and tourmaline. A few lithic fragments of earlier sediments are also present.

Matrix

The specimen is a grainstone with little matrix present. A grey-green ?clay rich silty matrix occurs within a few aggregate grains.

Cement

In this largely framework-supported sediment, three types of cement are present.

The grains themselves, almost without exception, are coated with layers of randomly oriented, granular calcite, meniscus cement. This applies to both carbonate and silicate grains, although the colourless cement is thicker, more continuous and better crystallised on the carbonate grains. Also present is a less-common meniscus cement composed of magnesium-poor calcite.

This carbonate is stained red and is too fine grained for individual grains to be distinguishable.

The almost complete lithification of the area at one end of the thin section has been produced by an intergranular and intragranular meniscus cement of accicular aragonite. In one system of bands lining both sides of a moderately large cavity five successive layers of aragonite crystals have grown on to the cavity walls.

The third type of cement is a yellow clay-bearing micrite. This occurs at the sediment surface and has produced an incipient crust. It is an extremely fine grained material and has not absorbed the alizarin red dye. It is cloudy yellow in colour and appears to contain clays of low birefringence as well as extremely fine dolomitic carbonate and possibly some limonitic iron oxide.

Dissolution processes

The accretion of the various cements has occurred with only limited dissolution of the original grains. Small deposits of meniscus cement appear to be continuous with the carbonate of the grains they are cementing and in the area where carbonate cement forms an almost continuous intergranular matrix, the outlines of the carbonate grains are blurred and tend to merge with the matrix carbonate surrounding them. It is reasonable to assume that this implies a dissolution of marginal carbonate material prior to the deposition of the cement.

Petrogenetic affinity

From field evidence there is little doubt that the sediment is Holocene in age and part of the St Kilda Formation. The abundance of unaltered skeletal fragments and the paucity of calcretization and pedogenic alteration are in agreement with the young age.

Specimen 5334 RS 14, TS C42545

Locality Fowlers Bay

Rock name Calcrete Lithoclast: Glanville Formation

Field Relationship Calcreted nodule of Glanville Formation at the base of VC98.

Hand specimen

The specimen is an ovoid nodule composed of fine pale yellow-brown grains in a pale grey matrix. The margin of the nodule is marked by well developed laminations, presumably caused by pedogenesis.

Thin section

Main features

Grains display floating texture in a pervasive micritic matrix. There is some doubt as to whether the sediment was originally framework-supported or matrix-supported. A depositional origin for the matrix appears more likely on the evidence of large foraminiferal tests and bivalve fragments which are very much coarser in grain size than the average of an otherwise well sorted sediment. A shallow marine or lagoonal environment is suggested.

Grains

The identity of many of the grains is uncertain owing to heavy micritization and staining by both limonite and the alizarin red dye. A large proportion of the grains are caliche peloids, but remains of foraminifera, bryozoa, echinoid, red algae and bivalve and gastropod fragments are identifiable. Silicate grains are moderately abundant and include quartz, coarse microcline, plagioclase and hornblende, locally derived from a calcalkaline granitoid.

Most grains, both skeletal and peloidal, have an accretionary rind of orange brown micrite which is sometimes visibly laminated (caliche microids). Because of the heavy iron staining, the composition of the carbonate cannot be determined. Grain cracking is common, with cracks infilled by matrix.

Matrix

The matrix is red brown micrite of too fine a grain size for individual crystals to be distinguished even under the highest magnification. At the margins of the nodule the colour of the micrite is pink from the alizarin dye but the limonite has been leached out. The micrite is massive and contains no carbonate grains. Even the silicate grains have been severely corroded and diminished in size. Around the margins of the nodule, are well developed laminated micrite bands. While some bands are completely without inclusions and may have been deposited by direct precipitation, the inner bands in particular have clearly been deposited by the corrosion and replacement of granular material. Disseminated organic matter is abundant in the laminae, presumably the remains of lichens that colonised the hardpan surface.

Cement

There is no evidence of a cement apart from the micrite of the matrix. The chambers of the large gastropods and forams are filled with the same micrite as the matrix.

Dissolution processes

Most detrital material, including silicate grains, has been corroded to some extent and marginally replaced by matrix. Within the hard-pan laminae the replacement of grains is almost complete.

Petrogenetic affinity

The balance of evidence indicates an original lagoonal or shallow marine origin for the sediment. The sediment underwent pedogenic alteration with development of a caliche profile. Nodules of this calcreted Glanville Formation have since been reworked into basal Holocene marine sediments.

Specimen 5334 RS 19, TS C42546

Locality Fowlers Bay

Rock name Shelly calcarenite. Glanville Formation

Field relationship Outcrop (S99)

Hand specimen

The weathered surface of the specimen is pitted and sculptured into a rugged relief. The surface is rough and porous on a granular scale except where well crystallised carbonate occurs as irregular patches and as joint facings in fractures. A large bivalve (Katelysia scalarina) forms an apparently unbroken fossil in or close to the life position. Root-mouldic porosity is evident.

The cut surface of the specimen has a very patchy appearance due to variations in brown colouration and in porosity. Root moulds and rhizoliths (root casts) are conspicuous.

Thin section

Main features

The patchiness of the cut surface is seen in thin section to be due to variations in cementation, iron staining and porosity. The major part of the sediment is of a rather open fabric with a high interstitial porosity and a light brown colour. Irregular, incipient nodular forms, and rhizoliths, consist of a denser matrix of heavily iron stained micrite with a very coarse solution porosity, giving rise to a well developed alveolar texture. The cavities are often outlined by a layer of isopachous fibrous carbonate with crystals perpendicular to the cavity walls and with a very weakly pink colouration from the alizarin red. Caliche glaebules and corroded grains are more common within the rhizoliths.

Grains

The majority of grains are structureless peloids, caliche microids and altered, micritized bioclasts. Where recognisable, the predominant bioclasts are foraminifera, coralline algae, echinoids and molluscs. Most grains display a well developed micrite rind and varying degree of alteration. The silicate component again consists of quartz, microcline, plagioclase and hornblende.

Matrix

In most of the specimen the matrix is restricted to a fine population of microids and disaggregated micrite. Within the rhizoliths there is a denser, largely continuous matrix. In these areas the matrix displays a clotted micrite fabric of somewhat lighter colour than the heavily iron-stained grains.

Cement

Outside of the rhizoliths, the sediment is grain supported and the spaces between grains are still largely open. Around many of the cavities, both within and outside of the rhizoliths, is a thin, generally isopachous layer of fibrous carbonate. In places, this varies to an irregular, stalactitic or pendulant cement. Cementation may have occurred in a ?seasonally phreatic, meteoric environment. As the carbonate does not stain heavily with the alizarin red dye, it is presumably dolomitic, possibly derived from the magnesium leached out of the granular carbonate.

Dissolution processes

The intragranular cavities of the major part of the sediment indicate that matrix was probably never present. The larger cavities, that make up the alveolar texture within rhizoliths, are of organo-sedimentary origin.

Petrogenetic affinity

The sediment is largely grain supported but only moderately sorted. The presence of large molluscs, though not paired, in outcrop, indicate a moderate energy, sandy intertidal environment.

Specimen 5334 RS 20, TS C42547

Locality Fowlers Bay

Rock name Calcrete lithoclast. Glanville Formation

Field relationship Calcreted nodule of Glanville Formation at the base of core VC100.

Hand specimen

The specimen is a nodule of dense, matrix-rich calcarenite containing large gastropod and bivalve shell fragments. A 3 mm thick, well develmoped and finely laminated micrite crust envelops the sample.

Thin section

Main features

The specimen is matrix rich and heavily stained with limonite and alizarin red. The grains are not sharply defined, dissolution of grains is advanced, and most grains have a thick micrite rind that merges with a similar micritic matrix. However, large shell fragments are enclosed by the fine grained matrix with fine structural features such as spines and ridges well preserved. In the marginal laminated micrite no carbonate grains remain and the quartz grains are very much finer in grain size than the average in the specimen.

Grains

Many of the carbonate grains are in an advanced stage of micritization. Forams and molluscan fragments are the most commonly recognisable forms. Caliche peloids are common. Quartz grains are corroded and comparatively frequent and a few grains of hornblende are present. The bivalve fragments are very much coarser than the average grain size and a few large forams are present. Occasional echinoid fragments are recognisable by their single crystal extinction, despite an advanced stage of micritization.

Matrix

The matrix is abundant and a floating fabric is conspicuous. From the heavy staining with alizarin red it is assumed to be calcite low in magnesium. Microscopic root hair moulds and intergranular cracking pervade the matrix, and in

places, the bioclasts. Amorphous organic matter is dispersed throughout the sample.

Cement

No cement apart from the micrite of the matrix is identifiable.

Dissolution processes

Much of the matrix and the laminated crust has been generated by dissolution and reprecipitation of framework grains in a calcrete profile. No subsequent solution porosity has been produced in this sample.

Petrogenetic affinity

The large molluscan fossils leave no doubt that the sediment was deposited in sub-aqueous marine environment.

Specimen 5334 RS 23, TS C42548

Locality Fowlers Bay

Rock name Muddy, peloidal calcarenite. Upper Bridgewater Formation.

Field relationship Outcrop (S101), 4 m above modern supratidal pan.

Hand specimen

The specimen is a pale creamy brown limestone in which a rather weakly defined granular structure is evident. The specimen also exhibits an apparently weak brecciated texture that has resulted from incipient nodule development. Root moulds are conspicuous and laminated micrite crust development has occurred in one section of the sample.

Thin section

Main feature

The arenitic character of the rock is more evident in thin section than in hand specimen. However, apart from the moderately abundant quartz, most grains have a thick micrite rind and are essentially calcrete microids and peloids, with or

without a nucleus. The specimen is generally well sorted and there are no large fossils present. Incipient nodule development is manifested as darker zones of more clotted peloids and micrite. Some rounded intraformational lithic fragments are also apparent.

Grains

Internal details of the grains are generally erased by micritization and the grain outlines blurred by grain clotting. A few remnants of forams and molluscan fragments are recognisable with some difficulty and a few oolitic forms in the inorganic component. The silicate component consists of moderately abundant quartz and a few hornblende grains. Most grains are nondescript.

Matrix

A fine micritic matrix is abundant and separates the grains and the sediment is now largely matrix-supported. It consists of a micrite with much granular fraction. It probably largely resulted from illuviation of carbonate within a caliche profile. As noted above, the matrix is darker in colour and in greater abundance in some rather poorly defined areas of incipient nodule development. Some root casts are infilled with lighter coloured matrix.

Cement

No distinctive cement is recognisable.

Dissolution processes

There are no obvious solution effects apart from the calcretisation process itself.

Petrogenetic affinity

The sample was probably well sorted (?an aeolian sand) and the grains were probably in contact before micritization and illuviation of carbonate matrix during calcretization.

Specimen 5334 RS 38, TS C42549

Locality Fowlers Bay

Rock name Coquina. Glanville Formation.

Field relationship Sampled from backhoe pit, 1.0 m below surface, and below 30 cm of laminar calcrete (S108).

Hand specimen

The sediment is weakly cemented and consists of an unsorted mixture of whole and broken bivalve and gastropod shells in a friable sandy matrix. Many of the bivalves are unseparated and little disturbed and with the internal cavity often void of sediment. Fine detail on the valves of both bivalves and gastropods are largely preserved. The larger molluscan specimens include Katelysia rhytiphora, K. scalarina, Anapella cycladea, Bulla botanica and Batillaria (Zeacumantus) diemenensis, and the large foraminifera Marginopora vertebralis are also present. An adjacent pit contains abundant large cockles, oysters and scallops and large specimens of Anadara trapezia.

Thin section

Main features

The sediment contains grains from silt to pebble sizes and constitute both bioclastic fragments and reworked caliche pebbles.

Grains

Grain sizes vary between microns and centimetres. Detritus varies from unaltered skeletal elements to fine micritic peloids with and without altered skeletal nuclei, and a few non-carbonate grains of quartz, microcline, plagioclase and hornblende. The microscopic faunal assemblage is dominated by foraminifera and echinoid fragments. Very few grains have accumulated a micritic rind and peloids have resulted from grain micritization rather than accretion of micrite laminae. On the evidence of alizarin staining the carbonate is magnesium-poor. One large lithic fragment is obviously a calcrete clast.

Matrix

Such matrix as is present consists mainly of fine clastic material. It is rare for patches of matrix to fill intergranular spaces without porosity.

Cement

It is cement rather than matrix which holds the sediment together. The cement is widespread but not abundant and of two quite distinctive physical types. Many grains carry a thin coating of finely crystalline, non-staining carbonate which expands to form a sparse meniscus cement where grains are in contact. The second form of cement has not been encountred in these specimens until now. It occurs in open cavities and may bind surfaces not in contact with a weak enough bond to make the sediment coherent but friable. It consists of long threads composed of a core of very fine crystals linked longitudinally with a sheath of slightly coarser crystals growing outwards from the core. In a few pore spaces a mesh of more common simple acicular crystals has developed. The crystals are too fine for optical identification but are probably aragonite.

Dissolution processes

Some dissolution is implicit in the cementation process but much of this carbonate may have infiltrated from above. A few cavities may be due to solution processes but the major open spaces are residual.

Petrogenetic affinity

The field relationship and macroscopic fauna of this sample indicate quite clearly that this is subcrop of Glanville Formation. Environment of deposition is interpreted as a sandy intertidal flat.

Specimen 5433 RS 11, TS C42585

Locality Lake Macdonnell

Rock name Bedded calcarenite. Upper Bridgewater Formation

Field relationship Outcrop (S75B), immediately overlying Glanville Formation and capped by a weakly developed calcrete.

Hand specimen

The specimen is a well sorted, medium grained, bedded calcareous sandstone with a sparse and patchy matrix. It is friable and required thorough imprgnation with epoxy resin.

Thin section

Main feature

The bedding is more prominent in hand specimen than in thin section but can be seen under magnification to consist of the preferred orientation of elongated carbonate clasts. Individual bands are not distinguishable. The most prominent feature of the specimen is the complete absence of matrix.

Grains

The grains are overwhelmingly of skeletal carbonate. Echinoids, coralline algae, bryozoa, forams and molluscs are frequently encountered. Reworked, rounded, skeletal aggregates are also common, and have apparently been reworked out of caliche horizons. Some individual skeletal grains have also obviously been derived from earlier sediments. These are micritized and have infilled chambers and are darker brown in colour. Most grains have been well rounded but recrystallisation has not obscured the organic markings on many fragments and the chemical alteration is less than the physical abrasion.

Quartz is the dominant silicate in a relatively small non-carbonate fraction and only a few grains of microcline, plagioclase and hornblende are present.

Matrix

No matrix is detectable in the specimen.

Cement

Such coherence as the sediment has is provided by a thin layer of clear blocky carbonate cement. It appears to be isopachous although grains only adhere at limited points of contact. There is very little evidence of meniscus cement and interstitial spaces remain open between grains. The chambers of a few foraminifera contain a blocky calcite mosaic. The chambers

of apparently reworked forams are filled with a dense, very fine grained, brown micrite which is quite distinct from the thin cement on the outside of the foraminiferal grain. This is another indication that much of the detritus may have been derived from an earlier sediment in which the matrix may have been similar to the filling of the foram chambers.

Dissolution processes

No evidence of any more dissolution than is implied by the cementation is detectable. The abundant porosity is residual rather than secondary.

Petrogenetic affinity

The sediment is subaerial in deposition and is cemented by solutions probably of vadose origin. Although many of the grains are reworked, the sediment itself from field evidence, is an aeolianite of equivalent or youngr age than the Glanville Formation.

Specimen 5433 RS 12, TS C42586

Locality Lake Macdonnell, Port Le Hunte

Rock name Weakly bedded calcarenite. Upper Bridgewater Formation

Field relationship Outcrop (S76a), immediately overlying ?Ripon Calcrete at 3 m above sea level and 20 m below top of cliff section.

Hand specimen

The specimen is very similar to 5433 RS 11, a well sorted, medium grained, calcareous sandstone, but is less clearly and finely bedded.

Thin section

Main features

Bedding is somewhat more pronounced in this thin section than in RS 11 since, in addition to the alignment of elongated grains, there are two coarser grained bands within the well-sorted specimen.

Grains

Apart from the coarser grain sizes in the two beds and a greater proportion of hornblende to quartz in the small silicate fraction, the grains are the same as in RS 11. The foraminifera from a similar sample from this site are described by Lindsay and Harris (1973) (Sample F4/73).

Matrix, cement and dissolution processes

No major differences are detectable between this specimen and RS 11. Some meniscus-type features are slightly better developed.

Petrogenetic affinity

Both field evidence and the petrogenetic similarities indicate that this sample is equivalent to sample RS11 (aeolianite, younger than or equivalent in age to Glanville Formation).

Specimen 5433 RS 13 TS C42587

Locality Lake Macdonnell, Port Le Hunte

Rock name Calcarenite. Upper Bridgewater Formation

Field relationship Duplicate outcrop to RS12 (S76B), sampled 400 m north of Jetty, just above Ripon Calcrete.

Description

The sediment is very similar to specimen 5433 RS 11 and 12. Respects in which it differs are in somewhat poorer sorting, coarser grains including lithic fragments of earlier calcarenites and of quartzites, and in more abundant feldspars.

Petrogenetic affinity

The presence of reworked lithic fragments of earlier calcarenites of similar type to Lower Bridgewater sediments reinforces the dating of the series of sediments 5433 RS 11, 12 and 12 as Upper Bridgewater Formation.

Specimen 5533 RS 105, TS C42550

Locality Lake Macdonnell

Rock name Calcilutite, St Kilda Formation

Field relationship Supratidal carbonate crust (S74) around margins of modern coastal salina, Lake Bell. Overlies gypsarenite.

Hand specimen

The specimen exhibits a weak and irregular banding which appears at first to be intraclastic, but on closer examination is seen to result from irregular cementation. The banding is distinguished by alterations of pale grey-brown sparry layers and white porcellaneous micrite layers. Yellowish nodular patches form a roughly delineated band at one edge of the specimen.

XRD peak height ratios Quartz (14%), calcite (12%), low magnesian calcite (12%), high magnesian calcite (12%), dolomite (50%).

Thin section

Main features

The banded structure is seen to be formed by alterations of grain-rich and matrix-rich layers. The abundance of grains appears to be controlled more by the extent of replacement by micrite than by initial sedimentation. Areas of micrite contain floating, corroded grains and a clotted peloidal fabric and vary in shape from rounded to lenticular to irregular. Numerous solution cavities of irregular to elongated shape and cracks are both conformable and discordant to the banding. One set of cavities appears to be excavated preferentially along a band of fine brown micrite which was almost certainly emplaced earlier by precipitation from solution.

Grains

Most carbonate grains have been recrystallised to the extent that their original form is now obscure. Some are now distinguishable only as traces in the micrite matrix. A few still retain enough structure to be identifiable as coralline

algae, mollusc, echinoid or foraminifera. Echinoderm fragments are identifiable through their characteristic single crystal extinction.

Fine acicular minerals of high birefringence are scattered through the micritic matrix and are parts of thin layers of molluscan shells, now disintegrated, or are disintegrated fragments of echinoid plates.

Some small, rounded (faecal) pellets are present, although micrite rinds are notably absent from all grains. Silicate grains are partially corroded but are more abundant than carbonate grains because the extent of the corrosion is limited to surface embayment and rounding by dissolution. Quartz is overwhelmingly the most abundant silicate but minor plagioclase, microcline, hornblende and chlorite have been identified.

Matrix

Matrix is abundant and varigated. Grain size, colour, birefringence and stain differ from place to place and indicate compositional variation in iron, clay and calcium contents. In some instances a micritic zone with one type of matrix is clearly broken up and penetrated by another type of micritic matrix. All types of matrix are lower in calcium content than the carbonate grains and the XRD results indicate the composition is largely dolomitic.

Cement

In addition to the matrix, a poorly developed mosaic of fine gypsum cement partially lines cavity walls and silica grains.

Dissolution processes

Dissolution, probably by meteoric solutions, has produced a network of coarse cavities. There is limited interstitial porosity.

Petrogenetic affinity

The high abundance of matrix in the specimen is the result of vadose supratidal dissolution, precipitation and cementation. The traces and relict grains which are still

distinguishable are not in contact and there is no evidence that the sediment was ever framework supported. On this basis the texture is consistent with a low energy, coastal saline lake environment.

Specimen 5533 RS 106A, TS C42651
Locality Tourville Bay
Rock name Shelly, nodular breccia. Glanville Formation or older coastal marine deposit.
Field relationship Outcrop (S59) of 20 cm thick shell bed beneath calcrete cap and 4 m above high water, Nadia Landing.
Hand specimen

The specimen is a very poorly sorted sediment composed of angular and rounded fragments from pebble to silt sizes with a rather weak cement which leaves a large intergranular porosity. The periwinkle Nerita (Melanerita) atramentosa and gastropod Lepsiella flindersi are prominent in hand specimen.

Thin section
Main features

There are three main structural elements in the sediment; the clasts, the granular matrix and the cement.

Grains

The framework grains consist principally of coarse lithic fragments, skeletal debris (bivalve, echinoid, foram, bryozoa, coralline algae) and inorganic accretionary grains. Margins of skeletal grains are etched and bored by endolithic algae. Others are partially micritised. The lithic fragments are reworked, multiple-generation calcrete clasts with a clotted peloidal micrite fabric, lichen structures, floating corroded grains and abundant silicates. Inorganic accretionary grains are found within calcrete nodules and are first-generation caliche microids, usually with a skeletal nucleus. Structureless peloids of smaller size form a large component of the granular matrix. The foraminifera, which are abundant in most of the sediments examined previously, are less abundant in this specimen, and largely occur as components in the calcrete nodules. Some larger

calcitic fragments are remarkably well preserved, particularly fragments of echinoids and bryozoa. By contrast, most of the red algae have been micritized to structureless peloids, some of which retain a diffuse cellular structure.

Matrix

The matrix is granular and occupies only part of the interstitial space between the lithic fragments and skeletal debris. The nature of the grains varies but small caliche peloids dominate. A few of these are miniature ooliths but most are structureless. A few silicate grains, mainly of quartz but occasionally of hornblende, also occupy interstitial positions. Most quartz grains, however, are concentrated within the reworked calcrete nodules.

Cement

Matrix and framework grains are cemented by coatings and threads of unstained, hence dolomitic, carbonate. Dolomite crystals grow outwards from the threads and in palces an almost continuous mass of finely crystalline carbonate results. The interstital spaces between large framework clasts are never completely filled by the combination of matrix and cement and the cement most commonly forms an open network of crystalline threads linking the clasts, together with thin layers of crystalline coatings to the clasts. A pink stained, pendulous, late-stage cement of acicular carbonate is also present around the margins of some lithoclasts.

Dissolution processes

The porosity is residual and no solution effects are observed.

Petrogenetic affinity

The lithology and biota indicate the sediment is a primary marine sediment deposited along an energetic, wave-dominated rocky shoreline. Much of the debris originated as reworked nodules out of an earlier calcrete profile. The paucity of matrix and the high remnant porosity indicates a deposition above the level of permanent water. The rock probably represents the

partially lithified sediment of a storm-built beach ridge above the high water mark. The field relationship indicates this deposit is most likely equivalent to the Glanville Formation. The reworked calcrete nodules are older, being derived from calcreted Lower Bridgewater Formation.

Specimen 5533 RS 106B, TS C42552

Locality Tourville Bay

Rock name Shelly nodular breccia. Glanville Formation

Field relationship Outcrop (S59 duplicate)

Hand specimen

The second specimen of this material contains a large calcrete nodule 7 cm across, within a similar very poorly sorted, shelly limestone breccia.

Thin section

The section consists of a thin band of sediment identical to that described for 5533 RS 106A at the margin of the large calcrete nodule visible in hand specimen.

The margin of the calcrete is strongly banded. The banding is partly the result of varying intensities of limonitic staining, but mostly due to the development of micrite bands within the mass of the calcarenite which was the original sediment. This has produced arenaceous bands alternating with bands of almost continuous micritic carbonate containing only corroded fragments of silicate grains.

Within the nodule, both carbonate and silicate grains are corroded, micritized to varying degrees, and host a rind of carbonate. The sediment, prior to calcretization, was a calcarenite with a well-sorted population of foram, bivalve, coralline alga, echinoid, bryozoa and silicate grains. A pervasive pedogenic dolomite matrix now encapsulates the grains within the nodule.

Petrogenetic affinity

As for sample RS 106A.

Specimen 5533 RS 106C, TS C42553
Locality Tourville Bay
Rock name Shelly nodular breccia. Glanville Formation
Field relationship Outcrop (S59 triplicate)
Hand specimen

The third specimen from this locality is similar to the previous but contains better rounded and smaller calcrete lithoclasts.

Thin section

The breccia matrix, bioclasts and lithoclasts differ little from the two specimens already examined from this locality. The major bioclasts are fragments of red algae, echinoids and the black periwinkle, whilst the calcrete lithoclasts contain a similar altered calcarenite fabric. Greater rounding has occurred, as noted in the hand specimen. Clast in clast structures are visible in some of the calcrete nodules.

Petrogenetic affinity

As for sample 106A.

Specimen 5533 RS 138, TS C42584
Locality Tourville Bay
Rock name Peloidal calcrete. ?Glanville Formation
Field relationship Calcrete at base of core VC78.
Hand specimen

The specimen consists of coarse grained, poorly sorted carbonate detritus including spheroidal lithic fragments up to one centimetre across. The sediment is rather weakly cemented, and has a thin (2 mm) laminar calcrete crust at the surface.

XRD peak height ratios Quartz (17%), K-feldspar (2%), calcite (81%).

Thin section

Main features

The dominant clastic component is inorganic rather than skeletal and consists largely of spheroidal peloids, and caliche microids with a heavily micritized bioclastic core. Large lithoclasts are calcrete nodules reworked from an earlier calcrete profile.

Grains

The skeletal components of the main part of the sediment are abraded and micritized grains in which echinoid, bivalve, coralline algal, bryozoal and foraminiferal forms are occasionally recognisable. Some organic forms are better preserved within the reworked calcrete nodules where they include recognisable gastropods, bivalves and foraminifera.

The main detrital forms are microids and peloids. Microids consist of an abraded and micritized nucleus on to which has been deposited concentric layers of brown micrite. Some of the grains are outwardly oolitic, having resulted from accretion of micritic carbonate rinds, but most are structureless. Peloids are spherical to oblate, structureless grains of micrite that have resulted from complete (or partial) micritization of a skeletal grain. Because of recrystallisation the nature of the nuclei in the most common forms is usually indeterminate. A few grains are composed of sparry carbonate which tends to be magnesium poor on the evidence of alizarin red staining. Most grains are brownish and the depth of staining is obscured but where this is not so the carbonate is of a medium pink colour.

The silicate component is moderately abundant and consists of quartz with minor microcline, plagioclase and hornblende.

Matrix

The sediment contains very little matrix. What may be considered as matrix is a coalescence of the finer peloids. Because of generally poor sorting there is no sharp distinction between matrix and framework. XRD results indicate peloids of all sizes and bioclasts have converted to calcite.

Cement

A very poorly developed accicular carbonate cement has formed around some of the voids.

Dissolution processes

A few solution cavities are evident within and round lithic fragments but the porosity of the sediment as a whole is residual.

Petrogenetic affinity

The original texture and lithology of the sediment has been largely destroyed by the calcreting processes. Its field relationship and the presence of a few larger mollusc fragments in the hand specimen indicate this may be Glanville Formation.

Specimen 5533 RS 148A, TS C42554
Locality Tourville Bay
Rock name Shelly, peloidal calcarenite. Glanville Formation
Field relationship Outcrop (S79) just above present supratidal level.
Hand specimen

The sediment contains large fragments and undamaged skeletons of marine organisms. A thin (5 mm) laminar calcrete crust is developed at the surface.

Thin section
Main features

The sediment is bimodal and poorly sorted, with a coarse bioclastic component and a finer peloidal component. The margin of the nodule is marked by laminar micrite and rhizomorphous solution voids.

Grains

The coarse bioclastic component is dominated by unaltered gastropod and bivalve fragments, and the large foraminifer Marginopora vertebralis. Small gastropods in particular appear to have been incorporated into the sediment with virtually no

skeletal damage and presumably with little transport. Many of the large grains are densely bored by endolithic algae. Tubules are about 8 μm in diameter and up to 200 μm long, and penetrate the unaltered skeleton below a 40 μm thick disaggregated, poorly consolidated micritic layer. The boring algae appear to be modern, related to the supratidal position of the sample. Many of the molluscan remains are deeply stained with alizarin red and must be composed of magnesium poor carbonate. A few bivalve fragments consist of alternating layers of deep red and light pink stained carbonate.

The finer fraction consists of unaltered and partially micritized skeletal organisms and fragments (foraminifera, mollusca, echinoids, algae), single and composite peloids, and silicate grains. Individual peloids often display a remnant cellular structure reminiscent of the coralline alga. These grains (of high magnesian calcite) are apparently more susceptible to micritisation in a vadose, caliche environment.

Silicate grains are not abundant but include quartz, microcline, plagioclase and green material which is either poorly crystalline amphibole or chlorite.

Matrix

The micritic carbonate of the laminated crust is seen to prevade discontinuously down into the main framework of the sediment and begin to form incipient nodules. The laminar crust has a clotted peloidal texture and a few floating and corroded grains. Root-mouldic porosity has developed an incipient alveolar texture. The micritic matrix is too fine grained to distinguish individual crystals and is deeply stained with alizarin red dyke. A second form of matrix is even finer grained and is cloudy with a yellow brown colour. The yellow micrite forms a layer on the surface of the red micrite in open cavities but over large areas the two forms are intimately intergrown. The laminar calcrete also displays alternation of colours.

Cement

A pink-staining, isopachous, sparry calcite cement infills the chambers of some foraminifera. A colourless, isopachous cement is poorly developed around other cavities. It occurs within cavities which have been formed by dissolution processes quite late in the history of the sediment. The solutions involved may be vadose or meteoric.

Dissolution processes

Root-mouldic porosity on a millimetre scale has resulted from previous rhizoliths. Some of the porosity in the sediment occurs within the chambers of gastropods and forams and is almost certainly residual in origin.

Petrogenetic affinity

The sediment was undoubtedly deposited in a lagoonal or low energy embayment. It is quite clearly equivalent to the Glanville Formation, which outcrops discontinuously around the margins of Tourville Bay. Calcitization, grain dissolution, and cementation are late stages in the petrogenetic history of the specimen. Renewed attack by boring algae may result from its present position in the supratidal zone, where the sample is subjected to periodic marine flooding.

Specimen 5533 RS 148B, TS C42555
Locality Tourville Bay
Rock name Shelly, peloidal calcarenite. Glanville Formation
Field relationship Outcrop (S79 duplicate)
Hand specimen

The specimen differs from RS 148A in that incipient calcrete nodule development has protected the bioclastic detritus from calcitization. The skeletal organisms are thus more easily recognized, and consist of bivalve, gastropod, bryozoa, echinoid and foraminifera fragments. Marginopora vertebralis is particularly abundant, but is preferentially micritized and limonite-stained. Clast in clast structures are also present. Endolithic algae and their tubules have penetrated the entire specimen.

Specimen 5533 RS 149, TS C42556

Locality Tourville Bay

Rock name Rhizomorphous, shelly calcarenite. Glanville Formation

Field relationship Bulldozer scrape (S80) of calcreted shelly calcarenite at modern supratidal level. Sampled below calcrete hardpan.

Hand specimen

The sample sectioned is a finer grained lithology from this locality. Macrofossils present but not included in this specimen include Anadara trapezia, Anapella cycladea, Tellina (Macomona) deltoidalis, Katelysia rhytiphora, Katelysia scalarina, Bulla botanica, Cominella eburnea and Niotha pyrrhus. The rock is friable in places due to a very patchy distribution of matrix, and to a prominent root-mouldic porosity and alveolar texture.

Thin section

Main features

The sediment is bimodal, with a few large bioclastic fragments and a major population of fine bioclastic sand. Rhizomorphs, root mouldic porosity and incipient calcrete nodule development are readily apparent.

Grains

The greatest proportion of carbonate grains are rounded bioclasts, micritized to varying degrees. Recognisable skeletons include those of coralline algae, bivalves, gastropods, forams (inc. Maginopora vertbralis) and echinoids. Remnant grains show evidence of intense boring. A minor proportion of grains are completely micritized (peloids) or contain an accretionary micritic rind (microids). Organic structures or relict traces of an organic origin and a few foraminiferal forms are moderately well preserved. Grain sizes do not vary greatly except for occasional large fragments of mollusc shells and a few large forams.

The silicate fraction of the detritus consists mainly of quartz but includes microcline, plagioclase, hornblende and epidote.

Matrix

The distribution of interstitial matrix is patchy. The red-brown micritic rind around altered skeletal grains in places coalesces to form a pseudo-matrix. In addition, a very fine, cloudy yellow, presumably magnesium rich, matrix forms an almost miniscus like cement. Disaggregated, amorphous organic matter is common in cavities and pore spaces.

Cement

A colourless, poorly crystallised, sparry carbonate cement which forms the latest deposit in the walls of cavities is a late stage, post dissolution, introduction. By extension of patchy and thread or ribbon-like growths into the open spaces it further decreases the porosity. However, the absolute abundance of this ?dolomitic material is low.

Dissolution processes

Some grain and matrix dissolution may have added to the residual porosity. Much of the clotted micrite produced by pedogenic alteration appears to have been illuviated lower into the profile.

Petrogenetic affinity

The lithology, fossil content and stratigraphic position of the specimen indicates it is from the Glanville Formation. The better sorting is presumably the result of deposition in more energetic waters. The higher porosity is patchily distributed and has resulted from pedogenetic alteration and dissolution.

Specimen 5633 RS 40A, TS C42557

Locality Tourville Bay

Rock name Shelly calcarenite. Glanville Formation

Field relationship Pit exposure of calcreted shelly calcarenite (S82) at modern supratidal level. Sampled below 1 cm thick laminar calcrete capping.

Hand specimen

The specimen is typical of the Glanville Formation in the combination of coarse skeletal debris, a fine grained matrix, and pedogenic alteration. In this specimen the matrix is stained brown. The specimen is friable and porous and has absorbed a large quantity of impregnating resin. The surface of the specimen includes highly reflecting surfaces, largely cleavage planes, and both straight and curved acicular crystals. This material when scraped off on to a slide is seen to be an isotopic mineral with a refractive index of about 1.5. Crystal forms include cubes and needles with a striated surface and long axes which are often curved. The mineral is highly soluble in water. The mineral is probably a solid solution of halite and sylvite. Chemical analysis was undertaken to determine more precisely the ratio of sodium to potassium (see RS40 B).

Thin section

Main features

The sediment consists of coarse fragments of bivalves and gastropods, coarse lithic fragments, a predominant population of altered finer skeletal grains, and a poorly sorted but generally fine grained matrix. A fairly large proportion of silicate grains is present. The specimen is highly porous and contains a late crystalline cement.

Grains

Large lithic fragments of calcretized calcarenite (reworked calcrete nodules) have been incorporated with large, unaltered, gastropods and bivalve fragments in an otherwise fine to medium grained sediment. The finer fraction consists of coralline algae up to 2 mm in size, foraminifera and echinoid and molluscan fragments. Many grains are heavily micritized or completely altered to caliche peloids. Alteration is accompanied by boring

by algae. Illuviation of matrix and grain alteration has created a clotted texture. The reworked calcrete nodules have only remnant silicate grains in a brown micrite matrix.

The silicate component consists largely of highly angular quartz grains with minor microcline, plagioclase, hornblende and chlorite. The angularity of the grains is as much the result of marginal corrosion and embayment as of physical abrasion. Grain size sorting is very poor.

Matrix

The matrix constitues very fine, limonite stained carbonate illuviated from higher in the pedogenic profile and from in-situ grain alteration.

Cement

A colourless, fine grained dolomite has been deposited in some of the open spaces within the rock. It is widespread as an irregular, blocky crust in the interstitial cavities but does not constitute a complete space filling. It is possible that the evaporite mineral tentatively identified as a mixed halide in the hand specimen may have occupied the remaining space in the porosity before dissolution during the preparation of the thin section. The composition of the halides requires confirmation by chemical analysis.

Petrogenetic affinity

The affinity of the sediment to the Glanville Formation is clear but the nature of the deposit has been modified by grain alteration and illuviation of matrix in a pedogenic profile, and subsequent deposition of dolomitic carbonate, and of a potassium-bearing halide in its present supratidal, vadose environment.

Specimen 5633 RS 40B, TS C42558

Locality Tourville Bay

Rock name Shelly calcarenite. Glanville Formation

Field relationship S82 duplicate sample

Hand specimen

Extremely poor grain size sorting is even more evident in this specimen than in the other from this locality. Large bivalve (Katalysia sp., Tellina sp.) and gastropod (Batillaria (Zeacumantus) diemenensis) shells are held in a fine, rather earthy matrix. In the rock chip cut for the thin section the gastropods display a conspicuous intraparticle porosity. The specimen appears glazed but without deep cavities on the cut surface. The rough surface is covered with the acicular crystals observed in specimen RS 40A and similarly reflecting surfaces as on the cut face give the glazed appearance to the specimen.

The rock must have been immersed in water during the making of the thin section and the present covering of halides is probably the result of the drying out of the specimen and consequent deposition of evaporite minerals on the surface after the making of the thin section. The hand specimen as collected may not have exhibited surface deposition of halides which may have been held within the pores. The outward appearance of the rock is not that of a potential source of evaporite minerals.

Thin section

The section displays the same granular component as RS 40A, including lithic fragments as well as coarse and fine grained skeletal remains (including abundant Marginopora vertebralis) and fine, angular quartz grains. Such matrix as remains consists mainly of fine clasts but the solution porosity appears to be even more pronounced in this specimen than in RS 40A. Micritic matrix is less common and the post-dissolution deposition of dolomite is not as advanced as in RS 40A. It may be speculated that the high porosity, now empty of any mineral filling in the thin section, may originally have contained an even higher halide concentration than specimen RS 40A.

Petrogenetic affinity

The affinity to the Glanville Formation is again clear.

Chemical analysis

Samples RS40A and RS40B were analyzed for extractable sodium, potassium and chloride (AMDEL Report AC 2723/87). The samples were crushed with an iron pestle and mortar to pass a 20 mesh screen. The crushed sample was weighed and heated in 50 ml of distilled water for three hours in a water bath. The liquid was filtered, and the solution and washings made upto 100 ml. Results were:

	Cl%	Na%	K%
5633RS 40A - solution	1.128	0.594	0.0585
- hand specimen	1.889	0.995	0.0980
5633RS 40B - solution	1.230	0.695	0.0330
- hand specimen	2.128	1.202	0.0571

and expressed as atomic weight % :

	Cl	Na	K
5633RS 40A - solution	0.032	0.026	0.0015
- hand specimen	0.053	0.043	0.0025
5633RS 40B - solution	0.035	0.030	0.0008
- hand specimen	0.060	0.052	0.0015

The results indicate that the soluble salt which occupies the pore spaces of specimens 5633RS 40A and 40B is halite with a small potassic component. The salt which coats the cut surfaces of the specimens is disproportionately high in potassium due to the higher solubility of sylvite.

Specimen 5633 RS 45, TS C42559
Locality Tourville Bay
Rock name Calcarenite. Upper Bridgewater Formation
Field relationship Reworked lithoclast in Holocene supratidal to intertidal core (VC84).
Hand specimen

The specimen is a calcarenite with a well sorted granular framework, and a surface mantled with a thin laminar calcrete skin.

Thin section

Main features

The sediment displays an Upper Brigewater Formation affinity in a generally good grain size sorting, in the presence of well-rounded peloids and microids, and in the absence of whole or partly fragmented, coarse skeletal remains.

Grains

The grains are generally of medium sand size but include occasional coarser grained lithic fragments. Alteration has obscured the structure of many of the carbonate grains and reduced them to peloidal forms of indeterminate origin. Peloids have a higher concentraton of microgranular, amorphous organic matter. Caliche microids and pisoids contain a nucleus which may have been skeletal, and an accretionary rind of laminated, micritic carbonate.

Silicate grains are not abundant and consist mainly of quartz with a few fragments of microcline and plagioclase and with green grains which are either poorly crystalline, altered hornblende or incipient chlorite.

Carbonate grains vary in the colour they have absorbed from the alizarin red dye but tend to the calcitic and, in a small proportion, highly calcitic.

Matrix

There appears to be no primary or secondary matrix in this sample.

Cement

The cement is coarse and blocky with crystal sizes to 40 μm, and its distribution is patchy. In composition it varies locally from dolomitic to calcitic. Late-stage dissolution has also affected the cement but tends to be patchy. It has produced an interstitial porosity in two large areas of the thin section.

Petrogenetic affinity

The clastic component of the sediment appears to have been originally developed in an aeolian environment and is probably of Upper Bridgewater Formation affinity. The cement may be related to its present position in the modern intertidal, phreatic zone.

Specimen 5633 RS 46, TS C42560
Locality Tourville Bay
Rock name Calcarenite. Upper Bridgewater Formation
Field relationship Reworked lithoclast in Holocene supratidal to intertidal core (VC84).
Hand specimen

The specimen is an irregular nodule with a very rough and somewhat friable surface. Grains visible at the surface display a high degree of both sphericity and rounding. Reflecting surfaces, either cleavage or growth planes, are seen to be in optical continuity over several millimetres on the surface, particularly the sawn surface of the specimen.

Thin section

The majority of grains are very well rounded, sorting is moderately good and the overall grain size and other characteristics are similar to specimen RS 45. The grains now appear to be cement-supported except where late stage dissolution has produced an extensive porosity.

Grains

Most carbonate grains have been altered to peloids, although recognisable skeletal forms include coralline algae, foraminifera, echinoid and mollusc fragments. Caliche microids, pisoids and reworked calcrete fragments with a composite structure are also common. Most grains are both well rounded and highly spherical. Grain size is generally fine to medium, with a maximum size of 2 mm.

The silicate component is composed of dominant quartz but with a few grains of plagioclase, microcline and a green mineral which is either poorly crystalline hornblende or chlorite.

Matrix

There appears to be little primary or secondary matrix in this sample.

Cement

An acicular to blocky cement similar to that in RS 45 is also developed in this sample. Porosity is related to less complete cementation in this case.

Petrogenetic affinity

The specimen is identical to RS 45.

Specimen 5633 RS 64, TS C42561
Locality Ceduna
Rock name Quartz arenite. Tertiary
Field relationship Outcrop (S58A), wave cut cliff.
Hand specimen

The rock is a well sorted, medium grained, purple, red and yellow mottled, friable quartz sandstone. Occasional large flakes of muscovite are randomly distributed. The texture of the sediment is massive, broken only by fractures and scattered cavities surrounded by sandstone in which the iron staining differs, usually towards a yellow brown, from the prevalent red and purple of the specimen.

Thin section
Main feature

The sediment consists mainly of closely packed, moderately well sorted, angular to rounded quartz grains separated by a cryptocrystalline silicate matrix. The other main constituent is an iron compound in various states of oxidation and hydration.

Grains

Quartz is by far the dominant framework constituent with plagioclase, muscovite and mica the other, minor, clasts. A few grains of quartzitic lithic fragments, zircon and opaque minerals are trace constituents. The shape of the grains appears to be the result of chemical reaction rather than physical abrasion.

Matrix

The optical identification of much of the matrix is uncertain owing to a cryptocrystalline structure. The major part appears to be composed of chalcedonic silica and textural evidence suggests that the margins of quartz grains have been converted to amorphous silica by solutions penetrating grain boundaries. Narrow sutures between areas of chalcedony are marked by thin layers of limonitic oxide and probably indicate the original grain boundaries.

Large patches of cryptocrystalline matrix surround some of the open cavities. Presumably substantial reaction between granular quartz and solutions in the cavities and along grain boundaries resulted in dissolution of crystalline quartz and reprecipitation of silica in an amorphous or cryptocrystalline form.

Some of the intergranular material may be kaolinite rather than chalcedony. The optical evidence is not definitive.

Cement

The cryptocrystalline silica has not acted as a strong cement, possibly because the actual contact between grains is minimised by the interpolation of limonite. Some of the weakness of the cement may be due to the presence of a kaolinitic clay.

Dissolution processes

Minor interstitial cavities have been formed from rhizomorphs.

Petrogenetic affinity

From field evidence, the sediment is of Tertiary age. It forms a continental mantle deposit over Proterozoic bedrock and underlies Bridgewater Formation.

Specimen 5633 RS 65A, TS C42562

Locality Ceduna

Rock name Lithoclastic arenite. Glanville Formation

Field relationship Outcrop (S58B) of shelly bed beneath 20 cm thick calcrete pavement.

Hand specimen

The rock is a very poorly sorted deposit in which large, round, calcrete nodules and coarse shell fragments are held with sandy carbonate and quartz detritus in a micritic carbonate matrix. The coarse shell fragments and abundant matrix indicate a Glanville affinity, and the large, round lithic fragments indicate storm reworking of a caliche profile. The composite sample is capped by a calcrete hardpan. Large shell fragments include the bivalves Amesodesma cuneata and Katelysia sp.

Thin section

Main features

The thin section has sampled a very coarse calcrete nodule and underlying shelly sediment.

Grains

The large calcrete nodule is a composite pisoid with abundant smaller caliche pisoids and microids, very few recognizable carbonate grains, and silicate grains floating in a clotted peloidal micrite matrix. Cracking and dissolution of silicate grains is also apparent. The remaining sediment consists of mollusc, foram and coralline algal fragments, smaller reworked caliche microids, and a patchy micritic matrix.

Matrix

The matrix consists of highly calcitic micrite closely intergrown with yellow micrite. Both these forms also occur as separate patches. Within the calcrete nodules, the matrix is unstained and presumably dolomitic.

Cement

A prominent fracture within the calcrete nodules has a well developed, microstalactitic, acicular aragonite cement. This is presumably a recent feature as the outcrop is subject to seaspray.

Petrogenetic affinity

The specimen is an example of Glanville Formation dominated by reworked lithoclasts rather than skeletal carbonate detritus. The deposit is limited in thickness and occurs as a storm accumulation at the top of a low cliff.

Specimen 5633 RS 65B, TS C42563
Locality Ceduna
Rock name Lithoclastic arenite. Glanville Formation
Field relationship Outcrop (duplicate specimen of S58B).
Hand specimen

The specimen is similar to RS 65A and includes the coarse lithic fragments and bivalve shell fragments of that specimen. Calcrete nodules show good development of accretionary micrite rinds, clast in clast structures and blackened centres.

Thin section

Calrete clasts and pisoids are similar to those in RS 65A. The blackened centres obvious in hand specimen are merely higher concentrations of limonite staining of the micritic carbonate. Skeletal fragments are more abundant and less altered, and silicate material, including quartz, plagioclase, microcline and chlacedonic lithic fragments, are not noticeably corroded. The

outer layers of sediment are cemented by relatively thin coatings of patchy, prismatic dolomite. A high porosity remains between the grains.

Petrogenetic affinity

As for sample RS 65A.

Specimen 5633 RS 67, TS C42562

Locality Smoky Bay

Rock name Calcarenite. Probably Upper Bridgewater Formation

Field relationship Reworked lithoclast in Holocene subtidal core (VC 66).

Hand specimen

The specimen is a pale grey carbonate sandstone with a high content of micritic matrix and a granular component which is mainly mediuim grained and well sorted but which includes scattered grains of much coarser size. The most prominent of these are rounded quartz grains but carbonate grains of similar size are present but less obvious as the margins merge with the matrix. The external appearance of the specimen indicates etching and dissolution in its present, marine phreatic environment.

Thin section

Main features

The sediment is matrix supported but a slightly patchy distribution of matrix leaves some grains in contact. The granular component includes silicate material but is mainly carbonate. More than one generation of carbonate detritus are evident. Sorting is generally good but some substantially coarser grains of both carbonate and silicate, mainly quartz, are present.

Grains

The carbonate detritus is heterogeneous. Many of the skeletal grains are partially or completely altered. The margins of some of these are transitional towards the micritic matrix and the outline of the grain is poorly defined. At the other

extreme, other skeletal fragments are sharply defined and evidence of recrystallisation and alteration is limited, even where boring algae are present. Many carbonate grains are intermediate in alteration between the two extremes. Forams, bryozoa, mollusc and echinoid fragments are recognisable. Reworked skeletal grains and peloids are recognisable by their much stronger alteration and greater limonitic staining.

The silicate grains are mainly quartz but also include microcline, plagioclase, hornblende and epidote.

Matrix

The matrix is somewhat variable in abundance but relatively constant in composition. It consists of a closely intergrown mass of fine grained calcium rich and magnesium rich carbonate. The non-stained carbonate is yellowish in colour. This and a red-stained micrite appear to be the two types of early, probably original, matrix. Borers penetrate both matrix and grains and are a late stage (?modern) feature.

Cement

No secondary cement is apparent aside from the matrix.

Dissolution processes

An interstitial porosity is probably of solution origin and is infrequently and patchily developed throughout the specimen.

Petrogenetic affinity

Despite the abundant matrix, the affinity of the specimen is with the Bridgewater Formation. The detritus was probably derived from the destruction of earlier calcarenites, together with a contribution from carbonate organisms contemporary with the sedimentation. It was subjected to pedogenic alteration after deposition and later dissolution.

Specimen 5633 RS 75, TS C42565

Locality Smoky Bay

Rock name Shelly calcarenite. Glanville Formation

Field relationship Reworked lithoclast at base of Holocene intertidal core (VC 67).

Hand specimen

Large fragments of gastropods and bivalves and large lithic fragments of reworked calcarenites are contained in a very porous, finer grained, sediment. The very high porosity is outlined by the impregnating resin in the hand specimen.

Thin section

Main features

The sediment is distinctly bimodal. The larger skeletal detritus is fresh and little abraded. The fine grained carbonate is more altered. Matrix is virtually absent and cement is not abundant. Porosity is interstitial and extremely high.

Grains

Lithic fragments are few but of extremely coarse grain size. Large gastropod and bivalve fragments are common and are usually broken, but not much abraded or altered. A thin micrite envelope is due to endolithic algae. Enamel coatings and ornamentation are retained on some fragments. At a much smaller grain size, the majority of carbonate grains retain some organic structures. These include coralline algae, foraminifera, echinoid and mollusc fragments. Many grains are peloidal or of indeterminate origin.

Quartz is the most abundant mineral in the small silicate fraction but a few grains of microcline and very few of plagioclase, garnet and epiote are present.

Matrix

Very little matrix remains in the sediment but there is strong evidence that this is the result of dissolution rather than non-deposition. Scattered small patches of the pink and yellow micrite may be found on thorough examination.

Cement

A colourless, fine grained, dolomitic carbonate has been deposited on the surface of all grains exposed in the porosity and also forms a meniscus cement. Needles, threads and compound ribbons of the same carbonate have grown out into open cavities and in places cross them completely. A drusy, sparry calcite infills some foraminiferal tests.

Dissolution processes

On the evidence of a small amount of residual matrix it is suggested that the abundant porosity is secondary and the result of post-lithification dissolution. The matrix was the main material dissolved and most of the porosity is interstitial but larger, irregulr cavities have also been formed and have involved the dissolution of framework grains. The removal of early micrite coatings to grains is common.

Petrogenetic affinity

Despite the absence of a significant matrix the affinity of the specimen is clearly to the Glanville Formation. It is assumed that the abundant porosity was formed at the expense of an equally abundant matrix.

Specimen 5633 RS 77, TS C42566

Locality Smoky Bay

Rock name Shelly calcarenite. Glanville Formation

Field relationship Outcrop (S68) at base of modern intertidal creek.

Hand specimen

The specimen is a pale grey brown powdery rock in which occasional large skeletal organic fragments are enclosed. Apart from these the grains tend to merge with the matrix, probably due to advanced micritisation. The weathered surface of the specimen is etched and heavily bored by algae and larger borers.

Thin section

Main features

The merging of grains and matrix into an almost structureless mass of micritic carbonate is evident in thin section. Only a few gastropod and bivalve fragments are included in the thin section.

Grains

Some of the carbonate grains retain organic structures but most of them are poorly defined due to heavy micritization and to boring by endolithic algae. The silicate fraction consists largely of quartz and quartzose lithic fragments but a few grains of microcline and rare plagioclase and hornblende grains are also present.

Matrix

An organic rich, clotted, peloidal matrix has resulted from merging of altered grains. Development of matrix at the expense of the framework originated in a vadose environment and is continuing in the present intertidal phreatic environment.

Cement

Fine grained but well crystallised carbonte of both pink-stained and non-stained types grows as patchy linings to open cavities.

Dissolution processes

Late-stage interstitial porosity is widespread and scattered cavities of substantially larger size are common.

Petrogenetic affinity

The gastropod and bivalve skeletal material in a finer grained matrix indicate an affinity to the Glanville Formation if primary depositional criteria are taken as diagnostic.

Specimen 5633 RS 113, TS C42567

Locality Smoky Bay

Rock name Shelly calcarenite. Glanville Formation

Field relationship Sub-outcrop (S85), now an extratidal plain.

Hand specimen

The rock is highly porous and contains abundant entire unbroken bivalves (Katelysia scalarina) in a fine grained matrix.

Thin section

Main features

A coarse grained fraction is made up largely of well preserved, entire and broken bivalves and gastropods. The fine grained fraction is largely peloidal and interstitial porosity is high.

Grains

The fine grained fraction includes partially altered coralline algae, echinoids, molluscs and foraminifera. Also abundant are completely altered peloids, and accretionary caliche microids. The silicate fraction consists mainly of quartz but includes microcline and lithic fragments of quartzite and granitoids, with a few grains of hornblende and epidote.

Matrix

There is little matrix except in places where incipient clotting of peloids and incipient caliche nodule development is visible.

Cement

The abundant porosity has only a patchy development of a fringe cement of unstained carbonate which extends threads and ribbons across the open pores.

Dissolution processes

Interstitial porosity is ubiquitous and is due to dissolution and associated caliche microid formation. Linear zones of greater porosity between large molluscs are due to root penetration.

Petrogenetic affinity

The specimen is clearly from the Glanville Formation.

Specimen 5633 RS 114, TS C42568

Locality Smoky Bay

Rock name Bedded calcarenite. Transitional Glanville/Upper Bridgewater Formation

Field relationship Surface sample (S86) of calcreted beach ridge.

Hand specimen

The specimen is a pale, buff coloured calcarenite which has undergone surficial and root-mouldic calcretization. A weak bedding is apparent.

Thin section

Main features

In thin section the oriented fabric is immediately apparent in the preferred orientation of elongated skeletal fragments. This is a bedded fabric, and also reflects some compositional variation between layers. Coarser layers appear to be more susceptible to illuviation of micritic matrix.

Grains

The grains of organic origin are about equally divided between highly abraded and rounded fragments (molluscs, echinoids, coralline algae, bryozoa) and almost undamaged tests of foraminifera. Most grains show little or no evidence of micritization or the formation of accretionary micrite laminae. A significant proportion of grains are reworked, as evidenced by heavy limonitic staining, and these include some lithoclasts and caliche microids.

The silicate fraction is composed of almost equal amounts of quartz and microcline with a few grains of plagioclase and epidote. Some silicate grains are well rounded, others are somewhat angular.

Matrix

Intense micritization has occurred around rhizoliths and root moulds. This clotted micrite matrix does not penetrate far into the sedimentary framework. Fine brown micrite has been illuviated into the coarser layers, but mostly the sediment is grain supported and weakly cemented.

Cement

A patchy development of carbonate cement is present, as threads and ribbons linking grains. Porosity is still high.

Dissolution processes

The absence of a micrite coating on the grains is most likely a primary characteristic of the grains, and subsequent limited calcretization due to sample elevation (beach ridge).

Petrogenetic affinity

The sediment was deposited in an energetic environment that produced an oriented fabric and possible graded bedding. It was probably deposited in shallow water, and field relationships indicate a shoreface/beach ridge environment. Some of the grains have probably been recycled from earlier sediment but much of the detritus is primary skeletal debris. The sediment may be classified as either Glanville Formation (Marine) or Upper Brigewater Formation (coastal aeolianite), the lithology being essentially transitional between the two.

Specimen 5633 RS 116, TS C42569

Locality Smoky Bay

Rock name Shelly calcilutite. Glanville Formation

Field relationship Reworked lithoclast in Holocene intertidal core (VC 87)

Hand specimen

The specimen is a highly porous, irregular nodule with a rubbly appearance. The remains of whole gastropods are recognisable in a fine, dense, white micritic matrix. Most of the cavities were made by boring organisms, although some may be solution cavities.

Thin section

Main features

The coarse debris consists largely of entire gastropods, fragmented bivalves and the foraminifer Marginopora vertebralis. The matrix is a very fine grained and dense micrite which is strongly stained by limonite and by alizarin red dye. It is thus highly calcitic. Large, round cavities are common and are infilled with younger (Holocene) skeletal detritus.

Grains

The coarse gastropod remains are stained pink but appear to be less calcitic than the matrix. Gastropod shells are also distinguished by abundant acicular inclusions in random orientation. The needles are not identifiable optically. The ornamentation of the gastropods is well enouth preserved to indicate that several different forms are present. Some of the shells are filled with micrite, some are partly filled with matrix which may or may not be the same as that of the main part of the sediment and some are open cavities with little or no filling.

Some of the skeletal remains are sharply distinct but others are in the process of being altered and merge with the matrix. Although the latter is dense and almost opaque in places due to the limonite staining, indistinct outlines of completely absorbed skeletal material are often visible.

Some of the cavities contain (Holocene) sand grains of considerably finer grain size than the gastropod debris. The carbonate grains include fresh skeletal debris and reworked grains and peloids.

Silicate grains are not abundant and consist largely of quartz. A few grains of microcline and hornblende are present. The silicate grains occur as highly corroded relics in the matrix and with fine carbonate grains in the pockets of sand in the cavities.

Matrix

The matrix is extremely fine grained and for the most part almost opaque. In places it can be seen to include a minor amount of yellow micrite in close intergrowth but it is mainly composed of red-stained micrite. Matrix within cavities in gastropod shells is often less strongly stained by limonite than the matrix outside the shells. The Holocene sand infilling cavities is framework supported and contains no matrix.

Cement

The Holocene sand infilling cavities contains a poorly developed meniscus cement of pink-stained carbonate.

Dissolution processes

Most of the large cavities in the matrix are the product of boring organisms. Others are produced by intertidal dissolution.

Petrogenetic affinity

Affinity to the Glanville Formation is evident. Quite notable is the degree of alteration that has accompanied Holocene intertidal inundation.

Specimen 5633 RS 129, TS C42570
Locality Smoky Bay
Rock name Lithoclastic calcarenite. Glanville Formation
Field relationship Well, sample (S88) from beneath 30 cm laminar caliche hardpan.
Hand specimen

Coarse molluscan fragments (Katelysia rhytiphora and Batillaria (Zeacumantus) diemenensis) and lithic fragments (calcretes) are contined in a pale to dark brown granular matrix. The skeletal material is broken but not strongly abraded or corroded.

Thin section

Main features

The thin section samples a large calcrete lithoclast and overlying sediment.

Grains

The large molluscan fragments are bored by endolithic algae but remain largely unaltered. Smaller grains are heavily micritized coralline algal fragments and foraminifera, structureless peloids, caliche microids, and reworked calcrete clasts. The reworked calcrete lithoclasts have a clast in clast structure, some with blackened centres, abundant caliche microids, and a clotted micrite texture. First generation clasts have a floating texture of remnant, corroded silicate grains.

Silicate grains include quartz, microcline, plagioclase and epidote.

Matrix

The reworked calcrete lithoclasts have a clotted micrite matrix. The later sediment has a less pervasive, illuviated micrite matrix with greater porosity and greater concentration of amorphous organic matter.

Cement

Original porosity within the calcrete lithoclasts is filled with a pink-stained, drusy carbonate. The later sediment has a poorly developed acicular carbonate cement within pore spaces.

Dissolution processes

Scattered small cavities within both the calcrete lithoclasts and later sediment may be of dissolution origin.

Petrogenetic affinity

This specimen is another example of Glanville Formation dominated by reworked lithoclasts in addition to coarse intertidal skeletal debris.

Specimen 5633 RS 130A, TS C42571

Locality Smoky Bay

Rock name Shelly calcarenite. Glanville Formation

Field relationship Well, sample (S89) of 30 cm thick shell bed beneath 30 cm of laminar and nodular calcrete.

Hand specimen

Large fragments of both bid lithoclasts in addition to coarse intertidal skeletal debris.

Specimen 5633 RS 130A, TS C42571

Locality Smoky Bay

Rock name Shelly calcarenite. Glanville Formation

Field relationship Well, sample (S89) of 30 cm thick shell bed beneath 30 cm of laminar and nodular calcrete.

Hand specimen

Large fragments of both bivalves (Katelysia rhytiphora) and gastropods (Batillaria (Zeacumantus) diemenensis) are contained in a highly porous, weakly cemented, calcareous matrix.

Thin section

Main features

Coarse fragments of molluscan debris, lithic fragments and large foraminifera (Marginopora vertebralis) are contained in a finer granular matrix of altered skeletal carbonate grains. Porosity is ubiquitous, and includes interparticle, intraparticle porosity, and incipient mouldic porosity through preferential dissolution of Marginopora vertebralis.

Grains

Apart from the coarse skeletal debris, the sediment is made up of moderately well sorted peloids and microids. Recognizable skeletal nuclei include foraminifera, echinoids, bryozoa and coralline algae.

The silicate fraction consists mainly of quartz but includes microcline plagioclase, epidote and hornblende.

Matrix

Finer caliche peloids contribute to a patchy matrix. These merge with a poorly crystalline, acicular cement.

Cement

Most grains are coated with threads and ribbons of a poorly-crystalline cement. The friability of the sediment reflects the weakness of this cement. The chambers of foraminifera have a better developed, isopachous fringe of carbonate cement.

Dissolution processes

Macro-porosity within the sample appears due to dissolution associated with root penetration. Dissolution is seen to affect preferentially the larger foraminifer Marginopora vertebralis

Petrogenetic affinity

The specimen is a typical example of Glanville Formation affected by caliche processes.

Specimen 5633 RS 130B, TS C42572
Locality Smoky Bay
Rock name Nodular caliche. Glanville Formation
Field relationship S89 duplicate, nodular calcrete horizon beneath laminar hardpan.
Hand specimen

The specimen differs in outward appearance from 130A in that it is dominated by calcrete nodules and collapse calcrete breccia.

Thin section

The major difference between specimens 130A and B is that alteration of skeletal grains and calcretization (formation of microids, pisoids and nodules) are more advanced. Most skeletal grains are altered to structureless peloids, and in addition most grains and peloids have an accretionary rind of dark brown micrite (microids and pisoids). The finer matrix has been removed from between the peloid and microid framework and is

concentrated in incipient nodules that display a clotted fabric and floating grain texture. The interparticle porosity thus left is substantial in these inter-nodule areas, but is low within the nodules. A poorly crystalline carbonate cement has formed in the interparticle voids.

Petrogenetic affinity

This specimen and RS 130A indicate the variability of alteration that can occur over only a few centimetres, in a calcrete profile.

Specimen 5633 RS 131A, TS C42573
Locality Smoky Bay
Rock name Shelly calcarenite. Glanville Formation
Field relationship Well, sample (S90) of 30 cm thick shell bed below 30 cm of laminar and nodular calcrete.
Hand specimen

The rock is a light brown, coarse grained, pedogenically altered, calcarenite. Some large skeletal fragments of molluscan shells are visible but the sediment is otherwise without structure.

Thin section
Main features

Extensive caliche alteration and remobilisation of components is the most prominent characteristic of the specimen. Even the coarse molluscan remains, which are usually unaltered in the specimens so far examined, are marginally corroded and replaced.

Grains

The skeletal grains that are still recognisable include foraminifera, coralline algae, echinoid and mollusc fragments. Peloids and microids are more common. Silicate grains are relatively coarse and include almost equal amounts of quartz and microcline with minor plagioclase and epidote.

Matrix and Cement

Because of successive episodes of recrystallization the matrix is highly variable. A patchy, clotted peloidal micrite matrix is pervaded by elongate rhizoliths. The cellular patterns of rootlet cell walls are outlined by encrusting calcite crystals, and the outer margins of rootlets are outlined by thin, brown micrite. A pink-stained drusy carbonate cement has also formed around the rootlet walls, and intervening voids are filled with random needle fibres of ?low magnesian calcite. In what must be the least altered parts of the specimen the grains are almost in contact with very little intervening matrix.

Dissolution processes

Dissolution has accompanied vadose pedogenic processes. Evidence of substantial solution porosity is abundant, particularly within rhizomorphs.

Petrogenetic affinity

Extensive recrystallization and alteration has obscured much of the evidence for the original affinity of the specimen. The residual fragments of molluscan shells and the field evidence suggest that the lithology was originally of Glanville affinity.

Specimen 5633 RS 131B, TS C42574

Locality Smoky Bay

Rock name Shelly calcarenite. Glanville Formation

Field relationship Duplicate sample S90

Hand specimen

The specimen is a rusty colour and is more friable than the duplicate, RS 131A.

Thin section

The major difference between this specimen and 131A is a much higher proportion of silicate grains, particularly quartz. A somewhat less prominent difference is that the extent of recrystallisation is slightly less and its distribution somewhat more even. One round patch of more compact calcarenite is

probably a lithic fragment rather than a residual patch of minimal alteration. The darker colour of the hand specimen is seen in thin section to be simply a heavier impregnation of limonite.

Petrogenetic affinity

As for sample RS 131A.

Specimen 5831, RS 59, TS C42575

Locality Venus Bay

Rock name Calcretized arenite. Bridgewater Formation

Field relationship Reworked nodule at base of Holocene intertidal core (VC 120).

Hand specimen

The specimen is a small calcrete nodule of a pale grey brown colour. Close examination reveals that it is granular but the dominant component is a fine micrite. A thin laminar crust is developed on one face.

Thin section

Main features

The dominant component of the section is a dark brown stained, fine grained micrite which is mainly structureless but in places is full of the forms of carbonate grains outlined in limonite. The abundant silicate component consists almost entirely of quartz, and silicate grains are concentrated in a layer immediately beneath a millimeter thick laminar micrite crust.

Grains

The carbonate grains are very largely absorbed into the matrix. A few fragments of molluscs, foraminifera and coralline algae are identifiable but most grains are mere outlines. Apart from a very few feldspar grains the silicate grains are all quartz. Both rounded and angular forms are present but the shape of grains is controlled more by marginal corrosion than physical

abrasion. Round grains are evenly corroded over the whole surface while grains in which corrosion is initiated at separate surface points and is enlarged into embayments are often bounded by sharply angular projections between merging embayments.

Matrix

The matrix is a relatively uniform brown micrite with fine organic matter outlining a clotted peloidal fabric. The margin of the nodule is composed of laminated micrite with a strong red stain.

Cement

The specimen is very sparsely porous and the few cavities are lined with limonite rather than a carbonate cement.

Dissolution processes

Apart from dissolution associated with calcretization, there is evidence of selective dissolution of Marginopora vertebralis.

Petrogenetic affinity

Calcretization has obliterated most evidence of the original sediment, but this specimen is not unlike other specimens of calcreted (?Upper) Bridgewater Formation.

Specimen 5831 RS 60, TS C42576
Locality Venus Bay
Rock name Calcarenite. Upper Bridgewater Formation
Field relationship Cliff outcrop of aeolianite (Sl22A) below 50 cm calcrete cap.
Hand specimen

The specimen is weakly cemented and faintly bedded, but not lithified. The surface is unevenly weathered and accentuates the bedding.

Thin section

Main features

The sediment is composed of well rounded skeletal fragments. There is no matrix and the integrity of the sample is the product of a framework supported structure bonded only at the points of grain contact. Bedding is expressed by a preferred orientation of elongated fragments and very weak grain size changes.

Grains

The grains are strongly stained by alizarin red but are not limonite stained. They consist of abundant foraminifera and coralline algae, together with mollusc, echinoid and bryozoan fragments. Reworked grains are also common and are present as composite grains and limonite stained individuals.

Matrix

The grains are in contact at a few points only and the interstitial porosity is very substantial. The sediment is virtually matrix free.

Cement

Each grain is coated by a very thin (<20 μm), irregular fringe cement of fine grained, unstained carbonate. This occasionally expands to form a meniscus cement and even to occupy part of an interstitial porosity but nowhere forms a continuous matrix. A pink stained, pendulous and meniscus drusy carbonate cement is well developed at the outer surface of the specimens.

Solution processes

There is little evidence of dissolution or caliche processes despite the sample having been collected from less than 1 m below a laminar calcrete crust.

Petrogenetic affinity

The sediment was almost certainly deposited in a coastal dune. Sediment grains originated from primary skeletal debris and from reworking of older calcarenites. Caliche processes have

had little effect at this level of the deposit. Vadose meteoric processes have resulted in weak calcite cementation at grain contacts, and a slightly stronger cementation by drusy calcite on the exposed face of the outcrop. Field criteria confirm this outcrop to be Upper Bridgewater Formation.

Specimen 5831 RS 61, TS C42577

Locality Venus Bay

Rock name Calcretized calcarenite. Lower Bridgewater Formation

Field relationship Cliff outcrop of aeolianite (S122B) below second calcrete horizon.

Hand specimen

The weathered surface displays a prominent nodular structure through differential dissolution. The sawn surface displays an irregular calcrete nodule which encapsulates further nodules that appear to have formed in-situ by calcretization of a calcarenite framework.

Thin section

Main features

The nodular structure is seen in thin section to be produced by variations in the extent of calcretisation as expressed in the density of the matrix. The granular component does not appear to vary except in the extent to which it has been replaced. The laminar micrite zones around nodules are diffuse accretionary features and the nodules are clearly not lithic fragments of earlier calcretes. Skeletal grains within the incipient nodules are slightly less altered than outside the zones.

Grains

Carbonate grains vary from moderately preserved foram tests and mollusc, coralline algae and echinoid fragments, to vague outlines in the matrix. However, grains are dominted by caliche peloids, microids and pisoids, both within and outside the incipient nodule zones. Cracked and solution embayed silicate grains consist mainly of quartz with a few feldspars, often of unidentifiable type.

Matrix and Cement

Within the first generation caliche nodules, the matrix is a dense, fine grained brown micrite that hosts floating silicate grains. Second generation nodules contain a patchy clotted peloidal matrix of similar fine brown micrite. Intervening voids have an irregular fringe cement of stained and unstained carbonate. Outside of the nodule zones, the primary sediment has a matrix of finer, coalescing caliche glaebules and little cement development.

Dissolution processes

The history of grain alteration, dissolution and redeposition in the rock is a complex meteoric process that has lead to redistribution of carbonate in a caliche profile. The residual porosity is vuggy and fabric selective.

Petrogenetic affinity

The absence of coarse molluscan debris identifies an aeolianite (Bridgewater Formation) affinity. The greater degree of calcretization evident in thin section, and the field criteria, indicate with high probability that the rock is older than latest Pleistocene and that the most likely affinity is with the Lower Bridgewater Formation.

Specimen 5831 RS 63, TS C42578
Locality Venus Bay
Rock name Shelly, peloidal calcarenite. Glanville Formation
Field relationship Sub-outcrop (S124) of low calcreted beach ridge.
Hand specimen

The sample is a pedogenically altered, shelly sandstone with larger bivalves and gastropods set in a finer, altered skeletal matrix.

Thin section

Main features

The original skeletal fabric has been strongly modified by pedogenic (caliche) processes. Larger bivalve and gastropod skeletons have been preferentially preserved within micrite envelopes.

Grains

Most of the granular carbonate material now composed of microids with accretionary rinds of micrite. The nuclei are either partially altered skeletons or completely altered peloids. The silicate component is largely of quartz with very few feldspars. Coarse molluscan debris is present but not abundant and has been much less abraded than the majority of grains.

Matrix and Cement

A patchy, illuviated matrix of fine micrite glaebules is present. It merges with a poorly developed, acicular, calcitic meniscus cement.

Dissolution processes

An irregular, interparticle to vuggy porosity has been produced by dissolution of interstitial material but the extent of this process is very much less than in 5831 RS 61. More than one episode of dissolution has occurred.

Petrogenetic affinity

The specimen is an example of Glanville Formation strata that has been substantially altered by pedogenic (caliche) processes.

Specimen 5831 RS 64, TS C42579

Locality Lake Newland

Rock name Shelly calcarenite. Glanville Formation

Field relationship Outcrop (S125) at present supratidal level, capped by 2 cm of calcrete.

Hand specimen

The specimen is a poory sorted mixture of coarse molluscan valves and a finer skeletal matrix. Bivalves include Anadara trapezia, Katelysia rhytiphora, Chlamys (Equichlamys) bifrons and Tellina (Macomona) deltoidalis. Diala lauta is the most abundant of a host of small gastropods.

Thin section

Main features

Large molluscan fragments are well preserved, but the finer skeletal material is variously affected by pedogenic alteration. Variation in the matrix is due partly to extensive dissolution, associated with rhizolith structures.

Grains

Gastropod skeletons have suffered less fragmentation and alteration than other carbonate detritus. Foraminifera, including Marginopora vertebralis, appear to have been more susceptible to dissolution and alteration in this sample. Microids are not well developed, rather micritized grains merge to form a clotted fabric. Silicates are rare and consist almost entirely of quartz.

Matrix

The matrix was originally a very fine grained, dark, limonite stained micrite which also takes a red colour from the alizarin red dye. It appears to have formed in-situ from clotting of peloids rather than by illuviation.

Dissolution processes

A substantial porosity is concentrated along rhizolith structures that pervade the specimen. Dissolution to form vuggy porosity has also concentrated within and adjacent to rhizoliths.

Petrogenetic affinity

Affinity to the Glanville Formation is much clearer in this specimen than in RS 63. There is a sharp distinction in grain size between the matrix and an abundant, lightly fragmented fraction of coarse molluscan shells.

Specimen 5831 RS 70, TS C42580
Locality Lake Newland
Rock name Shelly calcarenite. Glanville Formation
Field relationship Excavation, shelly bed (S127) below 30 cm thick calcrete pavement and overlying another massive calcrete.
Hand specimen

The rock is a medium grained calcarenite with scattered shell fragments of a coarser grain size. Sorting is poor and grain size ranges between very corse and fine sand size. Solution cavities are evident on the weathered surface and the specimen as a whole is rather friable. Large bivalves include Anadara trapezia, Katelysia rhytiphora and Tellina (Macomona) deltoidalis, and the large gastropod Batillaria (Zeacumantus) diemenensis is also abundant.

Thin section
Main features

Observations of a range of grain size made from the hand specimen are confirmed in thin section, where a few gastropods and bivalve shell fragments are substantially coarser than the majority of grains. A few whole forams are present. Interstitial porosity is high.

Grains

Skeletal grains include abundant bivalve and gastropod fragments, abundant foraminifera (including Marginopora vertebralis), and minor coralline algae and echinoid fragments. Also abundant are partially micritised grains and peloids, and a few accretionary microids.

Matrix

Very little matrix is present and what there is consists of finely granular material.

Cement

The specimen has a very high porosity and grains are coated with a pink-stained, irregular fringe cement.

Dissolution processes

The surface of the hand specimen shows large solution cavities, but in thin section the main porosity is intergranular. Despite subsequent deposition of cement, the porosity remains considerable. Some intraparticle porosity has also developed by internal dissolution of skeletal fragments, and by dissolution of remnant skeletal grains within peloids.

Petrogenetic affinity

This specimen is clearly identified as Glanville Formation.

Specimen 5830 RS 24, TS C42581

Locality Elliston

Rock name Peloidal limestone. St Kilda Formation

Field relationship Cemented laminae within Holocene coastal saline lake core (VC 128, 122 cm)

Hand specimen

The rock is thinly bedded, very friable and uniformly fine grained. The strong penetration of epoxy resin indicates a high porosity and this is seen to be controlled by alternating pelletal-rich and cemented micrite-rich laminae.

Thin section

Main features

This lithology has not been encountered in other specimens of this series and consists very simply of spherical to subspherical peloids concentrated in beds separated by thin layers of banded continuous micrite.

Grains

The grains are wholly peloids of apparent faecal pellet origin. They are oval shaped, approximately 500 μm in length, and always composed of red-stained, structureless calcitic micrite with finely dispersed, amorphous organic matter. The continuous bands of micrite display weakly defined sub-spherical domains and were formed by clotting of peloids. Very few skeletal carbonate fragments are present, and only one quartz grain is visible.

Matrix

Virtually no matrix is present, other than the clotted micrite layers formed by coalescence of peloids.

Cement

Peloids are everywhere coated with a regular fringe cement of acicular aragonite. In places the growth from adjacent grains intrlocks and forms the rather weak cement of this very friable rock. Many grains are only in contact at a few points and a few are not in contact with any grains in the plane of the section. At some points radiating clusters of aragonite needles grow without a nucleus.

Dissolution processes

The coalescence of peloids to form micrite laminae may have been accomplished through dissolution and replacement in an intertidal environment.

Petrogenetic affinity

Accumulation of faecal pellets on the windward side of a coastal saline lake has produced a unique peloidal deposit. Incipient intertidal cementation has weakly lithified parts of the sediment, but is still referred to as St Kilda Formation (Holocene coastal marine sediments).

Specimen 5830 RS 25, TS C42582

Locality Elliston

Rock name Shelly calcarenite. Glanville Formation

Field relationship Reworked nodules within Holocene coastal saline lake core (VC 128, 154 cm)

Hand specimen

The specimen is a nodule of coarse grained calcarenite containing broken fragments of molluscan shells.

Thin section

Main features

The majority of the skeletal detritus is well sorted but the rock includes coarse fragments of bivalve shells. Reworked detritus is also obvious by its limonitic staining.

Grains

Recognizable skeletal grains are foraminifera (incl. Marginopora vertebralis), echinoids, molluscs, bryozoa and coralline algae. Peloids and microids, from caliche alteration, are also common. The coarse fragments of molluscan shells appear to be derived from bivalves rather than gastropods. The few silicate grains are of quartz.

Matrix

There is no matrix in the sediment.

Cement

The integrity of the nodule is produced by a dolomitic cement. This consists of a thin surface layer round the grains but, more effectively in terms of cementation, also of a prolific development of threads and ribbons crossing the abundant porosity.

Dissolution processes

It is not clear whether the sediment originally contained a matrix. If so, it was completely removed. If not, the carbonate precipitated as the cement of the nodule was dissolved elsewhere. A considerable porosity remains.

Petrogenetic affinity

The specimen is a reworked fragment of Glanville Formation that is now incorporated into Holocene sediments. The sample itself contains reworked skeletal fragments that are older than Glanville.

Specimen 5930, RS 47, TS C42583
Locality Sheringa
Rock name Chalky calcrete. Bridgewater Formation
Field relationship Calcrete at base of core VC129
Hand specimen

The specimen is extremely friable, powdery and mainly fine grained. A few coarse grains are visible but no consistent structure apart from this is observed.

Thin section
Main features

The main feature of the specimen is the irregular pockets of extreme calcretization, and other pockets of less altered calcarenite.

Grains

The grains within less altered patches include bivalve, echinoid, coralline algal and foraminiferal fragments. They are mostly of fine sand size and are relatively un-micritized, are grain-supported, and are cemented by fine carbonate threads.

Matrix

Within chalky calcretized patches, the sediment consists of clotted peloids and microids, and original skeletal grains are now indeterminate. The boundary with unaltered calcarenite is marked by a thin laminated micrite layer.

Cement

As mentioned, fine threads of a pink-stained carbonate infill most of the intergranular voids within the unaltered calcarenite.

Dissolution processes

Vuggy porosity, presumably related to rhizoliths, is present within the calcretized parts of the sample.

Petrogenetic affinity

The unaltered calcarenite is clearly of Upper Bridgewater Formation affinity. The aeolianite has been affected by pedogenesis and now forms a chalky caliche.

DISCUSSION

Petrographic evidence may be used to indicate an environment of deposition and hence aid in interpreting the affinity and age of a particular sediment. It must be assessed as one of several other lines of evidence, however, and may be of less value than evidence gathered in the field, particularly where environments changed rapidly in both time and space and where evidence of sedimentation is obscured by subsequent alteration and calcretization.

In many sediments examined, the degree of alteration is dependent upon lateral or vertical sampling position within a pedogenic profile, and upon changing groundwater conditions with time (such as coastal deposits that are pedogenically exposed and subsequently re-inundated by a marine transgression). The result is that degree and styles of alteration may change over centimetres and decimetres within the outcrop scale, and change laterally with position in the landscape. For these reasons, where field and isotopic evidence conflicts with apparent petrographic evidence on the age of a deposit it is the former that has been accepted.

Attention has been paid to the composition of carbonate material in both framework and matrix or cement of the sediments. In many specimens the shade of colour produced by the alizarin red dye on the carbonate is obscured by limonitic

staining but where it can be identified there is a strong and generally consistent tendency for framework grains to be richer in calcium than the matrix, which is richer in calcium than the cement. Because the solubility of magnesium carbonate in water is higher than that of calcium carbonate, it is reasonable to expect that framework grains would be progressively leached of magnesium and that carbonate precipitated from solution as late cements would be rich in magnesium. It is true that some vadose cements are dolomitic but no systematic correlation was observed.

A porous sediment from Tourville Bay (5633 RS 40) contains a highly soluble mineral which forms long curved needles when the specimen dries out. The mineral is isotropic and has a refractive index intermediate between those of halite and sylvite. Chemical analysis indicates that potassium is present but not in quantities that warrant further investigation.

M.G. FARRAND

A.P. BELPERIO

REFERENCES

Bathurst, R.G.C., (1975). Carbonate Sediments and Their Diagenesis. Developments in Sedimentology, 12. Elsevier, 658 pp.

Esteban, M. and Klappa, C.F. (1983). Subaerial Exposure Environment. In: P.A. Scholle, D.G. Bebout and C.H. Moore (Eds), Carbonate Depositional Environments. AAPG Memoir 33, 1-54.

Lindsay, J.M. and Harris, W.K. (1973). Fossiliferous marine and non-marine Cainozoic rocks from the eastern Eucla Basin, South Australia. S. Aust. Dept Mines and Energy Rept Bk. 73/70.

Ludbrook, N.H. (1984). Quaternary Molluscs of South Australia. S. Aust. Dept Mines and Energy, Handbook No. 9, 327 pp.

Peryt, T.M. (1983). Coated Grains. Springer-Verlag, Berlin.

Tucker, M.E. (1981). Sedimentary Petrology, An Introduction. Geoscience Texts, Vol. 3. Blackwell Scientific Publications, Oxford, 252 pp.

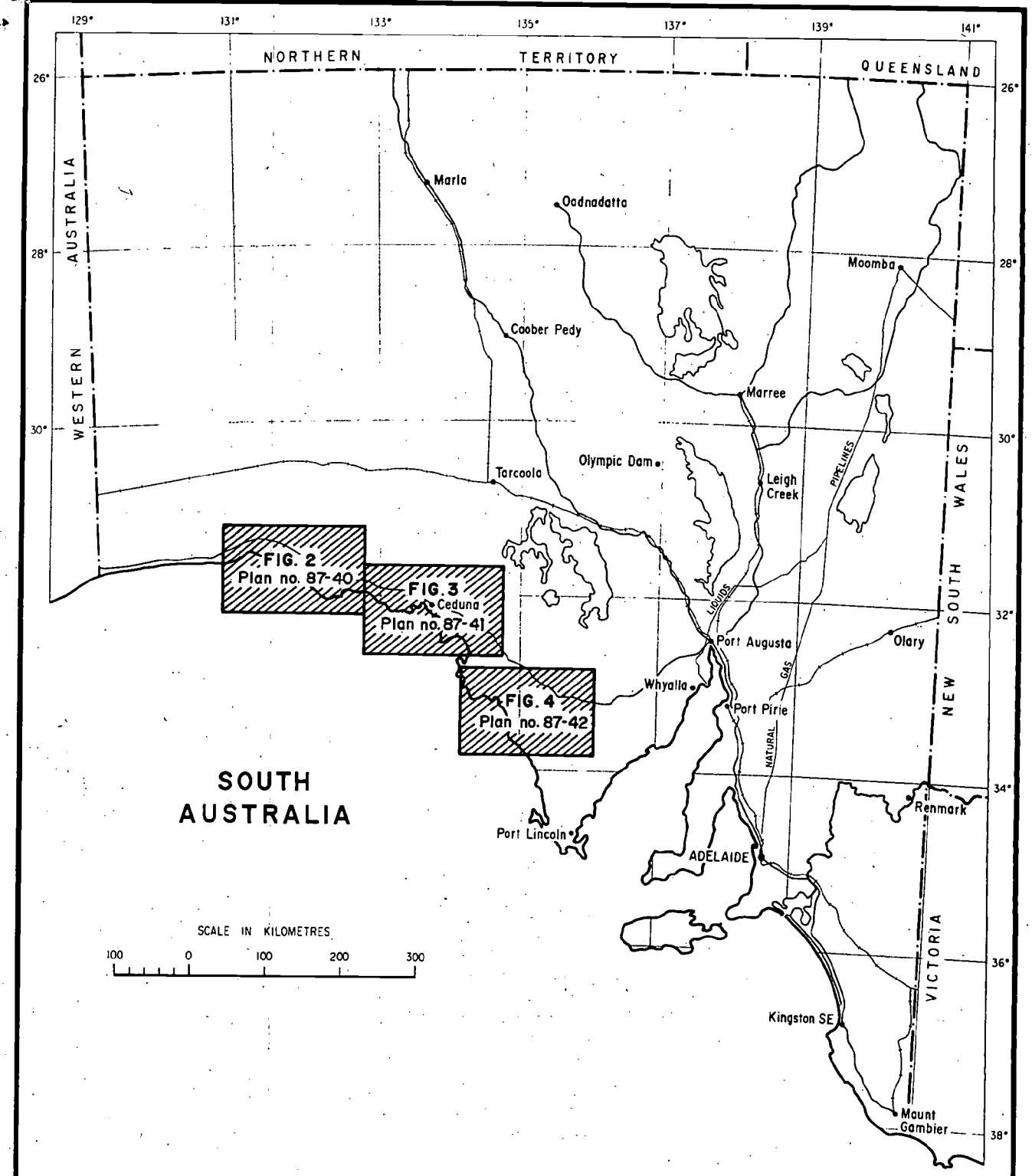

Figure.....1

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED A.P.B.	C.D.O.	DATE
QUATERNARY SEDIMENTS - SOUTH AUSTRALIA	DRAWN M.R.	SCALE	
COASTAL SEDIMENT SURVEY	DATE Jan '87	PLAN NUMBER	
LOCALITY PLAN	CHECKED	S 19037	

4283

5135

NME/84

NME/95

NME/85

NME/83

NME/82

RS 6

RS 12

WHITE WELLS

NME/86

Yalata Swamp

NME/87

HEAD OF BIGHT

NME/88

Yalata Mission

COLONA SPUR

Bice

HOPETOUN

DOG

BLACK HILL

Lucy

"Colona"

Trunch

FENCE

Russell

May

BROWN HILL

"Nundroo"

5334

RS 38

"Pintumba"

Sturdee

Caldwell

Nash

Magarey

Bookabie

BOOKABIE HILL

Giles

TALLALA HILL

Coorabie

Glen Boree

WANTIBY HILL

Wookata

RS 20

RS 23

D'Entrecasteaux Reef

FOWLERS BAY

RS 19

Fowlers Bay

RS 8

RS 9, 10, 14

1 : 100,000 map sheet area

RS 6 — Rock sample location and number (prefix with 1 : 100000 map sheet no.)

SCALE

10 0 10 20 30

kilometres

Figure..... 2

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED A.P.B.	C.D.O. 23·2·87 DATE
QUATERNARY SEDIMENTS - SOUTH AUSTRALIA	DRAWN M.R.	SCALE 1 : 500 000
YALATA SWAMP TO FOWLERS BAY LOCATION OF COASTAL SEDIMENT SAMPLES	DATE Jan '87	PLAN NUMBER 87-40
	CHECKED	

4283

KINTORE
"Cundilippy"
Magarey
Bookabie
▲BOOKABIE HILL
Giles
Cohen
COOPER HILL
Burgoyne
Bagster
KOONIBBA HILL
O'Loughlin
Koonibba Mission
Catt
WAY
Goode
Kalanbi
▲COPPUDURBA HILL
Pethick
Pureba
Penong
Kowulka
WOOLSHED HILL
Kevin
RS 11
Kevin
Lake Macdonnell
RS 12,13
Pt Sinclair
Port Le Hunte
Keith
Charra
RS 45,46
Moule
Moule
RS 40
Wandana
Maltee
NURKA HILL
Horn
RS 138
RS 64,65
Murat Bay
RS 106
Thevenard
Ceduna
Wandana
Chillundie
Merghiny
Guthrie
KONGWIRRA HILL
Mudamuckla
Hague
Puntabie
Nunnyah
▲OAK HILL
RS 105
RS 148
Tourville Bay
Pt Bell
Rocky Pt
Pt James
RS 149
DENIAL BAY
Bosanquet Bay
D'Ecres Bay
Laura Bay
Chinbingina
5433
5533
5633
Cape D'Estrees
ST PETER IS.
FLINDERS
Blacker
DUNN HILL
Nunjikompita
Carawa
Petina
Pimbaacla
PIMBAACLA HILL
NUYTS
LACY ISLANDS
Evans Is.
EYRE IS.
SMOKY BAY
Smoky Bay
Carawa
RS 75
Cape Missiessy
RS 67
HIGHWAY
Wirrulla
RS 114
RS 77
ARCHIPELAGO
RS 113
Haslam
EYRE
Perlubie
RS 116
RS 129
Pt Lindsay
Petina
Egg Is.
Franklin Islands
RS 131
Pt De Mole
Haslam
RS 130
West Is.
St Francis Is.
ST FRANCIS ISLES
Courela
Pt Brown
Pt Collinson
STREAKY BAY
Masillon Is.
Fenelon Is.
Finlayson
Tarlton
PERLUBIE HILL
10 0 10 20 30
kilometres

1:100000 map sheet area

• RS 11 Rock sample location and number (prefix with 1:100000 map sheet number).

Figure 3

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

QUATERNARY SEDIMENTS - SOUTH AUSTRALIA

FOWLERS BAY TO STREAKY BAY
LOCATION OF COASTAL SEDIMENT SAMPLES

COMPILED A.P.B.	MR C.D.O.	23·2·87 DATE	
DRAWN M.R.	SCALE 1:500000		
DATE Jan '87	PLAN NUMBER 87-41		
CHECKED			

4293

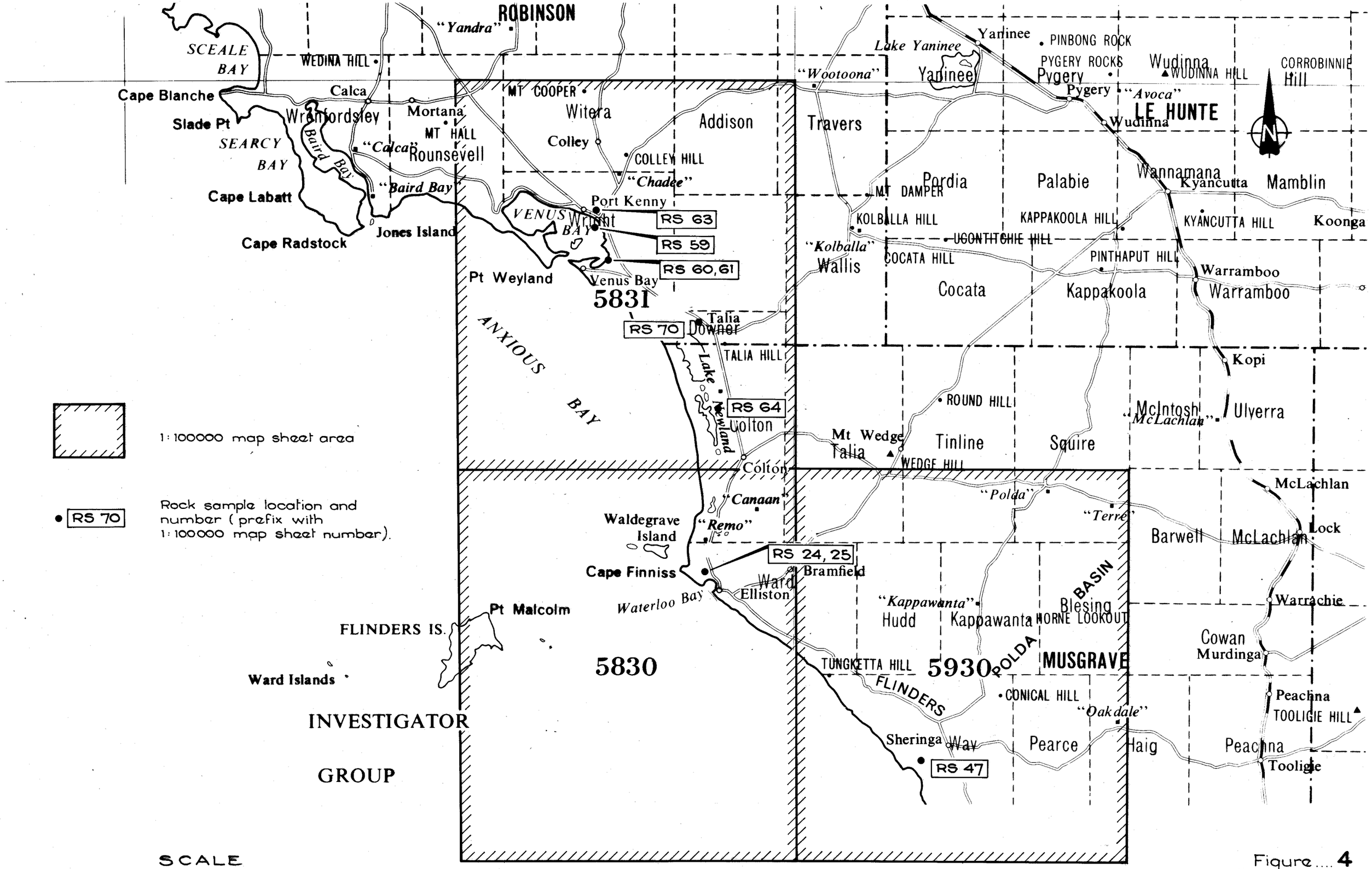

Figure 4

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED A.P.B.	C.D.O. 23.2.87 DATE
QUATERNARY SEDIMENTS - SOUTH AUSTRALIA	DRAWN M.R.	SCALE 1:500000
PORT KENNY TO SHERINGA LOCATION OF COASTAL SEDIMENT SAMPLES	DATE Jan '87	PLAN NUMBER 87-42
	CHECKED	

42993