NICKOL BAY - LEGENDRE

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

SHEET 2256 I AND PART OF SHEET 2257 II

URBAN GEOLOGY OF THE NICKOL BAY- LEGENDRE SHEET

The aim of this Urban Geology survey is to provide information for those concerned with aspects of raw material and water supply, rural, urban, industrial or transport development. The intention is to point out geological factors which may affect planning on a broad, rather than specific basis. Detailed site investigations will still be required but it is hoped that this information will provide a useful framework for such further work.

The area covered by the Nickol Bay and Legendre Sheets encompasses a variety of land–uses: stock grazing is carried out on two properties in the south; Karratha townsite covers some 3 km^2 and is currently being enlarged to approximately twice that size; a temporary bitterns pond of 9 km^2 holds reject fluid from salt production to the west; minor amounts of sand, gravel (for roads), limestone, and 'clay' (for levees) have been excavated; an airport serves Karratha and Dampier; a railway marshalling yard and repair shed are sited in the southwest; and areas of unused or seldom–used vacant land occur on the promontory northeast from King Bay and on the many islands of the Dampier Archipelago. The total land surface is 237 km^2 of mainland (including the bitterns pond) and 16 km^2 of islands.

The geology of the Dampier 1:250 000 sheet, which includes Nickol Bay and Legendre, was mapped previously by Kriewaldt, Horwitz, Ryan and Bock of the Geological Survey of Western Australia, the results being published in 1964. These two sheets were re–mapped in 1976 by Biggs of the Survey, using 1:50 000 topographic base–maps and 1971 and 1972 air photographs. The Precambrian rock subdivision of the earlier mappers was utilized with some modification.

PHYSIOGRAPHY

The Dampier area is very broadly divided into physiographic units which are shown on the inset map. The Dampier Archipelago division includes most of the islands and the promontory northeast of Dampier and is typified by rugged, often precipitous terrain with some sandy bays and mangrove fringes. The limestone islands are less rugged and of lower elevation. Coastal flats include tidal mangrove swamps and samphire flats as well as the extensive silt and mud flats which are submerged by rare, exceptionally high tides. The coastal plain is generally of low relief but includes dunes and broad river basins. The division labelled isolated hills encompasses a variety of landforms, all hilly to a greater or lesser degree and all separated from the main hill massif to the south; volcanic hills and ranges, steep spines of banded cherts and isolated erosional remnants (monadnocks) are included.

STRATIGRAPHY

Rocks of Archaean and Proterozoic ages crop out throughout the mapped area, thickly mantled in places by Tertiary and Quaternary sediments. Sedimentation is occurring at present, especially where mangrove thickets are colonizing the ocean margins. To a large extent, geology controls physiography – eroded granite and Quaternary sediments forming lowlands, the older rocks the uplands.

PRECAMBRIAN

The Archaean **'altered dolerite'** is confined to a small area southeast of Nickol Bay. It is a fine- or medium–grained, mesocratic grey rock with scattered microlites and phenocrysts. Calcite, chlorite and pyrite are common secondary minerals as veinlets and aggregations. At least part of the 'dolerite' is metamorphosed andesite, an intermediate intrusive. Close to this rock is a second dyke of metamorphosed **dolerite** which is not known to intrude Proterozoic rocks and is therefore either Proterozoic or Archaean in age. It is a fine– to medium–grained blue–grey rock with a distinctive dark red–brown weathering surface on the large subrounded boulders covering the outcrop. A few local developments of calcrete occur on the dolerite close to the ridgetop.

The **granite, gneiss and pegmatite** unit probably underlies much of the coastal plain west of Karratha but is susceptible to erosion and therefore crops out rarely. To the north it has been protected by resistant overlying rocks and appears at the foot of cliffs along the promontory to Dolphin Island. The granite is coarse grained and leucocratic, usually pink–grey. It is even grained to porphyritic with pink feldspar phenocrysts set in equal amounts of grey quartz and pink and white feldspar with subordinate ferromagnesians, usually dark brown biotite. The granite gneiss is sheared to greater or lesser degrees and is widely penetrated by quartz stringers.

The **chert and clastic sediments** comprise sedimentary rocks which have undergone some dynamic metamorphism. Cherts, being the most resistant to erosion, are visually more obvious but are subordinate to the clastic sediments and interbedded with them. Cherts are finely laminated to massive, vari–coloured (bands of several colours appearing even in single outcrops), and exhibit bedding structures from undisturbed, through penecontemporaneously folded, to contorted and fractured by subsequent tectonism. Interbedded schistose quartzite has been boudinaged in places. The clastic rocks are acid to intermediate, fine–grained ashes and coarse–grained tuffs, readily weathering to grey, grey–green, cream or brown. Subsequent quartz veining was injected generally parallel with bedding and introduced small gold deposits in two places. A tentative identification of greywackes in the sequence suggests submarine slumping of some of the clastic material before consolidation. Minor horizons are pale and apple–green prase, brown and blue silicified shale, and green–blue silicified kaolin (miloschite). Dark bluish manganese staining and coatings are common.

Within the **basic and intermediate volcanic** unit the rocks range from basalts, some spilitic, through andesites to minor porphyritic rhyolite. One large area of dolomite occurs near Fields Creek and hornblende schist is seen in one locality. The metamorphosed basalt is typically a dense, fine–grained, blue–grey rock of augite or hornblende and feldspar, with disseminated pyrites a common accessory. Hornblendite and the one noted occurrence of hornblende schist are probably further metamorphosed basic igneous rocks, consisting mostly of pleochroic green hornblende. Quartz occurs within both these rock types either as injected veins or as boudins and streaked, contorted bedding probably representing former sand or acid ash beds. Intermediate volcanics, fine– to medium–grained pale blue–grey rocks, have been identified as metamorphosed andesite, dacite and microquartz diorite, some exhibiting faint schistosity and others flow–banding. Minor acid rocks are fine–grained, mesocratic steel–grey porphyritic rhyolites, some containing disseminated pyrites. The dolomites are very fine–grained, brown–weathering, pale grey rocks with coarse calcite infillings, or fine–grained, blue– grey dolomitic siltstone, both containing significant but small amounts of acicular amphibole, suggesting metamorphic introduction.

At the extreme east of the sheet area a marked unconformity cuts steeply–dipping basic volcanics which are iron– and manganese–stained, strongly weathered and partly laterized, indicating a considerable time–lapse before deposition of the overlying beds.

The **ferruginous chert** unit, also known as banded iron–formation, consists mainly of very fine–grained, coloured cherts and jaspers interlaminated with hematite. Leaching and silification of iron laminae has produced some massive quartz horizons. Micro– and macro–tectonic effects are common. Interbedded are some thin shales with rare azurite coatings and some green prase. Calcrete is developed locally and at storm–tide level. White quartz veining and manganese staining are common.

Overlying the unconformity mentioned above are shallow–dipping **quartzo–feldspathic sediments** exhibiting false bedding and channel sedimentation. Previously considered part of the Archaean sequence, regional evidence suggests these sediments may be Lower Proterozoic in age. The rocks are pale feldspathic quartz conglomerate, medium–grained arkose and orthoquartzite, and fine–grained sandstone and dark siltstone. Only the orthoquartzite shows obvious evidence of metamorphism.

Resistant to erosion, **gabbro** forms hills with heavy scree obscuring its contact with underlying rocks. Characterized by a dark brown weathering surface, the blue–grey rock consists of coarse–grained plagioclase feldspar and mafic minerals surrounding hornblende phenocrysts up to 10 cm long, often in radiating groups. Gradations to feldspathic diorite and quartz diorite (tonalite) are common and assimilation of invaded granite has caused some hybridization.

Similarly erosion–resistant, massive and layered **granophyre** forms the spine of the promontory and major islands west of Nickol Bay. It is a fine– to medium–grained, porphyritic blue–grey rock, typically with a reddish–brown weathering surface, composed of equal amounts of grey quartz, pink feldspar and dark ferromagnesian laths and subordinate white feldspar. The phenocrysts are quartz, feldspar and, less commonly, epidote. Southwest of King Bay is a grey spherulitic rhyolite containing specular hematite in aggregations up to 15 cm diameter. Assimilation of granite (which also occurs as xenoliths up to 30 m long), arkose and basic rocks has produced several localized hybrid rocks. With the gabbro, this unit forms the Gidley Granophyre.

Dykes of dense, blue–grey, fine– to medium–grained **dolerite** intrude all Precambrian rocks. They are generally melanocratic, although mesocratic dykes occur. Accessory pyrite is disseminated or aggregated and rare to common in different dykes. Weathering surfaces are dusky brown, the dykes forming negative weathering features within granophyre and generally positive features within other rocks.

CAINOZOIC

Remnants of a massive **laterite** cap three small hills north of Lydia mine. A few pisolitic elements are seen but a massive brown and blue–black (iron– and manganese–stained) rock predominates.

The red–brown **silty sand** which forms the widespread 'red soil plains' probably includes alluvial, eluvial and colluvial units in a flood plain environment. The quartz sand is unsorted to poorly sorted, fine– to coarse–grained, frosted, subangular to subrounded and includes small but significant proportions of limonite grains. Pebbles, cobbles and boulders of adjacent or durable bedrock are common, in places completely covering the land surface, following erosion of the finer grains. Calcrete nodules (kankar) and discontinuous sheets occur typically one to two metres below surface and small, platy gypsum crystals are seen in areas of poor, saline drainage. Where the silt percentage is higher, as in areas of internal drainage, patches of 'bulldust' develop and the area is widely characterized by the minor sink–hole development known as 'crab–hole country'. Although dated as Pleistocene, some Holocene reworking may have occurred locally.

The **dune limestone** which occurs on Legendre and adjacent islands is a pink, lime–cemented dune sand, correlated with the Tamala Limestone further southwest.

Eolian sand has been mapped near Karratha airport and exhibits a characteristic subdued seif dune topography with dunes up to one metre high. The slightly clayey sand consists of fine– to medium–grained, subrounded to rounded quartz and limonite and has been derived from reworking of the Pleistocene red–brown silty sand.

Similarly derived from the silty sand, the **outwash gravel veneer** represents remnant pebbles after removal of sand and silt grade material by wind or water action. As mentioned above, such pebble pavements are common although seldom of mappable size. The pebbles are generally flattened, aligned parallel to the land surface and interlocked to form a continuous, vegetation–free, stone pavement. Usually only a few centimetres thick, the sub–unit grades vertically and laterally into its parent silty sand.

Colluvium is widespread on hill slopes in the area but has only been mapped where it forms a major topographic feature, typically as screes to chert ridges. The unsorted material ranges from clay particles to angular and subangular boulders of the parent rock–type. The coarser material predominates close to bedrock outcrop.

One area of **sand ridges** is distinguished east of Karratha airport and has almost certainly resulted from coastal reworking of the plain sand, probably during Holocene times. Grain characteristics are identical to the Qps unit with a slight decrease in finer material. Low parallel ridges aligned with the conjectured fossil coastline distinguish this unit.

Alluvium occurs in all present–day water courses in widths from a few centimetres to 200 metres. The sediments range from muds and fine silts through coarse sands to lenses of rounded boulders, the silt content being higher in the reaches near sea level.

At and near present–day high tide levels, a **lime–cemented beach conglomerate** occurs at several places along the coast. Formerly correlated with Pleistocene Tamala Limestone, the conglomerate is seen to include bottle–glass and steel cans and is therefore still being deposited. It consists of angular to subrounded shells, grit, cobbles and boulders of many rock–types set in a hard, pale orange–fawn, calcareous matrix which tends to deep orange and purple below high water mark. Sparse pisoliths are seen and *in situ* lithification of deltaic shingle occurs in one place.

The Holocene **silty sand** is distinguished from its Pleistocene counterpart by the presence of *Anadara granosa,* often in profusion as fragmented or whole shells (see sketch at far right). Other mollusc shells and fragments may occur in smaller numbers. Red–brown to fawn, the quartz sand is very fine to coarse grained, subangular to subrounded, containing up to ten per cent shell fragments and whole shells. Occurring on the lower side of a one to three metre topographic break, this horizon is probably derived from the Pleistocene unit with some material added during Holocene times.

The **shelly sand** units comprise fine to coarse quartz sand and between 30 and 70 per cent shell fragments. Rounded pebbles and boulders frequently occur and the silt content increases near mangroves. Fossil molluscs, especially *Anadara,* and massive corals are abundant on some storm–built beaches to the virtual or total exclusion of quartz. The units include deposits formed on beaches, foredunes, deltas and distributory channels. The older unit is distinguished from the younger by the partial development of soil, marked weathering of fossils, fewer corals and a base level some two to three metres higher. On the mainland east of Walcott Island the younger dunes have been built to a greater height and have encroached on the older. Elsewhere the younger deposits may occur as a thin (20 to 30 cm) veneer on foreshore rocks.

The **mud and silt** horizon is currently being deposited within the inter–tidal zone (especially between mangrove trees) and recently on the supra–tidal flats while samphire and other halophytes are colonizing the landward side. The stratigraphy ranges from brown gelatinous muds through grey–brown silts to brown silty sands, all heavily salt–impregnated. Some shells are encountered, particularly in the sandier lenses.

STRUCTURE

The Archaean structural trend is northeasterly, the layered rocks forming the northeastern section of a locally complex anticline to the south of a granite massif. The anticline is cut by a local unconformity. Proterozoic basaltic flows unconformably overlie Archaean granites on the Dampier Archipelago and promontory. A differentiated granophyre has been intruded at this unconformity.

ECONOMIC GEOLOGY

CLAY

No good quality clay is known in the area. A pit in the south–western corner of the Nickol Bay Sheet area has provided silty material used in the construction of levees to the northwest.

CONSTRUCTION MATERIALS

Small quarries and pits have been developed along the main roads and the Tom Price–Dampier railway line. Materials used include colluvium for road surfacing and granophyre and gabbro for ballast.

COPPER

No copper production is recorded from the area but minor malachite and azurite occur in banded iron–formation in the Cleaverville area 3 km east of Walcott Island.

GOLD

Gold was first discovered at the Nickol Bay centre towards the end of the nineteenth century. Total production to the end of 1976 was approximately 12.45 kg gold from 697 tonnes of ore. The gold occurs in steeply inclined quartz veins which intrude Archaean clastic sedimentary rocks. Little mining has been carried out since 1910 and the workings are now flooded.

IRON

Banded iron–formation and ferruginous chert crop out in the Cleaverville area, but iron content is far too low to warrant mining under present conditions.

LIMESAND

Shell sand is being extracted at Hearson Cove for use in the Dampier iron ore pellet plant. Calcium carbonate content is about 80 per cent, the chief impurity being silica. Other deposits occur as beaches and dunes on Conzinc and Angel Islands and the west coast of the promontory. Analysis of samples from these deposits indicate high grades between 85 and 95 per cent $CaCO_3$.

LIMESTONE

High-grade limestone suitable for cement manufacture, metallurgy, dimension stone and road construction occurs in the dune limestone of Legendre Island, Hauy Island, Cohen Island and eastern Collier Rocks Grades vary from 82 to 90 per cent $CaCO_3$.

SAND AND GRAVEL

Numerous small sand and gravel pits exist in the area. The gravel is of poor quality and much of the sand is either shelly or silty. Beach and dune sands east of Karratha have been used in house foundations.

WATER

The unreliable annual rainfall averages about 300 mm, mostly falling between December and April. Watercourses flow only briefly, after heavy rain.

Groundwater is generally brackish to saline and borehole and well yields are low, so that Karratha has to pipe its water supply from Millstream, about 100 km to the south.

The groundwater is contained in fractured and weathered Archaean and Proterozoic rocks, or in younger superficial deposits of alluvium and colluvium, generally of low permeability. Maximum yields from boreholes are, in consequence, unlikely to exceed 50 m^3/day.

On the coastal plain the groundwater is generally 5 to 10m below ground level and is mostly brackish to saline, generally increasing in salinity towards the sea. Stock quality water is usually available and small supplies of domestic quality groundwater (<1 000 mg/1 TDS) may be obtainable along larger creeks.

On the higher ground of the Dampier Archipelago and isolated hill ranges, groundwater in fractured rock is fresh to brackish but supplies are small and unreliable.

The dune limestone on Legendre Island might give limited supplies of fresh to brackish water.

ENGINEERING GEOLOGY

The engineering properties of rocks, which include such features as strength, suitability for foundations, stability on slopes and in excavations, and suitability as construction materials, depend on geological factors such as mode of origin, composition, and susceptibility to metamorphism, weathering and erosion. The generalized engineering properties of the rocks that occur in the area are described with this in mind.

ARCHAEAN

The Archaean rocks comprise a variable group with a wide range of engineering properties. Where the clastic sediments are exposed in shallow excavations beneath superficial material they are often soft and weathered. They would not stand well in excavations but would be satisfactory as foundations for structures of moderate loading. Their properties differ widely from those of the interbedded chert which more commonly crops out and is hard and resistant to weathering. Engineering problems could arise with the rock unit as a whole because of the differing properties of the two closely associated rock types. For example slopes and excavations could be unstable and differential settlement could occur beneath foundations. They are unsuitable as a source of aggregate.

The ferruginous chert unit which is generally durable forms ridges but contains well–developed bedding and joint surfaces which aid the production of abundant rock fragments in the colluvium that forms on the slopes. This contributes to the suitability of adjacent superficial deposits as a construction material. Because of thin interbedded shales the rock unit as a whole has some of the engineering defects of the previous group, such as instability on slopes and in excavations, but the predominantly chert sections would make satisfactory foundations in flat areas even for high load structures.

The quartzo–feldspathic sediments are moderately strong to weak, are more uniform, and have superior engineering properties to the clastic sedimentary phases of the two units described above.

All the Archaean igneous rocks are strong and stable when fresh, but near surface are generally weakened and less stable due to weathering of either the rock mass or joints.

The altered dolerite and the metamorphosed dolerite have similar engineering properties. They are both probably more susceptible to weathering than the basic and intermediate volcanic unit, but would have equally good engineering properties unless weathered to clay.

Although the igneous parts of the basic and intermediate volcanic unit are resistant to erosion and crop out to form ridges, detailed examination shows many defects and complex variations in composition and structure. In addition to jointing, the rocks are foliated in part, contain lenses of schist and other weak material and are cut by quartz veins and minor dykes of varied composition. These features may, but do not necessarily, make them unstable on slopes or in excavations or reduce their suitability as foundations. However these features detract from the value of the rock as a source of aggregate. The dolomite included in this unit has the defects of sedimentary rocks but it has superior engineering properties to the clastic sediments already described.

The granite, gneiss and pegmatite unit is weathered in part and forms low rounded outcrops cut by joints. This is not necessarily representative of the unit where it occurs beneath superficial material on the coastal plain. However, no major engineering problems are foreseen with rocks from this unit unless weathering is advanced and the rock mass has become predominantly clay.

PROTEROZOIC

Proterozoic gabbro, granophyre and dolerite are generally stronger and more uniform than the more deformed and variable Archaean rocks and consequently present fewer engineering problems. Problems with stability could arise from the development of scree on the gabbro. The use of the granophyre as a source of aggregate has been satisfactory.

TERTIARY

Laterite is a rock with varying engineering properties depending on its state of erosion, but is of minor engineering significanee in this area.

QUATERNARY

The Quaternary group includes a wide variety of superficial units with complex field relationships and differing engineering properties. For example, the behaviour of a unit is modified by the properties of an underlying unit, level and salinity of the local groundwater, and the pH of the unit. Because this material occurs in the flatter parts of the area where future development is expected, its varying properties and their complex distribution are significant. It is stressed that detailed investigation at the actual site of proposed development is necessary and the information given here can only serve as a guide.

One of the major engineering problems with the superficial materials is the presence of expansive clays in some parts of the silty sand. These areas are characterized by 'crab–hole country'. The expansive clays contain a high percentage of montmorillonite thought to be derived from the weathering of ferromagnesian minerals in the mafic and ultramafic volcanic and intrusive rocks of the region.

If the material containing expansive clays is not avoided in the siting of engineering works, it should either be removed or allowed for in the design of foundations. Allowance can be made by placing a foundation pad of stable material over it or by taking foundations below the surface zone of fluctuating moisture content. Both methods have been used in the area.

Low permeability in the superficial material inhibits drainage and allows the water table to rise in areas of housing development. Low permeabilities occur in the clayey parts of the silty sand, and in the colluvium and outwash soils with high pH values. In these latter soils the clays disperse when wet, further reducing permeability. These types of soils should be avoided for housing development, or precautions taken, such as provision of adequate drainage. In these areas, the construction of foundation pads aids the solution of both drainage and foundation problems.

The mud and silt of tidal areas are weak materials and pose foundation problems for roads, railways and levees. The problems can be solved by the provision of stable embankments of suitable, properly compacted material. Suitable materials for embankments include Quaternary outwash gravel, colluvium, and alluvium, as well as rock fill obtained from the stronger parts of the older rock units. For levees, silty sand containing clay has been used, but requires thorough compaction. Weak, unconsolidated mud and silt is displaced from beneath the fill when it is placed.

As well as providing suitable fill for the construction of foundations, the less clayey parts of the superficial units, such as outwash gravel, colluvium, alluvium and parts of the silty sand free of expansive clays, make suitable foundations for structures of moderate loading provided the normal precautions are taken.

The various beach and dune deposits are generally friable and when loose may be unstable in excavations and on slopes. They are liable to soil erosion if cleared of vegetation. Except for older leached deposits they are of limited use in construction because of their salt content. Shell beds from Hearson Cove are used for lime sand. In many cases the superficial deposits are thin or of too limited extent to have any engineering significance.

ENVIRONMENTAL GEOLOGY

The finer silt fraction of the coastal plain sediments inhibits free flushing of groundwater and this has probably contributed greatly to the retention of salts in the soil profile. Indiscriminate irrigation may remobilize these salts and cause salt–scalding down–slope from the irrigated area. Watering to establish vegetation in Karratha has already drawn attention to this problem which was alleviated in that case by changing from sprinkler irrigation to a trickle system. In other areas irrigation should be avoided on fine–grained soils, especially those where kaolinized granite occurs close to surface, unless adequate drainage has been provided.

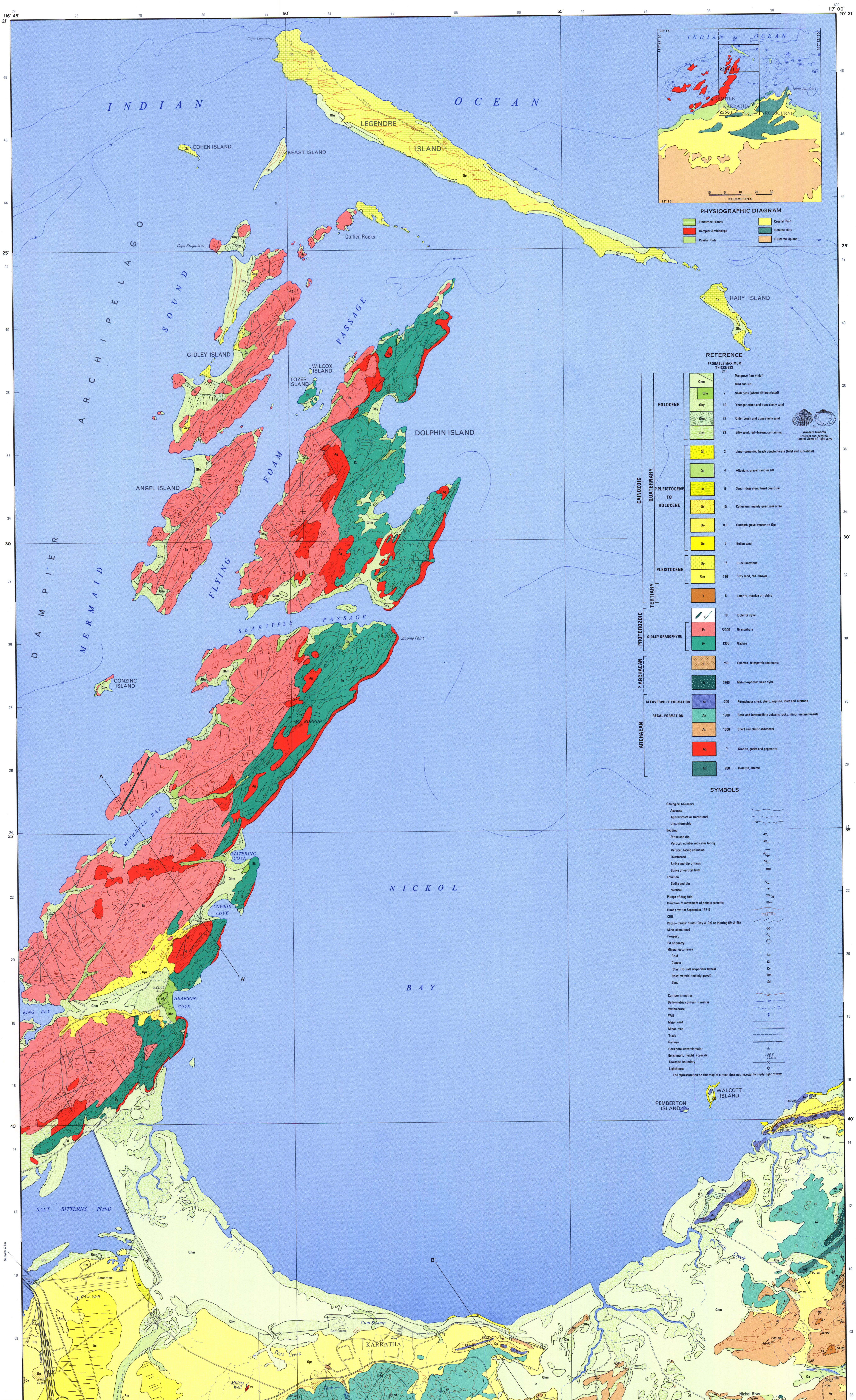
Waste disposal may present problems especially when the planned expansion of Karratha takes place. Above–ground disposal of waste is often unacceptable aesthetically and because of the cost of preventing dispersal by wind. The shallow soils in much of the mapped area limit suitable disposal sites and to date two abandoned gravel pits have been utilized. Further sites may be available when coastal dune sand–pits have been worked out. Longer–term possibilities are quarries on Legendre Island following limestone extraction. Sites should not be considered on flood–prone flats south of Nickol Bay. No suitable sites for toxic waste disposal occur within the mapped area.

Several small gravel pits have been opened alongside roads and tracks, many without planning permission. These cause visual pollution and lead to a waste of resources by piecemeal excavation. Extraction licenses should be obtained from the Shire Council which will in general favour inconspicuous sites, grouped for maximum resource utilization and for possible waste disposal areas when abandoned.

The salt bitterns pond is a temporary solution to disposal of the liquor because evaporation of water and precipitation of salts will eventually fill the available space. A long–term study is under way to assess the effects on marine life, especially breeding crustacea, in Nickol Bay, if the liquor is discharged from an underwater pipeline.

Soil erosion is a minor problem on the coastal plains, local remedial action being sufficient to repair gullying. The vestigial soil on the hills appears to be stable and at present is little affected by man. Sand dunes near Karratha suffer minor damage from human activities but the grain size is relatively coarse and the danger of a major blow–out seems low. No information is available about soil or dune stability on the islands.

Further information may be obtained from the Geological Survey of Western Australia, Mineral House, Perth.



Mt Tom Price 264 km

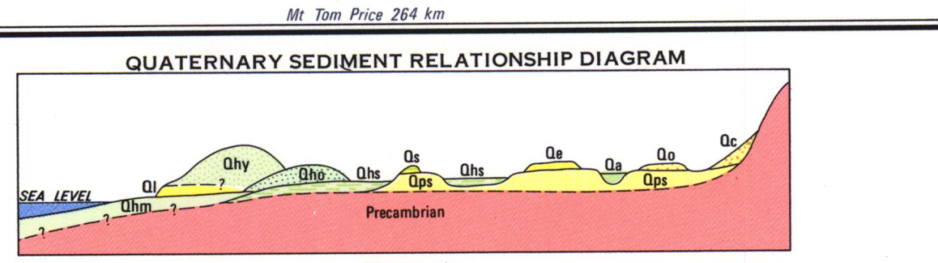
North West Coastal Highway 4 km

Geology : E.R. Biggs 1976

Compiled and published by Geological Survey of Western Australia. Cartography by Geological Mapping Section, Department of Mines. Topographic base from compilations by Department of Lands and Surveys. Printed by Government Printing Office, Perth, 1978.

Copies of this map may be obtained from the Geological Survey of Western Australia, in Perth.

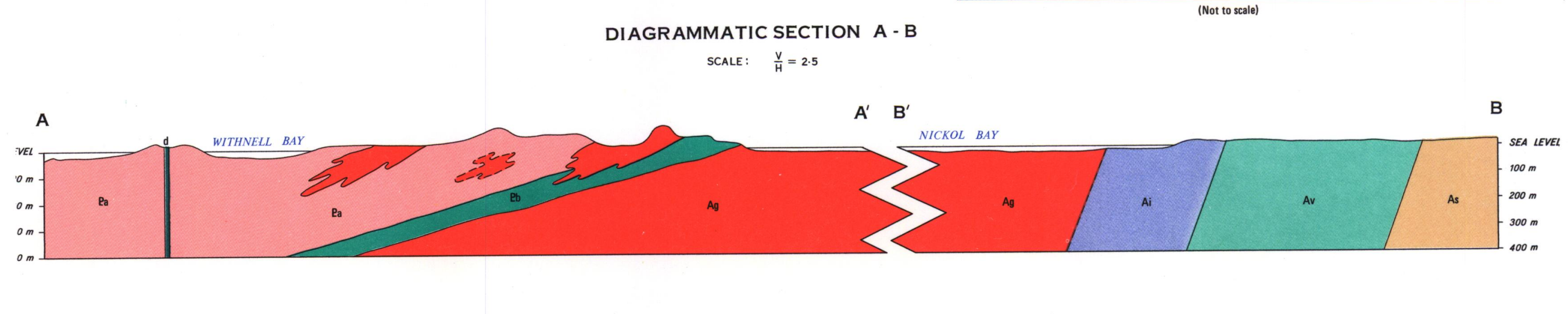
QUATERNARY SEDIMENT RELATIONSHIP DIAGRAM



(Not to scale)

DIAGRAMMATIC SECTION A - B

SCALE: $\frac{V}{H} = 2.5$



HON. A. MENSAROS, M.L.A.
MINISTER FOR MINES
J. H. LORD, DIRECTOR, GEOLOGICAL SURVEY

SCALE 1:50 000

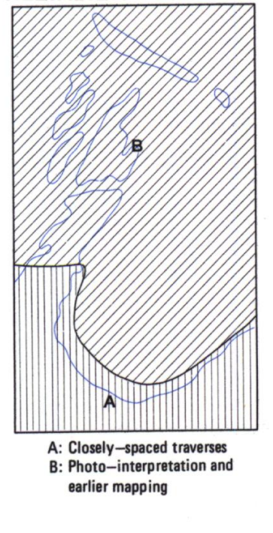
1 0 1 2 3 4 5 6

KILOMETRES

CONTOUR INTERVAL 20 m

Ticks inside the sheet edge represent 2000 metre intervals of the superimposed Australian Map Grid, Zone 50 AUSTRALIAN NATIONAL SPHEROID

RELIABILITY DIAGRAM



A: Closely–spaced traverses
B: Photo–interpretation and earlier mapping

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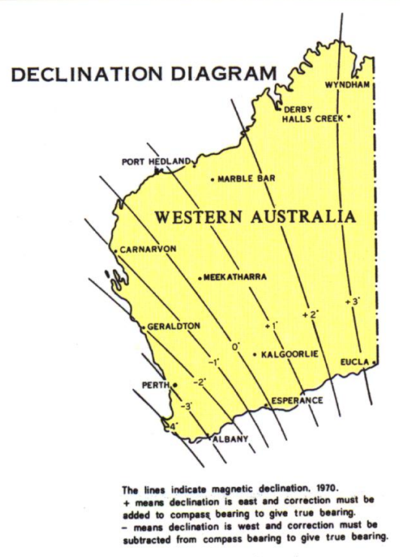
BAYNTON 2256 III	KARRATHA 2256 II	ROEBOURNE 2356 III

DECLINATION DIAGRAM



The lines indicate magnetic declination, 1970.
+ means declination is east and correction must be added to compass bearing to give true bearing.
– means declination is west and correction must be subtracted from compass bearing to give true bearing.

Annual change is -1′ westerly

NICKOL BAY - LEGENDRE
URBAN GEOLOGY
2256 I – 2257 II

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