MINES and ENERGY RESOURCES SOUTH AUSTRALIA

Report Book 97/25

PRELIMINARY REPORT OF PALAEODRAINAGE IN THE ST VINCENT BASIN AND MT LOFTY RANGES.

by

Rowett, A.I.
Mineral Provinces

OCTOBER 1997

CONTENTS **PAGE**

FIGURES **PLAN NO**

DEPARTMENT OF MINES AND ENERGY RESOURCES
SOUTH AUSTRALIA

REPORT BOOK 97/25

Preliminary Report of palaeodrainage in the St Vincent Basin and Mt Lofty Ranges.

Rowett, A.I.

Generalised contouring of the Mt Lofty Range has identified a number of possible Tertiary channels associated with the St Vincent Basin palaeodrainage. In the northern Mt Lofty Ranges the Broughton, Wakefield, Gilbert, Light and North Para palaeochannels have been identified. The Early Tertiary Broughton River flowed southward depositing sediments on the Condowie Plains with possible targets for placer minerals being the Miocene Snowtown Sand and Late Tertiary Koolunga Gravel units. The Middle Cainozoic Gilbert and Light palaeochannels were associated with deposition within the Barossa Basin and Olliver and Weir's "Gawler estuary" with the coarse basal units of the Rowland Flat Sand a potential placer target as well as the Early-Middle Miocene sands of the "Gawler estuary". The Late Cainozoic Wakefield, Light and North Para palaeochannels flowed westward over the northern Adelaide Plains depositing sediments in coastal fans and deltas located to the east of the present coastline. These deltaic sediments are possible targets for placer minerals.

In the southern Mt Lofty Ranges the Golden Grove, Torrens, Onkaparinga, Meadows, Myponga, Hindmarsh Valley, Chandler's Hill and Blackwood palaeochannels have been identified. The Early Tertiary Golden Grove palaeochannel can be mapped within Golden Grove Embayment as far south as Dernancourt. Coarse basal sediments of the North Maslin Sand are a target for placer minerals, with possible traps in the Hope Valley and Vista areas. The Quaternary Torrens palaeochannel flowed westward from the Echunga area into the St Vincent Basin with numerous changes in course before adopting its current course. Almost all potential targets lie beneath residential areas in Adelaide's western suburbs. It is suggested the Early Tertiary Onkaparinga palaeochannel may be associated with deposition within the Willunga Embayment and possibly linked to the Maslin Bay palaeodrainage. Coarse basal units in the North Maslin Sand are a likely target and with possible offshore traps in the vicinity of Maslin Bay and Aldinga. The Middle - Late Tertiary Meadows- Myponga palaeochannel flowed southward entering the sea in the vicinity of Normanville. Suitable targets for placer minerals maybe found in the terrigenous sediments in the Meadows and Myponga Basins. An offshore trap may also occur west of Normanville. The only possible target in the Middle Tertiary Hindmarsh Valley palaeochannel are the basal terrigenous sediments within the Hindmarsh Tiers Basin. The Blackwood and Chandler's Hill palaeochannels have both been inferred by generalised contouring but little or no geological information is available.

Data from geological and geophysical surveys and drilling programmes have contributed to the identification of the Melton and Barabba palaeochannels and the Port Gawler palaeodrainage systems located in the northern St Vincent Basin.

The ?Early Tertiary Melton palaeochannel occurs on the north-western margin of the Basin and was a substantial aquatic corridor to the Pirie Basin during the Middle Eocene - Middle Miocene. A possible North Maslin Sand equivalent at the base of the channel is a suggested target for placer minerals.

The Barabba palaeochannel is associated with the Barabba Gravity Low. Flow was southward from a source in the northern Mt Lofty Ranges to near Korunye, immediately north of the Port Gawler palaeodrainage system. The channel is possibly a continuation of the Gilbert palaeochannel. Early Tertiary palaeodrainage has been well mapped in the Port Gawler area. A series of channels flowed southwestward before combining offshore to form a single channel which parallels the present coastline. North Maslin Sand is a possible target. Further seaward, and also running parallel to the coastline, part of another palaeochannel has been identified using seismic data. Little is known of this channel.

Prospectivity for gold and diamonds is discussed in relation to potential targets within the St Vincent Basin and associated uplands. Palaeochannels sourced in the Echunga - Woodside, Birdwood, Gumeracha and Barossa areas in the southern Mt Lofty Ranges appear the most prospective targets. These areas have a long documented history of alluvial and reef gold discoveries as well as diamonds at Echunga.

INTRODUCTION

This report represents a preliminary study of palaeodrainage within the St Vincent Basin and associated uplands, the Mt Lofty Ranges and the potential for alluvial diamonds, gold and placer minerals. The main focus of this report is on the onshore palaeodrainage of the basin, extending from Crystal Brook down to southern Fleurieu Peninsula. In the course of studying palaeodrainage within the Mt Lofty Ranges and a number of small intramontane Tertiary basins whose origins have had a direct affect on the resultant drainage pattern within the St Vincent Basin have also been considered. These include the Barossa, Meadows, Myponga and Hindmarsh Tiers Basins and are recognised as one time traps for alluvial base metals and minerals (Figure 1).

The aims of the study are to:

- identify and map palaeodrainage channels within the St Vincent Basin,
- determine the relationship between upland and Basin channels,
- determine possible relationship with known offshore channels,
- identify those known sources of gold, diamond and placer deposits within the Basin that are associated with palaeochannels,
- identify possible stratigraphic units/localities as potential depositional traps for gold, diamonds and placer deposits may occur within the Basin.

BACKGROUND

The investigation of palaeodrainage channels in the St Vincent Basin has up until now received only minor consideration, palaeochannel identification being secondary to other project aims. The comprehensive groundwater drilling in the search for suitable Tertiary aquifers in the Adelaide Sub-Basin and the Willunga Embayment has produced a vast amount of hydrogeological data but which is limited in its application to palaeodrainage determination. Few of the vast number of wells drilled in these basins actually intersect bedrock and those that do are scattered, making contouring of older Tertiary strata extremely difficult (and speculative) and channel identification almost impossible.

In the investigation of sand mining resources in the Golden Grove Embayment McCallum (1988) identified several channels in the Tertiary sands including the fossil leaf-bearing Unit 2, from which Middle Eocene mummified leaves have been described (Barrett, 1987, Christophel and Greenwood 1987, Barrett and Christophel 1988). Mapping of these channels was, however, restricted to the Golden Grove Extractive Industry Area making it extremely difficult to predict the sequence of Tertiary drainage patterns within the embayment. Extending the overall palaeodrainage southward to the Highbury - Dernancourt area has been possible using a basal Tertiary sand contour map produced by Reed (1982) as part of his Golden Grove - Hope Valley hydrogeological investigation.

A similar situation has occurred in the sand pits of the Maslin Beach - Pedlar Creek area in the Willunga Embayment where channels have been identified as a result of an extensive sand resource drilling programme but very little is known of the palaeodrainage away from the Extractive area (Pain 1984, 1988).

The search for gold in South Australia resulted in several gold rushes in the Mount Lofty Ranges between the Mid 1800's and early 1900's, with the discovery of alluvial gold at a number of locations within the region. It was generally acknowledged by prospectors that gold could be found in ancient channel sediments which resulted in mines and workings being established along the course of a number of Tertiary (and Quaternary) palaeochannels. Little or no geological information is available on these sediments which were removed during exploration. Recent exploration for gold and diamonds in the Mt Lofty Ranges has focused on the Echunga area with companies Kimberley Diamond Quest NL, Nickel and Mineral Search NL in 1979, Western Queen (SA) Pty. Ltd. in 1981 and CRA Exploration Pty. Ltd. in 1982-83 applying a range of regional stratigraphic, tectonic and geophysical approaches (Gerdes 1988). Company interest in the area remains high today, eg. Capricorn Resources N.L. are currently drilling on the site of the "Bird-in-

Hand" Mine which was first worked in the 1880's and then again in the 1930's.

Existing palaeodrainage information has been reviewed on a number of occasions, but no new work undertaken. Work carried out by Pacific Exploration, consultants for CRA, in the early 1980's in which southerly flow directions were recorded for fluvial channel deposits in the Jupiter Creek Diggings in the Echunga area appears to has been the basis of all subsequent investigations.

The removal of Tertiary gravels was not only confined to the early exploration within the Mt Lofty Ranges. It continues today throughout the Adelaide Plains where outcrop is being completely removed or made inaccessible through the expansion of the Adelaide metropolitan area. As recently as the mid Sixties Tertiary outcrop existed north of Adelaide near the north western margin of the Golden Grove Embayment prior to the development of the suburb of Windsor Gardens (pers. comm. W.Preiss, 1996). Today we know nothing of these sediments which would have provided invaluable information on palaeodrainage in this part of the Golden Grove Embayment. Drilling now remains the only way in which geological information can be obtained within metropolitan Adelaide.

The St. Vincent Basin has throughout its history been associated with a prominent marine gulf (Cooper, 1985). Currently most of the basin, approximately 7000 sq km (Birt 1995) lies beneath Gulf St Vincent, a shallow marine gulf approximately 150km long and 65km wide. The Tertiary stratigraphy in this part of the basin has up until recently been only poorly known, relying on information obtained from the few wells drilled in the Gulf. Over the last few years numerous seismic surveys have been carried out in Gulf St Vincent and this has yielded a large amount of structural data about the underlying rocks. Unfortunately, the bulk of this seismic work targeted the much older rocks of the Cambrian Stanbury Basin and Permian-Carboniferous Troubridge Basin in search for oil (and minerals). The Tertiary information resulting from these investigations is of little use in the current project. One survey undertaken in 1994 as part of the MESA South Australian Exploration Initiative did include the St Vincent Basin as one of the targets. The data forming the basis of an Honour project investigating offshore Tertiary palaeochannels as potential diamond traps (Birt 1995). Unfortunately the survey grid pattern (Figure 2) only intersected two channels in the offshore Port Gawler region (Plates 4.3 & 4.5, Birt 1995).

GEOLOGICAL SETTING

The evolution of palaeodrainage within the St Vincent Basin is intrinsically tied to tectonic and structural evolution of the Mt Lofty Ranges, along with (global) sea level changes and climate.

Mt Lofty Ranges

The Mt Lofty Ranges were formed from Adelaide Geosynclinal deposits in Late Precambrian - Early Cambrian times and shaped through a process of extensive Cambrian - Ordovician tectonism, i.e. Delamerian Orogeny, Permian glaciation, Mesozoic weathering and erosion and Tertiary differential and episodic tectonism (Bourman, 1989). It was this latter series of tectonic events coupled with eustatic fluctuations, during the Middle Eocene, that were responsible for the development of the St Vincent Basin and subsequently a number of small basin within the Mt Lofty Ranges. Sedimentation commenced during this time with the first influx of terrigenous sediment, North Maslin Sand, carried by a network of rivers from catchments located in the uplands of the Ranges.

The Middle Eocene is recognised as having been a period of high rainfall and humidity. Palaeobotanical and palynological evidence, eg. Christophel 1994, Alley 1987, show that rainforest vegetation persisted in the region of the St Vincent Basin experiencing annual precipitation rates in the order of 2000mm and mean annual temperatures of around 20°C, eg. Golden Grove, (MAT 17-20°C, MAP 1900mm) and Maslin Bay (MAT 23-26°C, MAP 2000-2500mm). In such a climate water would have played a major role in shaping the landscape. Rivers, either as broad meandering, low energy channels or narrow, fast flowing high energy streams, eg. the Fly River in New Guinea, would have flowed continually, transporting large amounts of sediment from the Ranges into the developing basins. Drainage patterns would have been dynamic, changed by the episodic sea level fluctuations and tectonic activity resulting in marked changes in sedimentation rates and subsequently a variable succession of marine and terrigenous sediments throughout the basin. A look at the modern landsurface shows some surface evidence of the Tertiary palaeodrainage system within the Mt Lofty Ranges but within the St Vincent Basin most of these palaeochannels are buried beneath Quaternary sediments.

Palaeodrainage in the northern Mt Lofty Ranges has been controlled by topography and tectonism. Major faults (eg. Alma, Templeton, and Kitchener) divide the western and southern segment of the Mid North into meridionally trending blocks which combined with a series of structurally controlled ridges and valleys within the Precambrian rocks to form a series of north-south trending Early Tertiary channels (Alley 1977).

In the southern Mt Lofty Ranges reactivation of a number of ancient faults, eg. Para, Eden- Burnside, Clarendon and Willunga, during the Early Tertiary produced a series of southwest-northeast trending blocks which controlled Early Tertiary channel flow into an associated series of sub-basins, concordant with the grain of the Delamerian fold belt.

Base-metal mineralisation is wide spread throughout the Ranges (Figure 22, Newton 1996) with known deposits of copper, gold, silver, lead and zinc. Diamonds are also known but as yet a source has not been positively identified (Gerdes 1988, Townsend *et al* 1994).

St Vincent Basin

The St Vincent Basin is a Middle Eocene intracratonic basin, consisting of four sub-basins, i.e. Adelaide Plains Sub-basin, and the Golden Grove, Noarlunga and Willunga Embayments. The basin is bounded by the Delmerian fold belt in the east, Stuart Shelf and Gawler Craton in the west and Kangaroo Island and a basement high across Investigator Strait in the south (Figure 1). The basin has no direct contact with the southern continental margin. For the most part the generally flat lying Tertiary sediments lie directly on Precambrian basement but in some places Permian Cape Jervis Formation underlies them.

Stratigraphy

The St Vincent Basin has a sedimentary record dating from the Early Tertiary through to the present. (Figure 3 adapted from Figure 10.11 of Volume 2 of the Geology of South Australia: Correlation chart for Tertiary strata in the St Vincent Basin). Sedimentation became widespread within the Basin during the Middle Eocene as a result of the combined widening of the Southern Ocean, resulting in the widespread flooding of the continental margin, and the renewed uplift of the Mt Lofty Ranges. The succession begins with the fluvio-lacustrine North Maslin Sand which is conformably (for the most part) overlain by the marginal marine and glauconitic South Maslin Sand (Middle to earliest Late Eocene) in the Willunga Embayment. Remnants of fluvio-lacustrine sand and gravel are widespread at high levels within the Mt Lofty Ranges. Some of these, because of their geomorphic position, may be equivalent to North Maslin Sand (Lindsay & Alley 1995).

In the Adelaide Region and into the northern and eastern parts of the Basin the North and South Maslin Sand units are stratigraphically separated by the paralic to marine carbonaceous sediments of the Clinton Formation which becomes progressively younger towards the top of the St Vincent Basin, i.e. Middle Eocene to Early Oligocene. The marginal marine and diachronous character of the unit implies deposition occurred under conditions of gradual marine transgression, i.e. the Tuketja Transgression (McGowran 1981, McGowran *et al* 1992), from the south.

In the southern part of the basin the South Maslin Sand is overlain by the Late Eocene Tortachilla Limestone which extends into the Adelaide SubBasin and as far north as Campbelltown in the Golden Grove Embayment (Lindsay & Alley 1995). This unit is succeeded by the marine Blanche Point Formation (Late Eocene) and Chinaman Gully Formation (earliest Oligocene). The Oligocene to Middle Miocene was a period of widespread carbonate deposition in the St Vincent Basin with the bryozoal marly limestone of the Port Willunga Formation occurring over most of the Basin and extending into the small intramontane basins within the southern Mt Lofty Ranges. The Formation is divided into three units, the lowest, the Aldinga Member, Ruwarung Member and the uppermost unnamed Unit, which includes the Munno Para Clay Member. The marginal marine Rogue Formation present on eastern Yorke Peninsula correlates with both the upper part of the Blanche Point Formation and the Ruwarung Member of the Port Willunga Formation.

The Late Pliocene marginal marine Hallett Cove Sandstone unconformably overlies the Port Willunga Formation. The marine Dry Creek Sand underlies and intertongues with Hallett Cove Sandstone in the Adelaide Plains Sub-basin.

Intramontane Basins

Of the intramontane basins within the Mt Lofty Ranges, the Oligocene - Early Miocene Barossa Basin is the largest, with fluviolacustrine sediments and lignites occupying the present Barossa Valley and scattered deposits forming a second lobe that extends from Stockport in the north and the South Para River in the south. Sediments are thickest along the faulted eastern margin of the valley and overlie an irregular bedrock floor (Alley, 1995).

The Meadows, Myponga and Hindmarsh Tiers Basins are peripheral to St Vincent Basin (Lindsay & Alley 1995). The Meadows Basin lies within the present Meadows-Kuitpo valley in the southern Mt Lofty Ranges. Middle to late Tertiary sediments were deposited here in a shallow marine (possibly estuarine) to fluvial environment. A possible marine connection with the Myponga Basin has been suggested (Alley 1995). The Myponga Basin is small and narrow and contains a substantial thickness mid-Tertiary limestone. This same bryozoal limestone occurs in the Hindmarsh Tiers Basin. A pre-Middle Miocene marine interconnection between both basins and the St Vincent Basin has been suggested by Lindsay and Alley (1995).

METHODS

To determine the palaeodrainage within the onshore part of the St Vincent Basin and associated uplands, the Mt Lofty Ranges. Tertiary topography was reconstructed using generalised contouring. The Joint Operations Graphics 1:250 000 topographic, Series 1501, Edition 1 maps of Adelaide (Sheet SI 54-9), Barker (Sheet SI 54-13) and Burra (Sheet SI 54-5) displaying 50 metre contours were used. Only those showing marked changes to the land surface were mapped and used in the reconstruction. The three maps were then combined to produce a revised topography map of the St Vincent Basin and Mt Lofty Ranges. Tertiary sediment distributions, as shown on the Adelaide, Barker and Burra 1:250 000 Geological Maps were then added. From the is revised combined data it is possible to determine former Tertiary river valleys and channels (Figure 4).

The majority of the figures present in this report have been adapted from previous publications and Department of Mines and Energy, South Australia reports. All others have been produced using the computer-graphics software Corel Draw5™ .

ST VINCENT BASIN PALAEODRAINAGES

BROUGHTON PALAEOCHANNEL

Of the palaeodrainage systems within the northern Mount Lofty Ranges, the Broughton palaeochannel is the largest and most extensive (Figure 5). The present westward flowing Broughton River is the principal watercourse into which feed the south flowing, Crystal Brook, Yackamoorundie, Fresh Water and Booborowie Creeks, and Rocky River and the north-flowing Hutt and Hill Rivers and Farrell Creek.

It would appear that at least since the early Tertiary the ancestral Broughton River has flowed westward across the Ranges out onto the Condowie Plains (Alley 1973), at the head of the St Vincent Basin, being fed by a number of north and south flowing tributaries. Deposition over this low lying plain during the Middle -Late Eocene produced a succession of lignite carbonaceous clay, sand and silt, i.e Clinton Formation (Figure 5a). Deposition continued but under increasing marine influence into the Early Oligocene with the Snowtown Sand and its correlatives Werrindi and Tarella Silts deposited (Figure 5b). Alley (1995) recognises these latter sediments as being the product of a gradual marine transgression from the south.

All marine influence was effectively removed from this part of the basin by the Late Cainozoic with the formation of the Nantawarra Hills (Figure 5c). This upland impeded drainage to the north and produced a large lake. The thick fluvio-deltaic sediments deposited in the lake are known as the Koolunga Gravel.

Recent tectonism is likely to have been responsible for redirecting the Broughton River, through stream capture, northwestward over the Pirie Plain to drain into Spencers Gulf, i.e the Pirie Basin (Figure 5d). This uplift also appears to have caused the capture of Crystal Brook, Rocky River and Yackamoorundie Creek which are redirected westward before joining the Broughton River.

GILBERT AND LIGHT PALAEOCHANNELS

The Gilbert and Light palaeochannels are both associated with the Barossa Basin (Figure 5). From the early Tertiary both channels are likely to have maintained a southerly flow, through lowlands in the Tarlee - Freeling area and the modern Barossa Valley respectively, up until the Late Oligocene - Early Miocene whereby rising sea level led to the formation of a large estuary occupying the Tarlee-Freeling lowland and Barossa Valley (Barossa Basin) and the deposition of a succession of fluvio-lacustrine sand, silt, clay and lignite, i.e. Rowland Flat Sand (Alley 1995) (Figure 5b). Palaeocurrent and mineralogic studies indicate that the sediments were eroded from a deeply-weathered landsurface and deposited by powerful streams flowing largely from the north (Alley 1973). This is consistent with the geomorphic history of the area (Alley 1995). The sand-dominated Early-Middle Miocene estuary, referred to as the "Gawler estuary" by Olliver and Weir (1967) would appear to be associated with the palaeovalley containing the Barossa Basin. Located between the Para and Alma Faults west of Gawler (Figure 17, Belperio and Bateman 1986) the estuary contains 30m of interdigitating marine shelly sands and fluvial sands and gravels (Belperio and Bateman 1986).

The subsequent Late Cainozoic (Pliocene) regression resulted in the draining of the Barossa Basin and the confluence of the Light and Gilbert palaeochannels to produce the Light palaeochannel (Figures 5c). This was achieved by capture from the west by other streams cutting back through the Alma Range (Alley 1973), with the resultant palaeochannel flowing westward into the St Vincent Basin (Figure 5d).

NORTH PARA PALAEOCHANNEL

The North Para palaeodrainage system consists of the paleo-Gawler and North Para Rivers as well as the north-flowing South Para River. The palaeochannel post-dates the Latest Oligocene - Early Miocene deposition within the Barossa Basin, developing during the Late Cainozoic regression and being responsible for the subsequent draining of the Basin (Figure 5c). The North Para palaeochannel probably followed a southeasterly course within the existing palaeovalley (Barossa Valley) while the South Para palaeochannel appears to have evolved from drainage off the north-eastern end of the southern Mt lofty Ranges. Both palaeochannels uniting with the ancestral Gawler River, before flowing out through the Para Fault Scarp at Gawler and south along the escarpment into a large Pliocene coastal delta, approximately 4km north of Elizabeth (Figure 13, Belperio & Bateman 1986).

By the end of the Tertiary drainage via the Gawler palaeochannel had been redirected westward, to flow into Gulf St Vincent in the vicinity of Port Gawler.

Quaternary palaeochannels in the Waterloo Corner area have been suggested by Olliver and Weir (1967) as representing the courses of ancestral Gawler and Little Para Rivers which would indicate a northerly shift in channels since the Tertiary.

WAKEFIELD PALAEOCHANNEL

The Wakefield palaeochannel (Figure 5c) would appear to be the result of capture of the upper tributaries of the Gilbert River by the ancestral Wakefield River cutting back through the Alma Fault Scarp. It is possible that the channel is the same age as that of the North Para palaeochannel, with stream capture being stimulated by the drop in sea level during the Pliocene regression. The channel flowed westward draining into the northern tip of the St Vincent Basin (Figure 5c).

GOLDEN GROVE PALAEOCHANNEL

The Golden Grove palaeodrainage would appear from the reconstructed landsurface (Figure 4) to have originated east of the Para Fault Scarp in the vicinity of Bare Hill (Parrawirra Recreation Park) flowing south westward and entering the St Vincent Basin via the Golden Grove Embayment. Within sand quarries in the Golden Grove Extractive Industry Area (McCallum 1988), two main Late Middle Eocene channels (Hos 1977, Alley 1988) are shown cut into the basement and filled with fluviolacustrine sand, gravel, shale and carbonaceous clay (Figure 6). Flow direction at this time was in a southerly direction (McCallum 1988). There is an overall fining up of sediments within these channels from poorly sorted course sand and gravel to fine sand and clay. In the south-eastern parts of the drainage system a large plastic clay unit (i.e. Unit 2, McCallum 1988) interrupts the cycle. This unit is fossiliferous containing an abundance of well preserved plant fossils, i.e wood, mummified leaves, dispersed cuticle, flowers, and palynomorphs. Palaeobotanical investigations (Barrett 1987, Barrett and Christophel 1988, Christophel and Greenwood 1987, Rowett 1993, Rowett and Sparrow 1994) have identified a rainforest flora containing more than 50 parataxa including Elaeocarpaceae (*Sloanea/Elaeocarpus*), Lauraceae (*Cryptocarya* and *Endiandra*), Myrtaceae (*Myrtaciphyllum*), Proteaceae (*Banksieaephyllum*, aff. *Neorites*), Sterculiaceae (*Brachychiton*) and the fern *Lygodium*. Leaf physiognomic analyses give an estimated mean annual temperature of 18.7°C and mean annual precipitation of 1910mm (Greenwood 1996).

Sedimentation within the channel indicates an overall drop in stream energy from a high energy river capable of carrying coarse sands, gravels and large boulders up to 2m in diameter to a low energy lake where fine sands and clay are deposited (McCallum 1988). This rapid change in stream energy is possibly the result of either a blockage of the channel down stream, due to channel abandonment (McCallum 1988), or localised tectonism. Meandering of the river within the main channel produced minor disruptions to the overall sedimentation cycle with clay/silt/fine sand lenses interspersed. The large fossil-bearing plastic clay lens (Unit 2, McCallum 1988) is the likely product of a large ox-bow lake.

Varying concentrations of heavy minerals, including ilmenite, altered ilmenite, rutile and zircon and lesser quantities of monazite, tourmaline, staurolite, sillimanite and kyanite occur in the channels sediments. These are probably derived from the reworking of Tertiary sediments with a primary source of pegmatites, granitoid rocks and schists exposed to the north-northeast of the Golden Grove, possibly near Williamstown (McCallum and Morris 1980).

Tertiary sands extend as far south as Highbury-Dernacourt (Olliver & Weir 1967, McCallum 1978, Pain *et al* 1978, Reed 1982, Sheard & Bowman 1996). These sands are correlative to those of the Golden Grove Extractive Area which would indicate the Late Middle Eocene Golden Grove palaeochannel maintained a southward flow through the Golden Grove Embayment at least as far south as Dernancourt. The occurrence of a basal Tertiary clay unit (Reed 1982) in the Vista and Hope Valley areas would suggests the channel had a slow meandering course southward. This clay is probably the same as Unit 2 in the Golden Grove Extractive area (McCallum 1988) at the northern end of the Embayment (Figure 6). Mapping this channel further south becomes increasingly difficult as the Tertiary sediments thin markedly and become increasingly difficult to trace within the suburban area.

East- west Quaternary channels are also recognised in the exposures within the quarries. These channels cut across the Tertiary sediments being up to 8m thick near the eastern margin of the embayment becoming gradually broader and shallower to the west (McCallum 1988).

Further to the south in channel sediments within the St Agnes sand quarries palaeoflow measurements indicate an east-west flow direction (pers. comm. M Sheard 1996). It is possible that these channels are related/linked to another series of east-west channels identified in basement in the Modbury area (pers. comm. M Sheard 1996). The latter channels contain Quaternary infill. It could be further suggested that this east-west drainage may have been associated with an ancestral Dry Creek. This palaeochannel appears to have flowed westward over the Para Block, turning northwestward on entering the coastal plain and establishing a large alluvial fan at the base of the Para Fault Scarp before entering the sea probably through a marine inlet in the Outer Harbour area (Figure 7). The modern Dry Creek appears to have maintained the same course.

Olliver and Weir (1967) made the following general comments that.... "On the Adelaide Plains fossil stream beds remain probably to be discovered; surface expression is generally absent though some channels are marked by a gentle topographic rise. The channels are narrow and irregular ..... Because the ancient streams meander across the ancestral Adelaide Plains only a very detailed drilling programme would be adequate to define the deposits..."

TORRENS PALAEOCHANNEL

Further south in the Golden Grove embayment the modern River Torrens appears to follow the course of the Torrens palaeochannel (Figure 4). This Pleistocene channel flowed through the South Mt Lofty Ranges westward from near Mt Pleasant through the Torrens Gorge over the Eden/Burnside Fault Scarp along the Torrens Valley in the Golden Grove Embayment down the Para Fault Scarp and out onto the Adelaide Plains. Once on the coastal plain the palaeochannel changed its course northwestward forming a large alluvial fan extending to the modern Port River (Aitchison *et al* 1954, Sheard & Bowman 1996). (Figure 7). From possibly the Late Quaternary until the present the

River Torrens has flowed westward into coastal lagoons/swamps in the vicinity of Henley Beach, to eventually enter the sea via either the Port River estuary to the north or the Patawalonga Creek to the south (Figure 8 after Taylor *et al*, 1974). The construction of an artificial channel in 1937, from near Lockleys to the Gulf at Henley Beach, established the modern mouth of the River Torrens (Sheard & Bowman 1996).

Channel sediments have also been identified in drillholes at West Beach which would suggest that at least at sometime during the Quaternary the ancestral River Torrens flowed into the sea at West Beach (Sheard & Bowman 1996).

PORT GAWLER AND BUCKLAND PALAEOCHANNELS

In the region of Port Gawler a number of Early Tertiary channels are eroded into bedrock. Some of which have been identified as containing Middle Eocene cross-bedded, fluviatile sediments of the North Maslin Sand (Belperio & Bateman 1986, Belperio 1987, Cockshell 1979). The channels occur in the region bounded by the East-West and Redbanks Faults and flowed westward, i.e. Middle Beach palaeochannel, and southwestward, i.e. the Buckland, Redbanks and Port Gawler palaeochannels, into Gulf St Vincent, to join another palaeochannel (unnamed) which flowed southward, parallel to the existing coastline (Figure 9). The full length and course of this offshore channel remains unknown. It would appear to be unrelated to the offshore Tertiary palaeochannel identified by Birt (1995) using seismic data, which lies further out in the gulf. However, it is interesting to note that this channel appears to also run parallel to the existing coastline. The "Birt" palaeochannel is possibly the same as the inferred Late Palaeocene - Early Eocene palaeochannel illustrated by Benbow *et al* (Figure 10.42, 1995) which flowed from the present Mid - North of South Australia southward through the middle of the modern Gulf St Vincent then westward between Yorke Peninsula and Kangaroo Island to join up another inferred palaeochannel off the northeastern end of Kangaroo Island. Unfortunately the authors make no direct reference to this channel. A small palaeochannel on the southern side of Kangaroo Island which supposedly flowed southward, is currently being investigated as a source of alluvial diamonds.

BARABBA PALAEOCHANNEL

To the north of Port Gawler, between Mallala and Balaklava, a major Early Tertiary river system within a trough-like depression in Precambrian bedrock has been identified associated with the Barabba Gravity Low (Cockshell *et al* 1978). The feature is fault-bounded, with the north-south trending Redbank-Owens and Whitwarta Faults to the east and west respectively, and east-west faults in both the north and south (Figure 10). Enlargement of the river channels to the south indicates the river system matured from north to south. Tertiary channel sediments thicken to the south (approx. 200m) with The Late Eocene to Pliocene marine sediments overlying Late Eocene non -marine Clinton Formation (Cockshell *et al* 1978). It is possible that input from the north came from an Early Tertiary watercourse in the northern Mt Lofty Range, possibly the Gilbert palaeochannel (Figure 4).

The minimal deformation of the Cainozoic sediments after deposition suggests only a single phase of faulting occurred in the area allowing erosion of the fault scarps to continue throughout the Tertiary causing a reduction in relief across these faults (Cockshell *et al* 1978). However, the East - West Fault (Belperio & Bateman 1986) at the southern end of the palaeochannel does appear to have prevented drainage into the Port Gawler area, at least during the Late Eocene.

MELTON PALAEOCHANNEL

The Melton palaeochannel is found on the north-western margin of the St Vincent Basin (Figure 11). Recent detailed drilling of construction sand deposits on northern Yorke Peninsula has defined the course of the channel which extends for more than 60km northwards from near Alford in the north to Ardrossan.

To the south of Ninnes, the palaeochannel follows the core of a syncline of gently dipping to flat-lying Cambrian Kulpara Limestone. Basal topography shows a marked relief in the region between Ninnes and Melton becoming more gentle and undulating near Kainton (Figure 11) (Pain *et al* 1992).

The north-north-easterly trending Ardrossan Fault marks the southeastern margin of the channel. South of Kainton, the western margin of the palaeochannel is marked by an escarpment which parallels the Ardrossan Fault. A north-northwesterly trending escarpment to the west of

Melton similarly marks the western limit of the palaeochannel in this area (Pain *et al* 1992).
The channel sediments are up to 90m thick and consist of basal ?Eocene fluvial sand, gravel, silt and clay. Bedding indicates flow direction was southward with sedimentation occurring in a fluvial to deltaic environment. Although unfossiliferous, these sediments have been tentatively correlated with North Maslin Sand (Pain *et al* 1992). In some places this sand is overlain by the Late Oligocene to Early Miocene Melton Limestone. Five units have been identified in the Melton Limestone (Lindsay 1970) which represent five transgressive intervals (Alley & Lindsay 1995). The limestone is overlain by the Late Tertiary mottled clayey sands, sandy clays and conglomerate of the Gibbon Beds (Parker & Flint 1983).

It would appear that the palaeochannel was a substantial aquatic corridor between the St Vincent Basin and Pirie Basin during the Middle Eocene to Middle Miocene.

ONKAPARINGA PALAEOCHANNEL

The Onkaparinga palaeochannel appears to have been a single Early Tertiary channel (Eocene, Bourman 1989) which was located to the south of the modern Onkaparinga River, on the northeastern margin of the Willunga Embayment. It would appear that following post Eocene tectonic uplift the channel altered course northward (Bourman 1989).

Chemical similarities in cemented channel sediments collected from a number of localities between a road cutting on the Clarendon-Kangarilla Road (Rix and Hutton 1953) and the Chapel Hill Mine near Echunga has been interpreted by Bourman (1989) to demarcate a palaeochannel related to the ancestral Onkaparinga River (Figure 12). The Clarendon - Kangarilla channel sediments are dated as Eocene, based on leaf fossils described as *Magnolia sp.* (Mawson 1953) and can therefore be equated with the North Maslin Sand. Bourman (1989) concludes that if the gravels near Echunga are the same age then it demonstrates the occurrence of an ancestral Onkaparinga River in the Eocene. It can be further concluded that the North Maslin Sand which occurs throughout the Willunga Embayment was probably deposited by a southward flowing Early Tertiary palaeochannel whose origin was some distance to the north-northeast within the Mt Lofty Ranges. The Onkaparinga palaeochannel was possibly responsible for the deposition of these sediments but until more information is available a southward course for the channel during the Eocene remains speculative.

MASLIN BEACH PALAEOCHANNELS

In the Maslin Bay - Pedlar Creek Area, along the northern margin of the embayment, detailed drilling for the extractive industry has identified a number of Early Tertiary palaeochannels. How these are related to the Early Tertiary Onkaparinga palaeochannel remains unknown.

Tertiary palaeoflow direction in the Maslin Bay-Pedlar Creek area follows that of a series of deeply incised southwesterly trending valleys in the Adelaidean basement which probably converge a few kilometres offshore of Maslins Beach (Pain 1988). Five palaeochannels containing North Maslin Sand have been identified, three within operating sand pits in the area, the remainder interpreted from Pain's 1988 North Maslin Sand structure contour map, which has been revised here as Figure 13. The longest palaeochannel lies a kilometre east of the Christies - Noarlunga sand pit extending from the Martins - Victor Harbor Roads junction southwest to near the Communication - Bayliss Roads junction. A second palaeochannel is mapped from immediately west of a small L-shaped sand pit on Tatachilla Road southwestward through the Christies - Noarlunga sand pit and continuing southwestward over Sherriffs Road. Two small channels can be identified in the Readymix - Pedlar Creek sand pit, both flowed southwestward joining a few hundred metres west of the Main South - Maslin Road junction. From the structure contours it appears this channel maintained a southwestward flow through the southeastern corner of the Monier (Rocla) Maslin Beach Sand Pit, continuing southwestward towards the modern coast. In the southwestern corner of the Monier (Rocla) Maslin Beach Sand Pit the unconformable contact between the North and South Maslin Sands (Plate 10, Pain 1984; Photo 42499 pg 171, Lindsay & Alley 1995) has been identified as a palaeochannel. This would appear to be the same channel identified as the Maslin Beach palaeochannel on Figure 13. Another small palaeochannel is mapped from approximately 1 kilometre north of the Monier (Rocla) Maslin Beach Sand Pit extending southwestward for a kilometre over Commercial Road towards the coast. It is possible that the two latter palaeochannels were evident in the old (rehabilitated) Readymix Maslin Bay sand pit and responsible the accumulation of plant matter that formed the Maslin Bay fossil flora.

This famous fossil flora has been studied in detail by a number of palynologists and palaeobotanists since their discovery in the mid 1960's including, Lange (1970), McGowran *et al* (1970), Lange and Smith (1971), Harvey (1974), Christophel and Blackburn, (1978), Blackburn (1981) and Alley (1987). The most recent study of the flora revealed a diverse flora comprising more than 200 leaf types and plant cuticle types (Dr L.Scriven, pers. comm 1995). The palaeobotanical information obtained from this locality has been of particular significance in Australian Tertiary palaeoclimatic interpretation and vegetation reconstruction. Recent foliar physiognomic and palaeobotanical analyses of the Maslin Bay flora suggest it represented a mesothermal - megathermal rainforest which experienced a mean annual temperature range of 23-26°C, the warmest documented Australian Middle Eocene flora (Christophel 1994), and annual rainfall of 2000mm - 2500mm, i.e. a markedly warmer and more humid in this coastal lowland than at present (Greenwood 1994).

Palaeodrainage information for the rest of the Willunga Embayment is limited. Recent investigations undertaken by the Groundwater Division, Department of Mines and Energy Resources, South Australia has seen a number of preliminary isopach maps produced which suggest a southwestward flow probably persisted throughout the Embayment up to the Late Eocene (Figure 10). Drilling has also revealed an east-west oriented Late Eocene palaeochannel midway between McLaren Vale and Willunga infilled with Chinaman Gully Formation sediments, thickening to the east between 20 - 30m (pers. comm. N. Watkins). This is probably the same channel recognised by Cooper (1979) but is now been shown to contain much thicker sediments to the east.

MEADOWS AND MYPONGA PALAEOCHANNELS

The Meadows palaeodrainage is represented by a single Middle - Late Tertiary channel confined within the modern Meadows-Kuipto Valley whose headwaters occurred in the vicinity of Echunga and paralleled the course of the modern Meadows Creek (Figure 4). The valley is bounded on the west by the Willunga Fault Scarp and to the east the Meadows Fault Scarp. Permian Cape Jervis Formation sediments are found at depth in the southern part of the valley which are overlain by up to 90m of Early Tertiary sediments (Alley and Lindsay 1995) possibly equivalent to North Maslin Sand. A southerly flow direction has been recorded for Tertiary fluvial channel deposits from a site within the palaeochannel, at Forestry Reserve 393 in the Echunga Goldfield (Gerdes 1988). Until Middle Tertiary times this channel probably included the Myponga palaeochannel and drained into the sea in the vicinity of Normanville. ?Latest Oligocene/ Miocene uplift of the fault block followed to produce the Meadows and Myponga Basins. This tectonism was accompanied by a marine transgression which was responsible for the deposition of Oligocene limestones (Port Willunga Formation) in the Myponga and Hindmarsh Tiers Basin and the inundation of the Myponga palaeodrainage system, with a marine influence possibly extending into the Meadows Basin.

A younger Miocene marine transgression is recorded in the Myponga Basin with the deposition of a bryozoal limestone (Lindsay and Alley 1995). This unit, up to 120m thick, is interrupted by intervals of carbonaceous clay and quartz sand, representing at least four regressive phases, which would suggest the fluvial input of sediments via the Meadows-Myponga palaeochannel occurred during latest middle Tertiary.

HINDMARSH VALLEY PALAEOCHANNEL

The modern Hindmarsh River appears to follow the course of this Tertiary palaeochannel. The Hindmarsh Valley palaeochannel probably originated from the upland region between Myponga Hill and Mount Cone and flowed south eastwards to Encounter Bay. It is remotely possible that the Meadows-Myponga palaeochannel adopted this course at some time during the Middle Tertiary. The terrigenous sediments at the base of the Late Oligocene limestone of the Port Willunga Formation (Lindsay & Alley 1995) within the Hindmarsh Tiers Basin were probably deposited by this Middle Tertiary palaeochannel. The limestone which formed during the Late Oligocene Janjukian marine transgression is also present in the Myponga Basin (Figure 4).

BLACKWOOD PALAEOCHANNEL

In the Blackwood rail cutting an unconformable contact is exposed between weathered, bleached and mottled Precambrian metasediments and Tertiary mottled sands, gravels and clays. These ferruginsed sediments have been interpreted as channel infill and dated as Eocene by Bourman (1989). Unfortunately the sediments are not easily defined elsewhere but it appears that the course of the modern Sturt River follows a similar course to that of the suggested Eocene channel, passing through the Sturt Gorge area on the Eden Moana Fault Scarp, into the Adelaide sub-Basin (Figure 12). Where the channel may have entered the sea remains unknown.

CHANDLER'S HILL PALAEOCHANNEL

The generalised contouring (Figure 4) of the Mt Lofty Ranges shows a channel having flowed north eastwards from Chandler's Hill to Cherry Gardens with a smaller tributary, i.e. Ironbark, to the east trending in the same direction. The only remaining Tertiary sediments occur on the modern ridges.

The generalised contouring of the Mt Lofty Ranges also identified a number of palaeochannels on the eastern side of the Ranges which flowed eastward into the Murray Basin, i.e. Bremer, Finnis River, Reedy Creek and Marne River palaeochannels. These are not discussed in this report.

MINERAL RESOURCES IN THE MOUNT LOFTY RANGES

GOLD

Gold was first discovered in the southern Mt Lofty Ranges at Castambul in 1846 (Drexel 1982) and by 1900 several significant local discoveries had been made including alluvial gold at Echunga, Forest Range, Birdwood, Gumeracha, Woodside, Uraidla, Lobethal, Para Wirra and in the Barossa Valley (Figure 14). The Echunga goldfields located in the central part of the Ranges was South Australia's most important (Drew 1992). Gold was found at shallow depth in Quaternary and Tertiary fluvial sediments. Some gold was also recovered from quartz veins in the underlying Adelaidean Aldgate Sandstone and Woolshed Flat Shale (Newton 1996).The alluvial diggings of the Forest Range goldfields yielded mainly small nuggets from the Quaternary and possibly Tertiary sediments. The Woodside goldfields on the eastern side of the Ranges operated from the late 1800's up until 1938. Gold was recovered from the nearby water courses as well as quartz-sulphide veins in the Umberatana Group metasediments (Newton 1996).The Birdwood Goldfield located in the eastern Ranges, approximately 15km north of Woodside was probably the most extensive with alluvial and quartz reefs being mined. Workings extend across Adelaidean metasediments of the upper Burra Group and Cambrian Kanmantoo Group metasediments (Newton 1996).

The principal gold mining operation in the northern Mt Lofty Ranges was the Barossa Goldfield (Figure 14). Discovered in 1868, it was the largest alluvial gold mining operation in the Mt Lofty Ranges. Gold was recovered from gravels at the base of the Tertiary fluvial sediments and in modern drainage channels. It was also found in quartz and haemitite veins within underlying schist and gneiss of the Palaeoproterozoic Barossa Complex (Newton 1996).

Gold has been mined at Moppa, approx. 3km north of Greenock in the Umberatana Group, Yudnamutana subgroup.

The Ulooloo goldfield, northeast of Hallett consists of two main areas, alluvial workings along Coglin Creek and Twighams Lead 5km to the northeast (Figure 14). In 1871 gold was found in alluvium of three ages in the Coglin Creek area, cemented Tertiary alluvium, shallow leads on present alluvial flats and creekbeds. In the Terowie area gold was recovered from a quartz-ironstone reef on Waupunyah Creek in 1886 and at the turn of the century from an alluvial deep lead at Mittopitta.

Another mine is located on the northern slopes above Walton Palace Creek, approximately 18km east of Spalding.

Mongolata Goldfield is on the eastern edge of the Mt Lofty Ranges, 15km north-east of Burra (Figure 14). The underground gold is found in quartz and ironstone veins and stockworks in Umberatana Group Cox Sandstone Member quartzite and in underlying slate (Newton 1996). It would appear to have little or no association with any of the palaeodrainage channels shown on Figure 4.

DIAMONDS

The largest number of diamonds to be found in South Australia have come from the Echunga area, having been recovered during gold panning operations. Of the 200 diamonds found, 50 are of gemstone quality. However, a local source of these gemstones has not been found. A 1982 morphological study of two Echunga diamonds from the Department of Mines and Energy, South Australia collection by CRA geologists indicated that they are alluvial, and therefore possibly of distal origin (Gerdes 1988). Based on this and other geological, chemical and geophysical information Gerdes (1988) suggested the gems may be of Ordovician-Silurian age and sourced from kimberlites possibly in the Gumeracha area, 30km NNE of Echunga (Figure 15).

As the only location in South Australia where sizeable gem-quality diamonds have been discovered, finding the source of these stones remains a prime exploration target. In a recent review of diamond resources in South Australia undertaken by the Department of Mines and Energy, South Australia it was suggested that based on the association of diamonds with a 'rutile' anomaly at Echunga, a mineral resembling rutile might be an important indicator of lamproites (Townsend *et al* 1994).

There have been no reports of diamonds being recovered from sites within the northern Mt Lofty Ranges. Detailed geological mapping currently being undertaken as part of the revision of the Burra 1:250 00 Geological Map has identified a number of outcrops that are potentially diamondiferous, i.e. the Yackamoorundie, Yongala, Ucocola and Whyte Park (Cowley and Preiss 1997). However, none of these sites have been adequately tested.

PALAEODRAINAGE TARGETS

A number of potential palaeodrainage targets exist within the St Vincent Basin. The most prospective targets appear to be associated with Tertiary palaeochannels that flowed out of the southern Mt Lofty Ranges. It should be noted that only very general target localities are possible at this stage as in all areas discussed a great deal more drilling, stratigraphy, sedimentology and biostratigraphy is required to map these palaeochannels.

ONKAPARINGA PALAEOCHANNEL

The Onkaparinga palaeochannel was sourced in the Echunga - Woodside area (Figure 4). Alluvial and reef gold discoveries, as well as diamonds, have been numerous in this area, indicating sources have existed in the area since the erosion of the Ranges began, i.e. pre-Tertiary times, and making it a particularly prospective area. Identifying specific targets is currently not possible but alluvial gold and diamonds are most likely to occur in the basal gravels and courser units of the North Maslin Sand.

With the possibility of the ancestral Onkaparinga River having had a significant change in course during the Tertiary and the Maslin Bay-palaeodrainage being part of the Onkaparinga system then likely targets exist within both the Noarlunga and Willunga Embayment. In the Noarlunga Embayment residential development and conservation areas along the modern Onkaparinga River make target exploration extremely difficult. The most accessible traps would therefore be immediately offshore.

The Willunga Embayment would appear more prospective with extensive North Maslin Sand deposits in the Maslin Bay - Pedlars Creek area and Aldinga Beach area which may be a source of alluvial gold and diamonds. The implied confluence of the palaeochannels to the west of Maslin Bay (Figure 13) would also suggest the possibility of a near offshore Tertiary gold/diamond trap existing in the Gulf to the west of Maslin Bay. A similar offshore trap is likely to occur in the Gulf west of Aldinga Bay being part of the Tertiary drainage that flowed along the base of the Willunga Fault Scarp.

MEADOWS - MYPONGA PALAEOCHANNEL

The Meadows - Myponga palaeochannel also flowed from the Echunga - Woodside area. Unlike the Onkaparinga palaeochannel this palaeochannel had a well defined course, having always been confined within the modern Kuipto - Meadows Valley. Possible targets may exist in the Tertiary channels sediments that occur within the valley, the Meadows and Myponga Basins and possibly in near offshore traps in the vicinity of Normanville.

TORRENS PALAEOCHANNEL

The source of the Torrens palaeochannel lies within the Birdwood goldfields, in the Mt Lofty Ranges (Figure 14) which makes the channel sediments in this region prospective targets. These are the only accessible targets along the course of the palaeochannel. Quaternary gold discoveries have been made in fluvial sediments from a number of sites along the River Torrens including, Windsor Gardens, Adelaide and Hindmarsh, but none recently. The Quaternary/Recent River Torrens Fan (Figure 7) which extends from the base of the Para Fault block immediately to the west of Adelaide to Port Adelaide lies beneath the western suburbs of Adelaide and therefore not a realistic target. Similarly, the region between the Patawalonga Creek and the Port River where more recent Torrens sediments were deposited is no longer a feasible target. The Port River itself may be a possible target area for Recent alluvial gold.

NORTH PARA PALAEODRAINAGE

The Late Tertiary North Para and South Para palaeochannels are possible targets for alluvial gold, both having been the sites of previous discoveries (Figure 14). The South Para palaeochannel is the more prospective of the two being associated with four goldfields, i.e. the Deloraine, Gumeracha, Para Wirra and Barossa goldfields. Late Tertiary channel sediments are likely targets along the course of the palaeochannel. The region around the Barossa Goldfield is a likely target. The South Para and Warren reservoirs on the upper reaches of the modern South Para River may also be considered possible traps. Channel sediments in the vicinity of the Angaston and Gomersal goldfields are possible targets in the North Para palaeochannel. Another possible area for exploration would be the Pliocene deltaic sediments located at the mouth of the palaeochannel, on the Late Tertiary shoreline near Elizabeth. Unfortunately the target lies beneath the suburbs of Elizabeth and Salisbury area. It is possible some of these sediments have been reworked by the ancestral and modern Little Para Rivers, in which case the Quaternary sediments of the Little Para Fan, which drained into the Outer Harbour estuary near Bolivar, is another potential target.

WAKEFIELD RIVER PALAEOCHANNEL

The Late Tertiary Wakefield palaeochannel appears to have little prospectivity. A small amount of alluvial gold has been recovered from channel sediments near the head of the Wakefield palaeochannel, just south of township of Mintaro (the same source area for the Middle Tertiary Gilbert palaeochannel). This may be a target for some further investigation. Deltaic sediments deposited at the mouth of the Pliocene channel, located a short distance eastward of the modern shoreline on the lower reaches of the modern Wakefield River may be a possible target. It is likely these sediments have been reworked by the modern river and transported into shallow marine ?traps at the head of Gulf St Vincent at Port Wakefield.

LIGHT PALAEODRAINAGE

The Light palaeodrainage system appears to have three possible gold targets, the lower Rowland Flat Sand (Late Oligocene - Early Miocene) in the Freeling and Tanunda areas within the Barossa Basin and the Late Oligocene - Middle Miocene deltaic sediments of the "Gawler estuary "(Olliver and Weir 1967) located at the base of the Para Fault Scarp near Gawler (Figure 5). The Freeling target was probably sourced from the Mintaro area by the Middle Tertiary Gilbert palaeochannel while the Tanunda target was probably sourced from the Mt Rufus area by a tributary of the Middle Tertiary Light palaeochannel. Both palaeochannels probably responsible for depositing sediment in the younger "Gawler estuary". The small amount of alluvial gold recovered from goldfields in both source areas would suggest these targets are probably of low prospectivity. Residential expansion of the township of Gawler, over the "Gawler estuary", will make access to this target difficult.

BROUGHTON PALAEOCHANNEL

With the Ulooloo and Terowie goldfields situated near the head of the Booborowie palaeochannel it is likely alluvial gold is present within the Broughton palaeodrainage system. The most probable traps are beneath the Condowie Plains, in a number of small basins, north of the Nantawarra Hills, into which the Broughton palaeochannel drained for most of the Tertiary (Figure 5). Alluvial gold is possibly associated with a number of terrigenous units including the Bumbunga Sand Member, Condowie Silt Member and Tarella Silt (Early Tertiary), Snowtown Sand (Middle Tertiary) and Koolunga Gravels (Late Tertiary).

A post-Tertiary change in flow direction to the northwest resulted in drainage into Spencer Gulf and therefore the site of recent alluvial gold deposition, i.e. in the vicinity of Port Pirie.

BARRABA PALAEOCHANNEL

In the absence of an obvious source for this Early Tertiary channel it is difficult to estimate target potentials. It is possible there was a connection between the Early Tertiary Gilbert palaeochannel and the Barabba palaeochannel (Figure 5), in which case alluvial gold may have been deposited in the fluvial sediments at the southern end of the Barabba Gravity Low, i.e. just north of Mallala (Figure 10).

PORT GAWLER PALAEODRAINAGE

This palaeodrainage system does not appear to be associated with any of the Early Tertiary channels which flowed off the uplands to the west, i.e. Mt Lofty Ranges. Likely traps would be the North Maslin Sand unit within the Buckland Port Gawler and Middle Beach palaeochannels. Little is known of the offshore palaeochannels but they too are potential traps.

FUTURE WORK

As a preliminary investigation of St Vincent Basin palaeodrainage information the focus has been on the identification of palaeochannels and their potential for, primarily, gold and diamond exploration. Production of a generalised contour map of the study area has revealed many possible Tertiary channels and a literature review provided information on a number of these. However, a lot of the reviewed information has been anecdotal making it difficult to develop a temporal and spatial record of palaeodrainage for the region. The overall lack of palaeoflow and age data made it extremely difficult determining the relationship, if any, between channels, and subsequently mapping channels from their source area to where they entered the Gulf St Vincent.

What happens to these drainage systems in the offshore part of the St Vincent Basin remains for the most part unknown. It is therefore intended that a key focus of the next phase of the study will be Tertiary palaeodrainage within the St Vincent Basin which will include the reprocessing of seismic data from a series of lines across the Gulf St Vincent (Figure 16). It is essential that the links between the onshore and offshore palaeodrainage are identified if suitable gold, diamond and other placer mineral traps are to be located.

Proposed future work will include ;

- Confirming the location of the mouths of the palaeochannels, i.e. where they enter the Gulf St Vincent
- Further investigation of the temporal relationship between the Gilbert, Light, and Wakefield palaeochannels.
- Biostratigraphic analyses of Tertiary sediments within the Barossa Basin, “Gawler Estuary” and “Elizabeth Delta”.
- Further investigation of the connection between the Light, Barabba and Port Gawler/Buckland palaeochannels.
- Mapping the Golden Grove palaeochannel through the Highbury- Dernancourt and the Adelaide area.
- North Maslin Sand equivalent in the Melton palaeochannel.
- Investigating the east-west orientation of the Quaternary palaeodrainage pattern over the Adelaide sub-Basin, including the Dry Creek ,Sturt River, Brown Hill Creek and First - Fifth Creek channels.
- Further investigation of the temporal relationship between the Onkaparinga and Meadow-Myponga palaeochannels and the Onkaparinga and Maslin - Bay palaeochannels.
- Investigation of the Late Tertiary course of the Onkaparinga palaeochannel.
- Investigation of Kangaroo Island palaeochannels and their relationship with southern Mt Lofty Ranges palaeodrainage systems, eg. the Onkaparinga and Meadows-Myponga palaeochannels.
- Investigation of the existence of a northeasterly - southwesterly flowing palaeochannel along the western face of the Willunga Fault Scarp.
- Biostratigraphic analyses of Tertiary sediment s within the Chandler’s Hill and Blackwood palaeochannels.
- Palaeobotanical investigation of the Tertiary flora in the Claredon - Kangarilla Road sediments.
- Palaeoflow measurements of Tertiary sediments within the Meadows - Myponga and Finnis River palaeochannels.

- Investigation of Tertiary terrigenous sediments in the Myponga and Hindmarsh Tiers Basin as well as along the western margin of the Murray Basin.

REFERENCES

Aitchison, G.D., Sprigg, R.C. and Cochrane, G.W., 1954. The soils and geology of Adelaide and suburbs. *South Australia. Geological Survey. Bulletin* 32.

Alley, N.F., 1973. Landsurface development in the Mid North of South Australia. *Transactions of the Royal Society of South Australia*, 97(1):1 - 16.

Alley, N.F., 1977. Age and origin of laterite and silcrete duricrusts and their relationship to episodic tectonism in the Mid-North of South

Australia. *Journal of the Geological Society of Australia*. Vol.24(2): 107-116.

Alley, N.F., 1978. Middle Eocene age of the megafossil flora at Golden Grove: preliminary report, and comparison with the Maslin Bay Flora. *Transactions of the Royal Society of South Australia*, 111:211-212.

Alley, N.F., 1988. Middle Eocene age of the megafossil flora at Golden Grove, South Australia: Preliminary report and comparison with the Maslin Bay Flora. *Transactions of the Royal Society of South Australia,* Vol.111 (4): 211-212.

Alley, N.F., 1995. Barossa Basin. *In* Drexel, J.F. and W.V. Preiss (Eds) The Geology of South Australia. Volume 2, The Phanerozoic. *South Australia. Geological Survey. Bulletin* 54.

Alley, N.F. and Lindsay, J.M., 1995. Pirie Basin. *In* Drexel, J.F. and W.V. Preiss (Eds) The Geology of South Australia. Volume 2, The Phanerozoic. *South Australia. Geological Survey. Bulletin* 54.

Barrett, D.J., 1987. The Eocene Flora of Golden Grove, South Australia. The spatial and temporal components of a fossil deposit. University of Adelaide, B.Sc. (Hons) Thesis. Unpublished.

Barrett D.J. and Christophel, D.C., 1988. The spatial and temporal components of two Australian Tertiary plant megafossil deposits. In Christophel D.C. and Douglas, J. (Eds) Proceedings of the 3rd. International Organisation of Palaeobotanists conference. A-Z Printers, Melbourne.

Belperio, A.P., 1987. Vincent Map Sheet 1:50 000 Geological Series. South Australian Department of Mines.

Belperio, A.P. and Bateman, J.M., 1986. Cainozoic stratigraphy and structure of the Gawler and Vincent 1:50 000 map sheet areas. *South Australia. Department of Mines and Energy, Report Book 86/49.*

Benbow, M.C., Alley, N.F., Callen, R.A. and Greenwood, D.R., 1995. Chapter 10, The Tertiary, Geological History and Palaeoclimate. *In* Drexel, J.F. and W.V. Preiss (Eds) The Geology of South Australia. Volume 2, The Phanerozoic.*South Australia. Geological Survey. Bulletin* 54.

Birt, T.R., 1995. The Interpreted Tertiary Stratigraphy and Structure of the Offshore St. Vincent Basin. Flinders University of South Australia, B.Sc. (Hons) Thesis. Unpublished.

Blackburn, D.T., 1981. Tertiary megafossil flora of Maslin Bay, South Australia: numerical taxonomic study of selected leaves. *Alcheringa* 5:9-28.

Bourman, R.P., 1989. Investigations of ferricretes and weathered zones in parts of the southern and southeastern Australia. - A reassessment of the ‘laterite’ concept. University of Adelaide, Ph.D. Thesis. Unpublished.

Christophel, D.C., 1994. The early Tertiary macrofloras of continental Australia. *In* History of the Australian Vegetation: Cretaceous to Recent. R.S.Hill (ed.) Cambridge University Press, Cambridge.

Christophel, D.C. and Blackburn, D.T., 1978. The Tertiary megafossil flora of Maslin Bay, South Australia: a preliminary report. *Alcheringa* 2(4):311 319.

Christophel, D.C. and Greenwood, D.R., 1987. A megafossil flora from the Eocene of Golden Grove, South Australia. *Transactions of the Royal Society of South Australia.* Vol.111 (2):155-162.

Cockshell, C.D., 1979. Exploration for underground gas storage targets in South Australia. *South Australia. Department of Mines and Energy, Report Book* 79/146.

Cockshell, C.D., Nelson, R.G. and Cooper, B.J., 1978. Northern Adelaide Plains storage study. Barabba gravity low. *South Australia. Department of Mines and Energy, Report Book* 78/13.

Cooper, B.J., 1979. Eocene to Miocene stratigraphy of the Willunga Embayment. *South Australia. Geological Survey. Report of Investigations* 50.

Cooper, B.J., 1985. The Cainozoic St Vincent Basin - tectonic, structure, stratigraphy. *In* Lindsay, J.M. (Ed.) Stratigraphy, Palaeontology, Malacology: papers in honour of Dr. Nell

Ludbrook. *South Australia. Department of Mines and Energy, Special Publication*, 5:35-49.

Cowley, W.M. and Preiss, W.V., 1997. Geology and mineral potential of diapiric inliers in the northern BURRA 1:250 000 map area. *MESA Journal*, 5:37-45.

Drew, G. J., 1992. Goldfields of South Australia. *South Australia. Department of Mines and Energy, Report Book* 92/53

Drexel, J.F., 1982. Mining in South Australia: A Pictorial History. *South Australia. Department of Mines and Energy, Special Publication* 3.

Gerdes, R.A., 1988. Geophysical appraisal of the Echunga District, with reference to mineralisation. *Mineral Resources Review, South Australia*. 156:27-35.

Greenwood, D.G., 1994. Palaeobotanical evidence for Tertiary climates. *In* History of the Australian Vegetation: Cretaceous to Recent. R.S. Hill (ed.) Cambridge University Press, Cambridge.

Greenwood, D.G., 1996. Eocene monsoon forests in central Australia? *Australian Systematic Botany*, 9 95-112.

Harvey, W.J., 1974. The Maslin Bay Flora: an analysis of cuticular features. Unpublished M.Sc. thesis, University of Adelaide

Haq, B.U., Hardenbol, J. and Vail, P.R., 1987a. Chronology of fluctuating sea levels since the Triassic. *Science*. 235(4793):1156-1167.

Hos, D.P.C., 1977. Eocene palynology of a sample from Golden Grove,. *South Australia. Department of Mines and Energy, Report Book* 77/78

Lange, R.T., 1970. The Maslin Bay Flora, South Australia 2. The Assemblage of fossils. *N.Jahrbuch f. Geologie u. Paläontologie Mh.* 8:486-490.

Lange, R.T. and Smith, P.H., 1971. The Maslin Bay Flora, South Australia 3. Dispersed fungal spores. *N.Jahrbuch f. Geologie u. Paläontologie Mh*. 11:663-681.

Lindsay, J.M and Alley, N.F., 1995. Myponga and Hindmarsh Tiers Basins, *In* Drexel, J.F. and W.V. Preiss (Eds) The Geology of South Australia. Volume 2, The Phanerozoic. *South Australia, Geological Survey, Bulletin* 54.

Lindsay, J.M., 1970. Melton Limestone: multiple mid-Tertiary transgressions, south-eastern Gawler Platform. *South Australia. Geological Survey. Quarterly Geological Notes*, 33:2-10.

McCallum, W.S., 1988. Geology of the Golden Grove Extractive Industry area. *South Australia. Department of Mines and Energy, Report Book* 88/46.

McCallum, W.S. and Morris B. J., 1980. Heavy-mineral sands investigation Golden Grove, South Australia. *Mineral Resources Review, South Australia*. 148:46-60.

McGowran, B., 1991. Maastrichtian and early Cainozoic, southern Australia: planktonic foraminiferal biostratigraphy. *Geological Society of Australia Special Publication*, 18:79-98

McGowran, B., Harris, W.K. and Lindsay, J.M., 1970. The Maslin Bay Flora, South Australia 1. Evidence for an Early Middle Eocene Age. *N.Jahrbuch f. Geologie u. Paläontologie Mh*. 8:481-485

Mawson, D., 1953. The Willunga Basin. Introductory and historical notes. *Transactions of the Royal Society of South Australia*. 76:108-113.

Newton, A.W., 1996. Mineral exploration and development in South Australia. *South Australia. Department of Mines and Energy, Report Book* 96/1

Olliver, J.G. and Weir, L.J., 1967. The construction sand industry in the Adelaide metropolitan area. *South Australia. Geological Survey, Report of Investigations*, 30.

Pain, A. M., McCallum, W.S. and Spencer, W.G., 1978. Fine tailings investigation drilling of tailing dams and the results of laboratory evaluation. *South Australia. Department of Mines and Energy, Report Book* 78/56.

Pain, A. M., 1984. Sand and clay resources of the Maslin Beach - Pedlar Creek area. *South Australia. Department of Mines and Energy, Report Book* 84/7.

Pain, A.M., 1988. Sand and clay resources of the Maslin Beach - Pedlar Creek area. *Mineral Resources Review, South Australia*. 156:36-50.

Pain, A.M., Valentine, J.T. and Hayball, A., 1992. Reconnaissance drilling of construction sand deposits, northern Yorke Peninsula, report No.1. *South Australia. Department of Mines and Energy, Report Book* 92/56.

Parker, A.J. and Flint, R.B., 1983. WHYALLA map sheet. South Australia. Geological Survey. *Geological Atlas 1:250 000 Series,* sheet SI53-8.

Reed, J.A., 1982. Golden Grove - Hope Valley Hydrogeological Investigation, E & W.S. South Australia. *South Australia. Department of Mines and Energy, Report Book* 82/57.

Rix, C.E. and Hutton, J.T. 1953. A soil survey of the Hundred of Kuitpo in the Mount Lofty Ranges of South Australia. *South Australian Land Tax Bulletin* No.1.

Rowett, A.I., 1993. The use of dispersed cuticles in the biostratigraphic correlation of Australian Eocene sediments. *South Australia. Department of Mines and Energy, Report Book* 93/5.

Rowett, A.I and Sparrow, A.D., 1994. Multivariate analysis of Australian Eocene dispersed cuticle floras: influence of age, geography and taphonomy on biozonation. *Review of Palaeobotany and Palynology* 81, 164-183.

Shackleton, N.J., 1986a. Paleogene stable isotope events. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 57:91-102.

Sheard, M.J. and Bowman, G.M., 1996. Soils, stratigraphy and engineering geology of near surface materials of the Adelaide Plains. Volume 1. *South Australia. Department of Mines and Energy, Report Book* 94/9.

Taylor, J.K., Thomson, B.P. and Sheperd, R.G., 1974. The Soils and Geology of the Adelaide Area. *South Australia. Geological Survey. Bulletin* 46.

Townsend, I.J., Morris, B.J. and Farrand, M.G., 1994. Review of Diamond Resources in South Australia. *South Australia. Department of Mines and Energy, Report Book* 94/34.

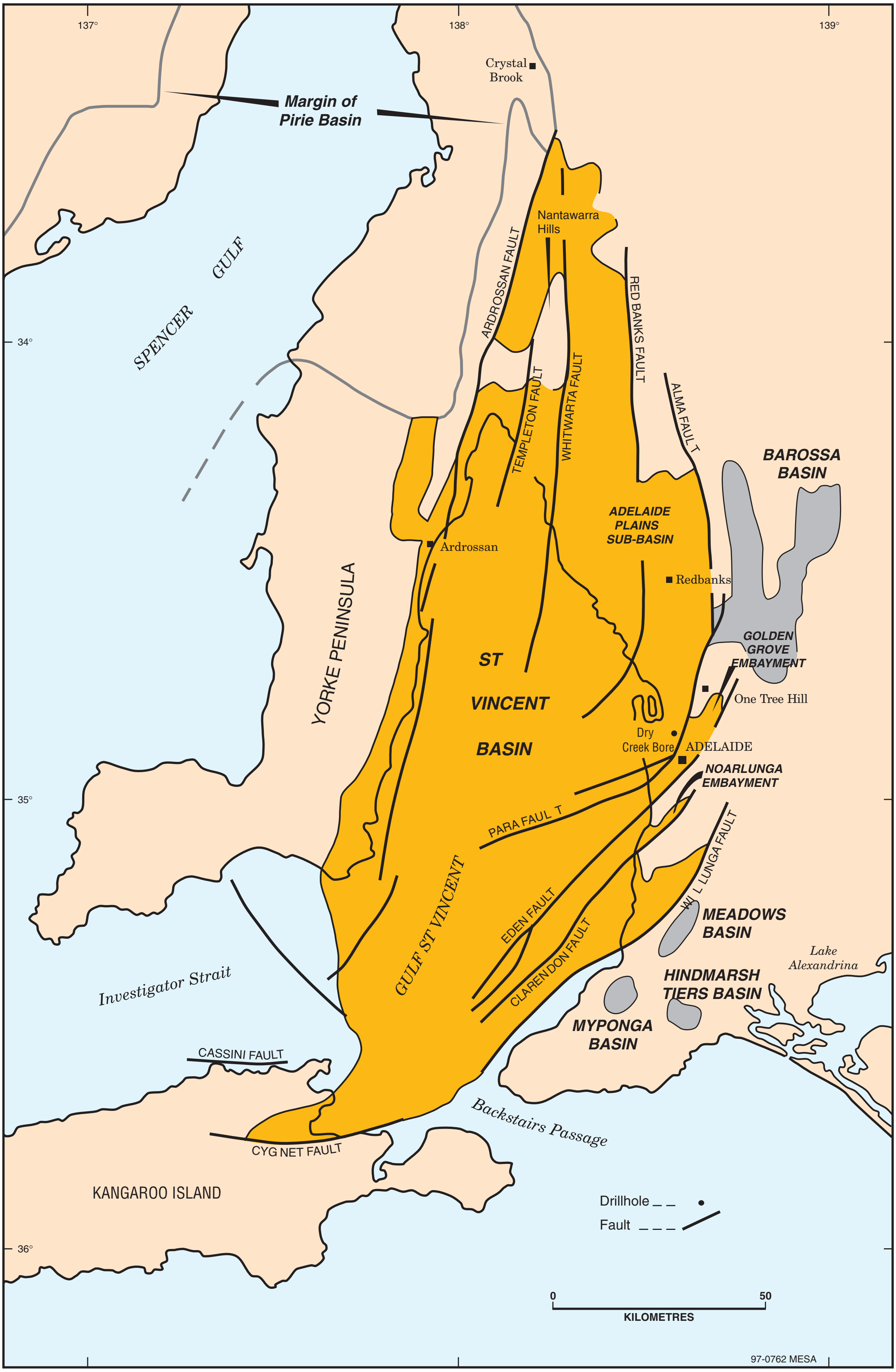

Fig. 1 Locality plan of the St Vincent Basin and the intramontane Barossa, Meadows, Myponga and Hindmarsh Tiers Basins.

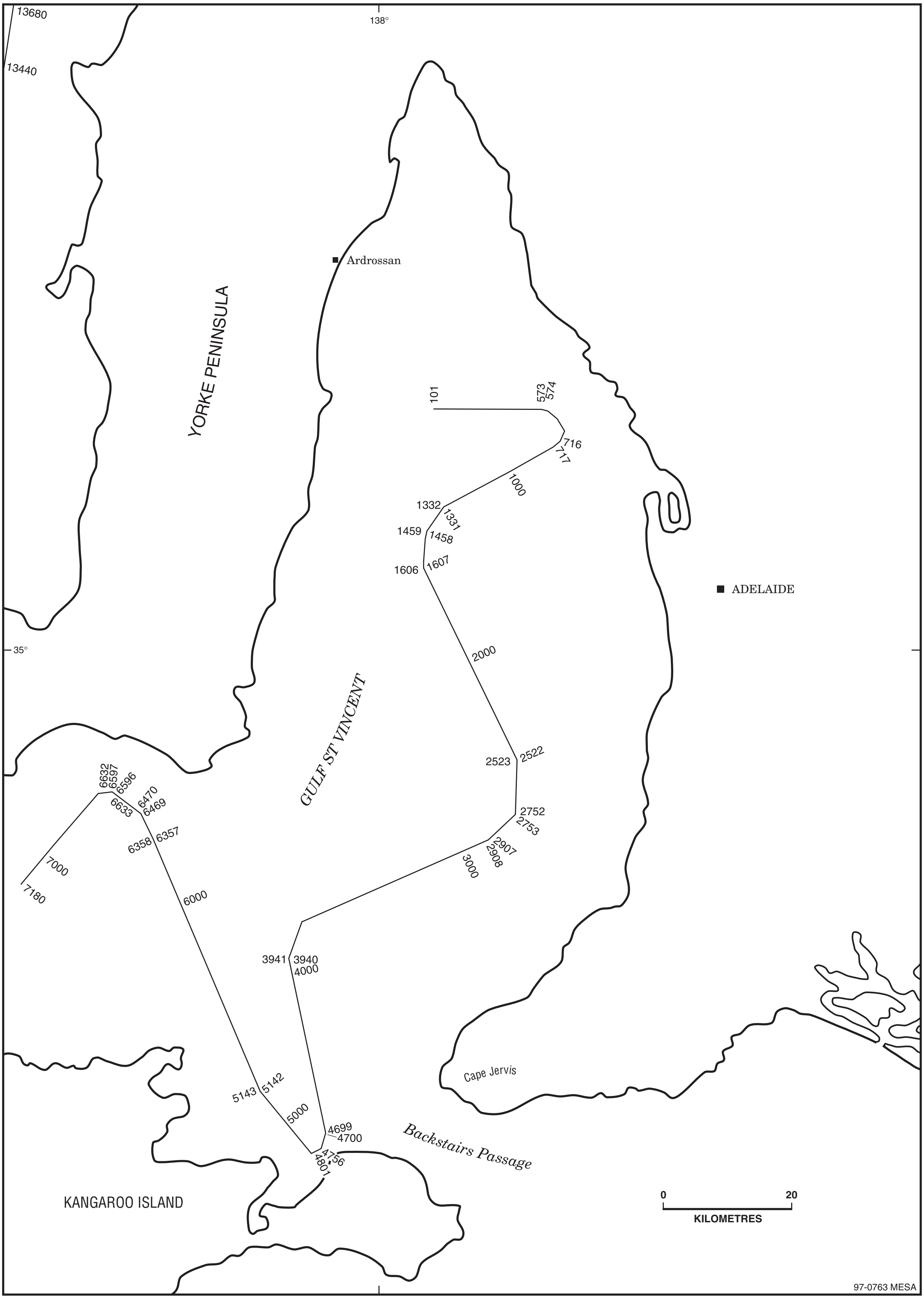

Fig. 2 *Location of offshore seismic line used in Birt's 1995 investigation.*

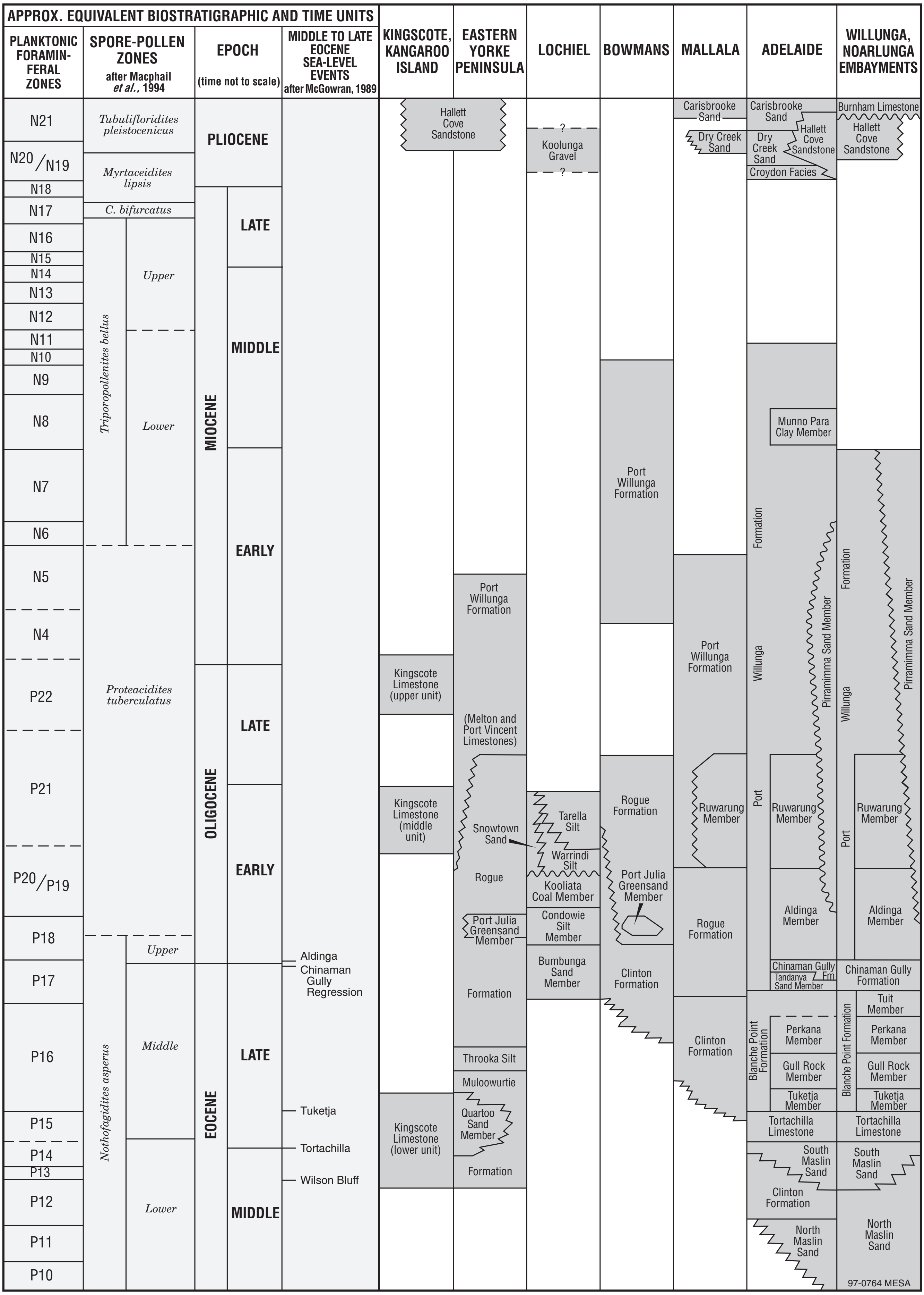

Fig. 3 *Correlation chart of Tertiary sediments in the St Vincent Basin.*

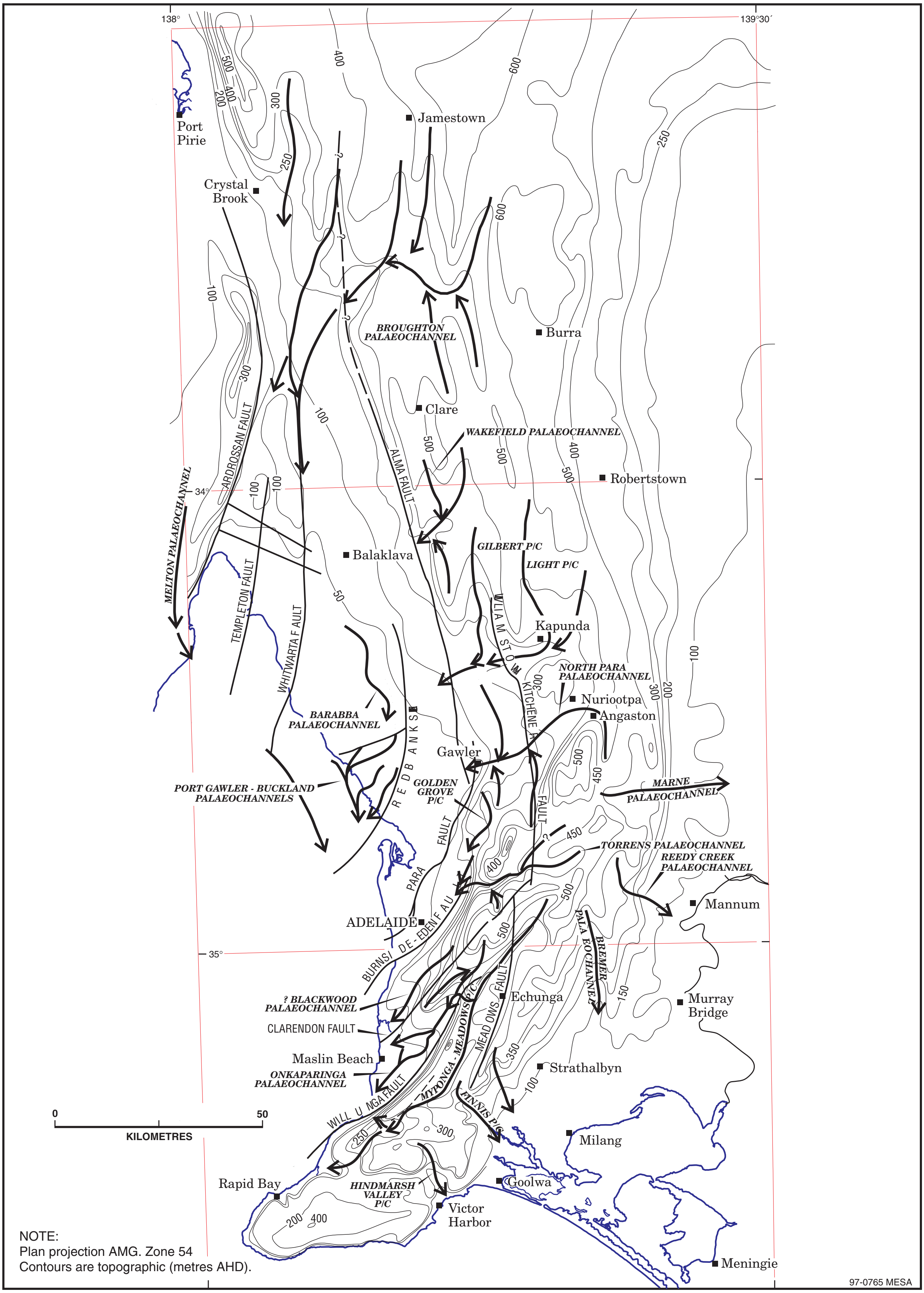

Fig. 4 Inferred Tertiary palaeodrainage in the St. Vincent Basin and Mt Lofty Ranges as derived from generalized contouring.

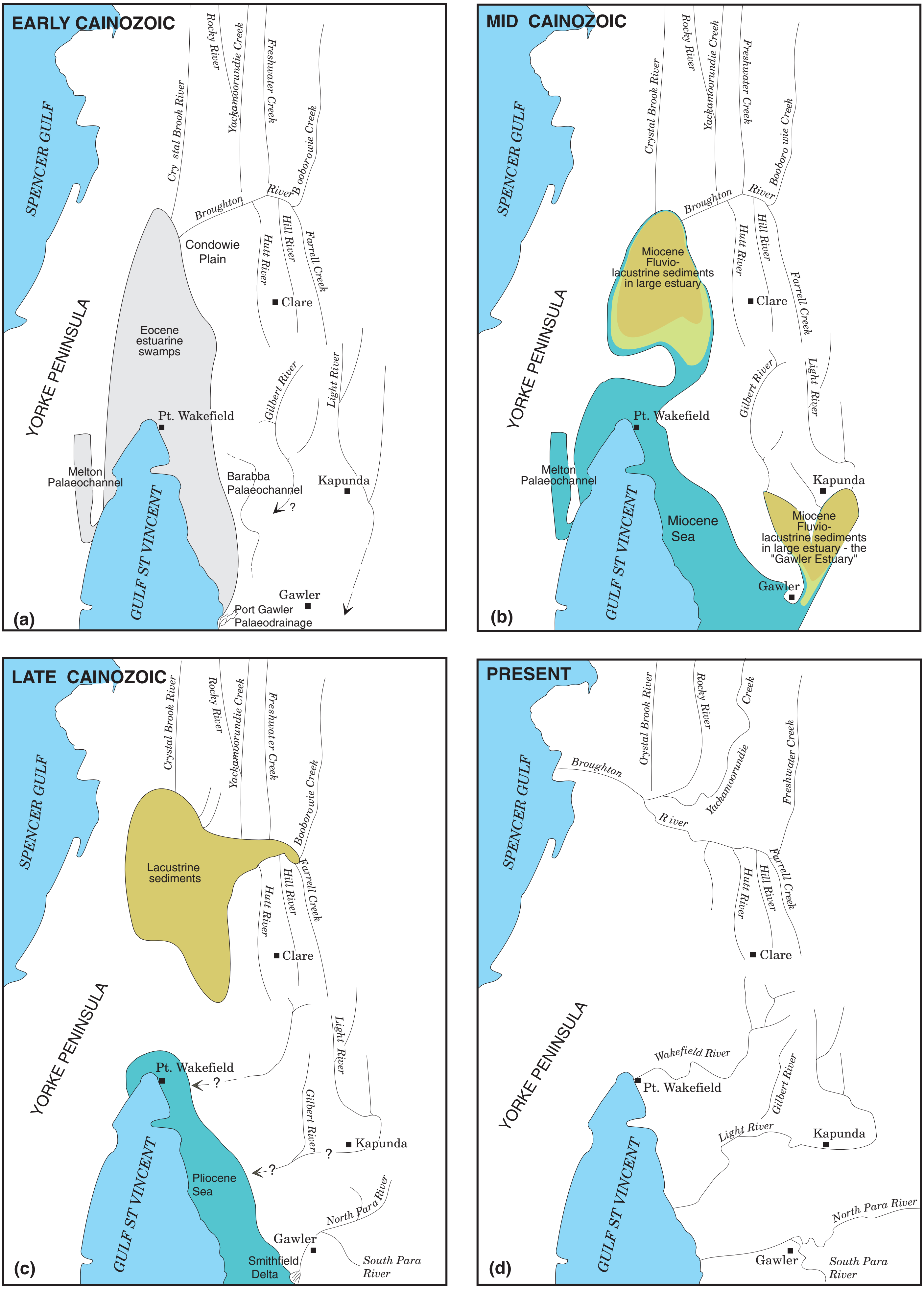

Fig. 5 Drainage patterns during the Cainzoic era in Northern Mt Lofty Ranges.

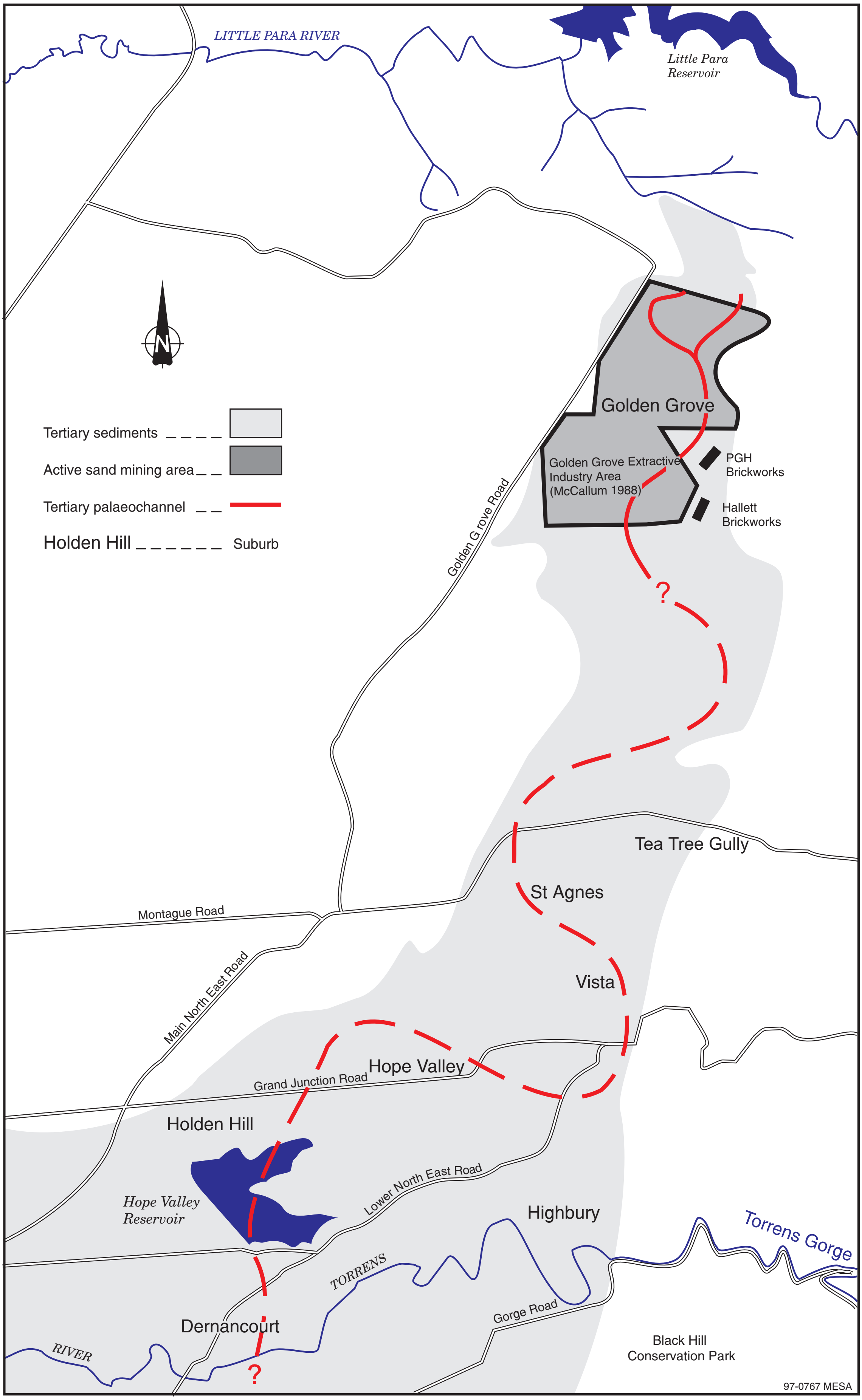

Fig. 6 Tertiary Palaeodrainage in Golden Grove embayment.

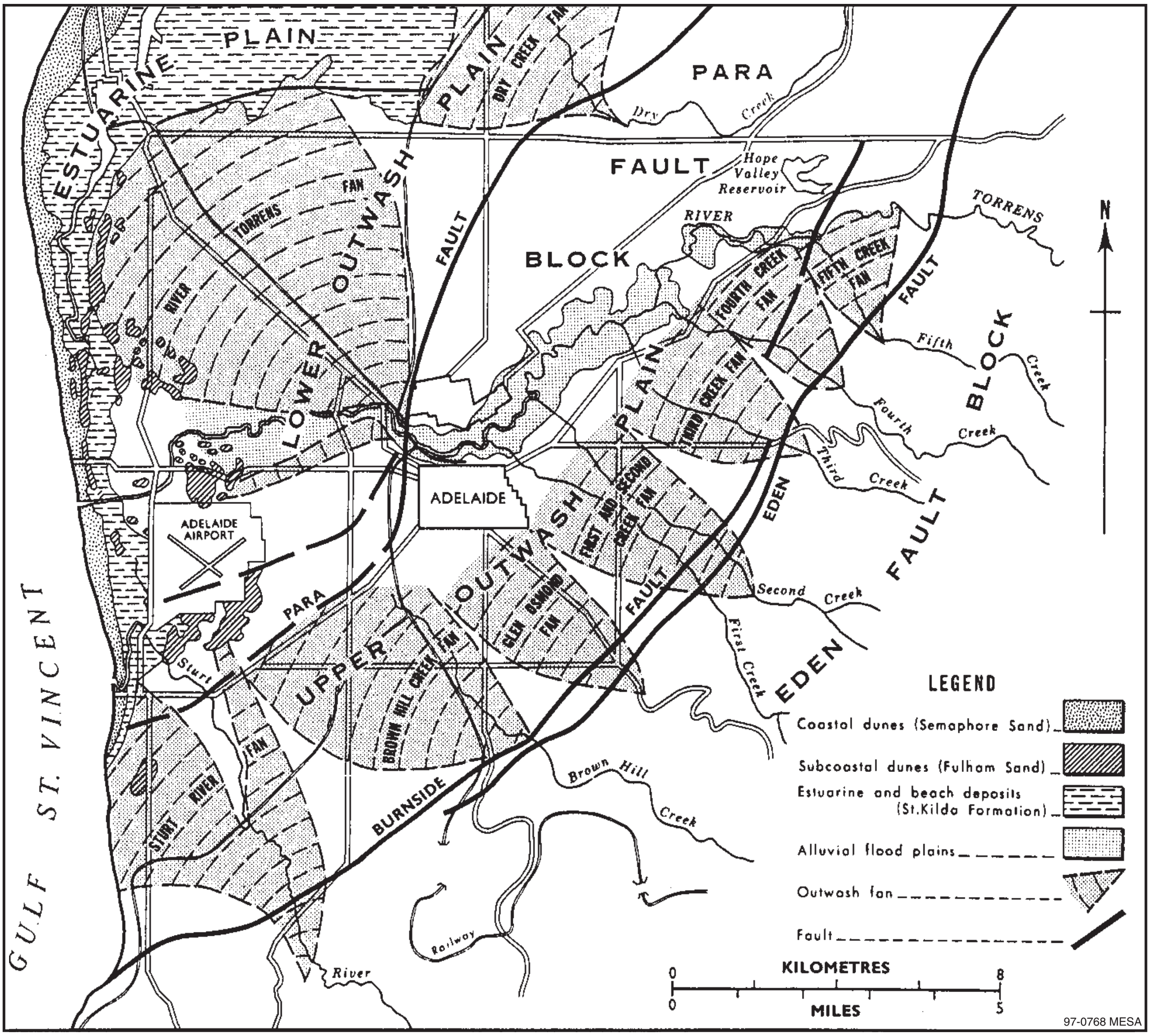

Fig. 7 Quaternary palaeodrainage of the Adelaide sub-Basin and southern Mt. Lofty Ranges (after Aitchison et.al., 1954).

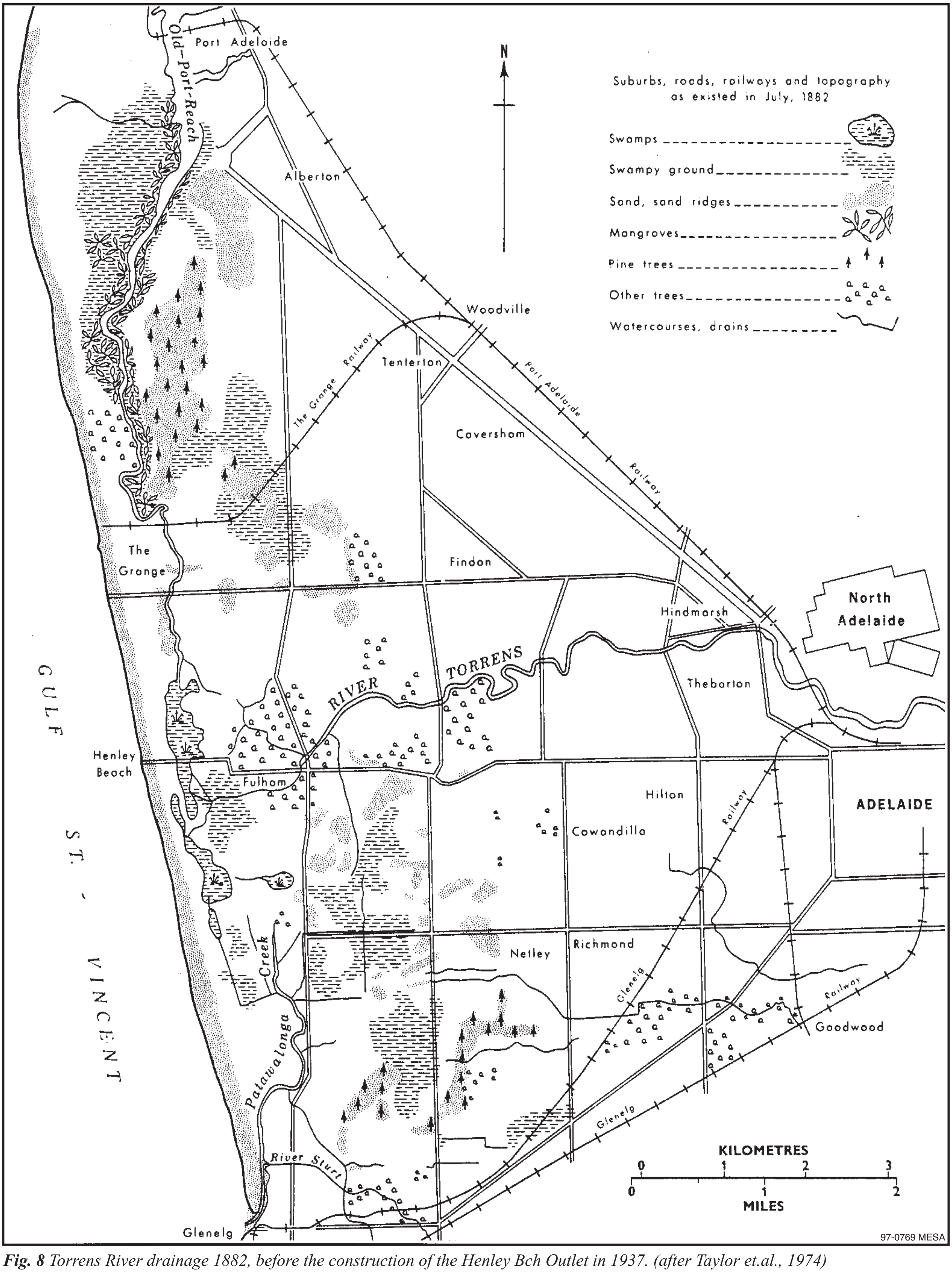

Fig. 8 *Torrens River drainage 1882, before the construction of the Henley Bch Outlet in 1937. (after Taylor et.al., 1974)*

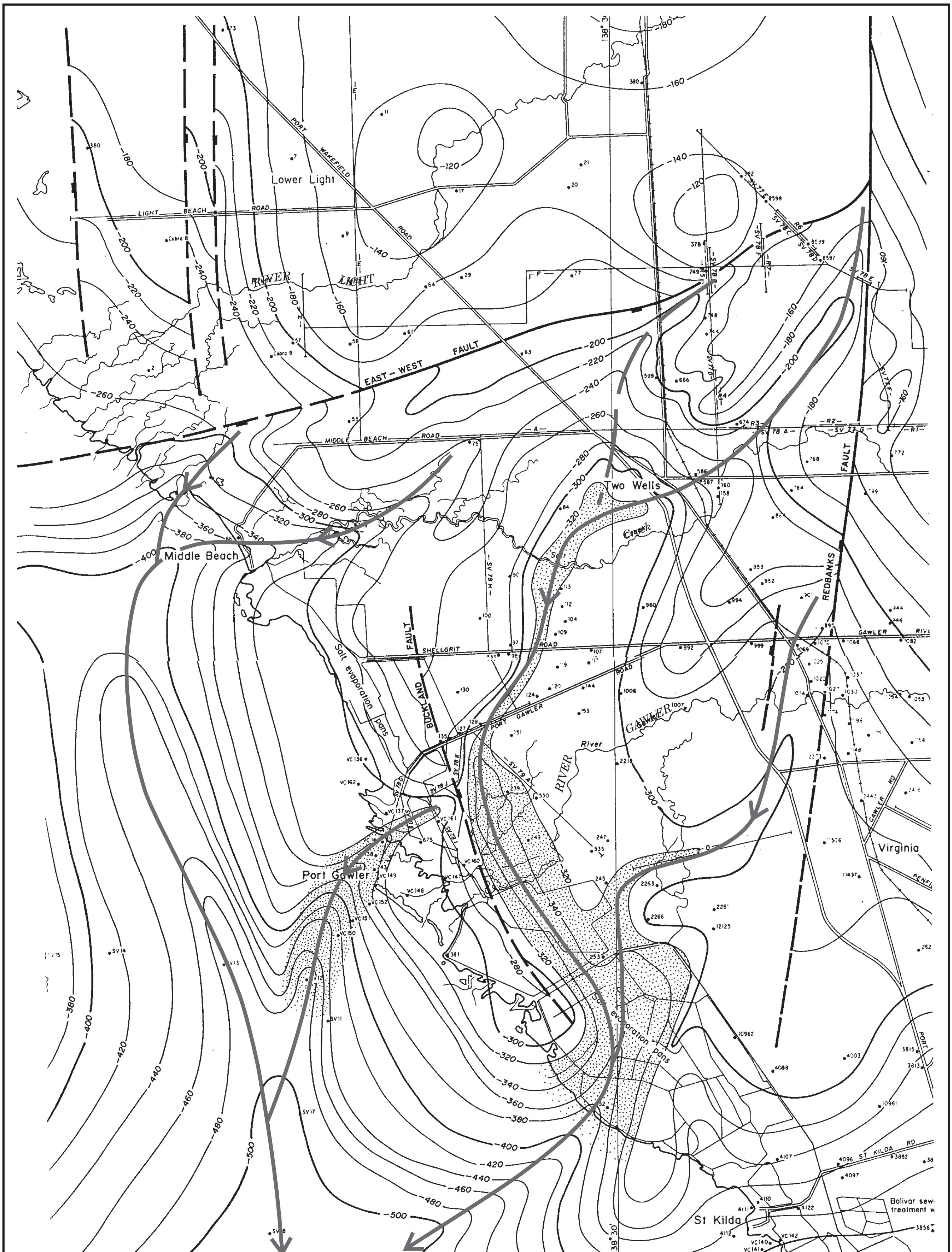

Fig. 9 *Pt. Gawler palaeodrainage (after Belperio and Bateman 1986).*

Fig. 10 Barabba palaeochannel.

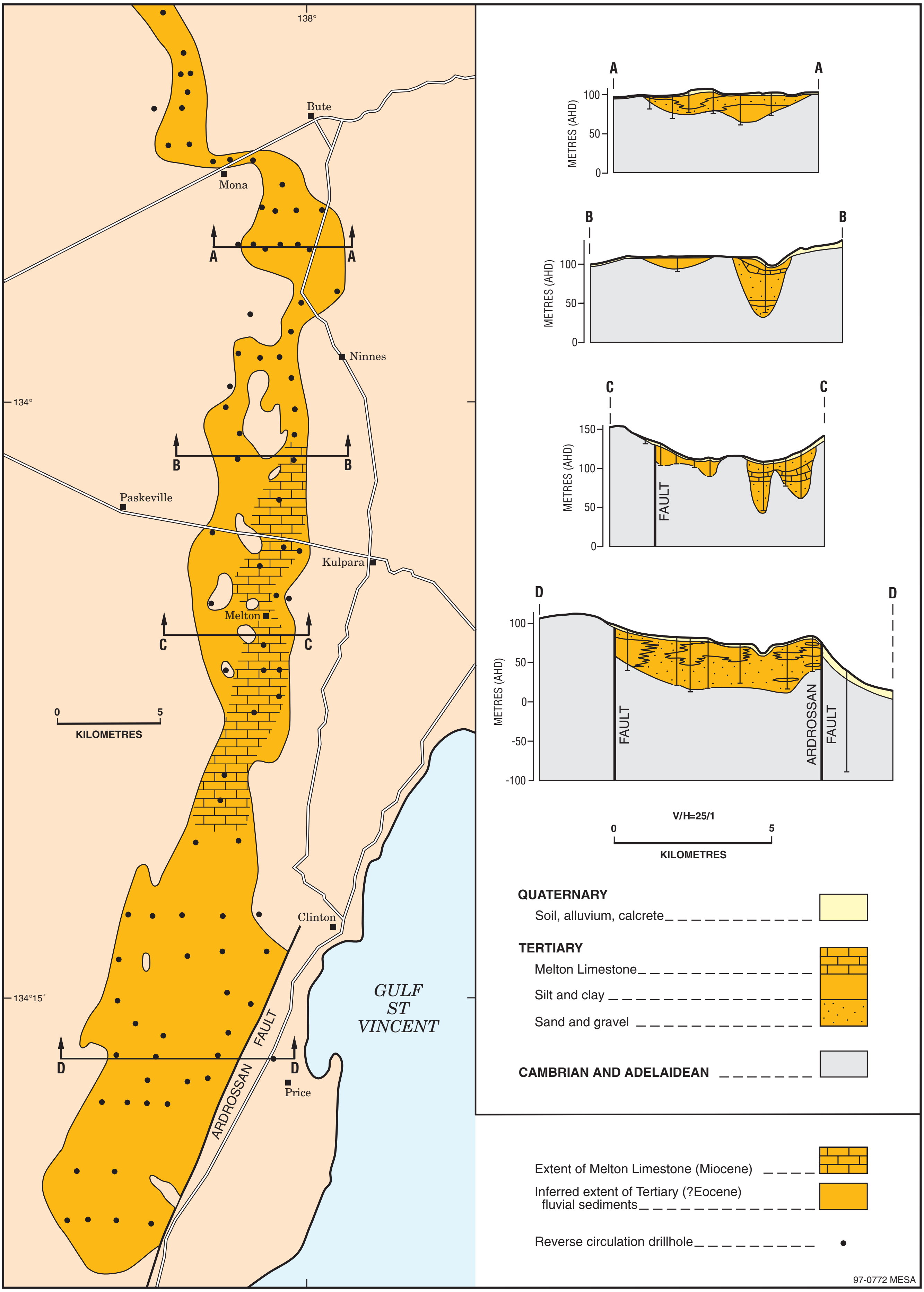

Fig. 11 Melton palaeochannel.

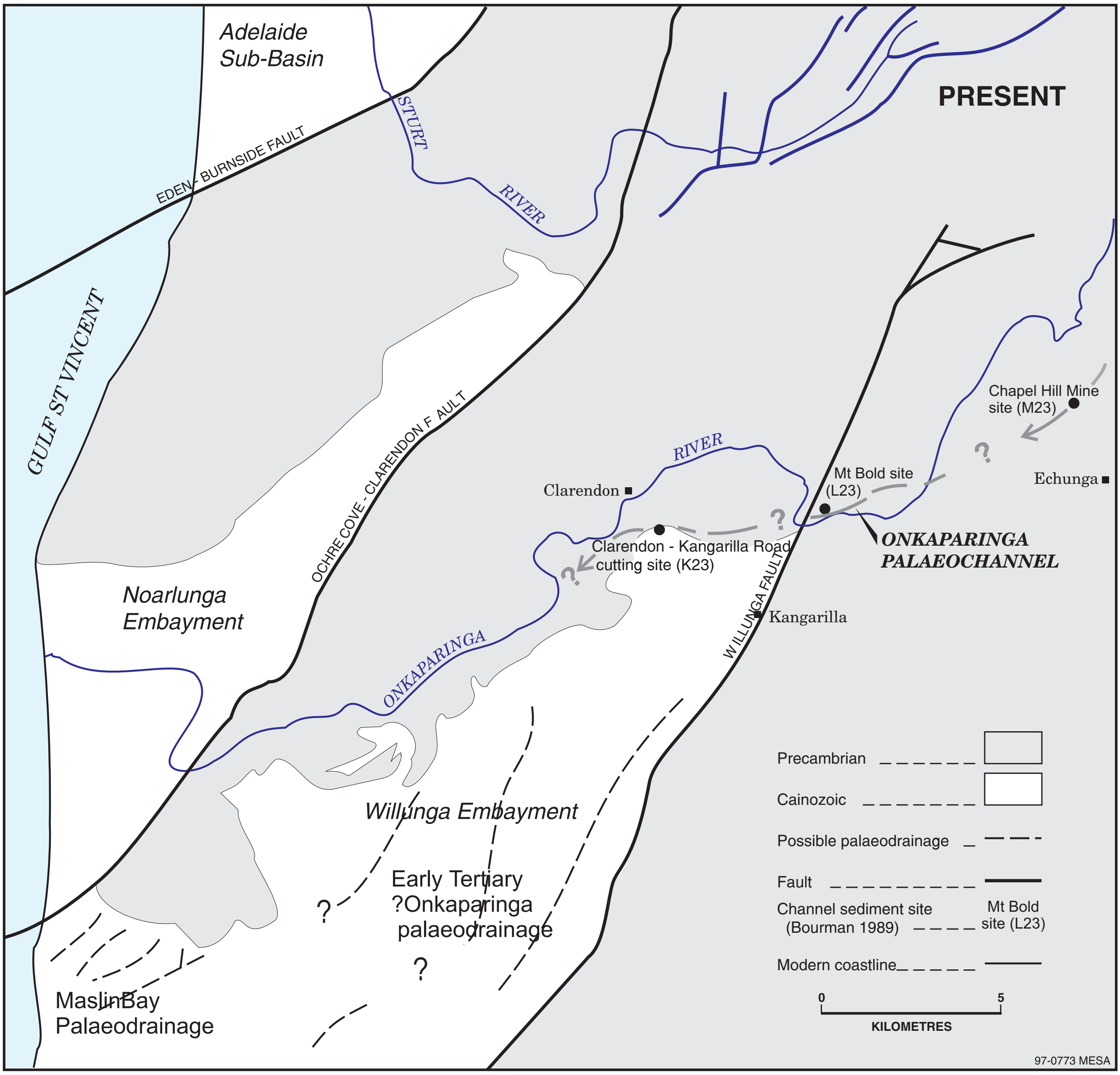

Fig. 12 Onkaparinga palaeochannel and associate palaeodrainage within the Willunga Embayment.

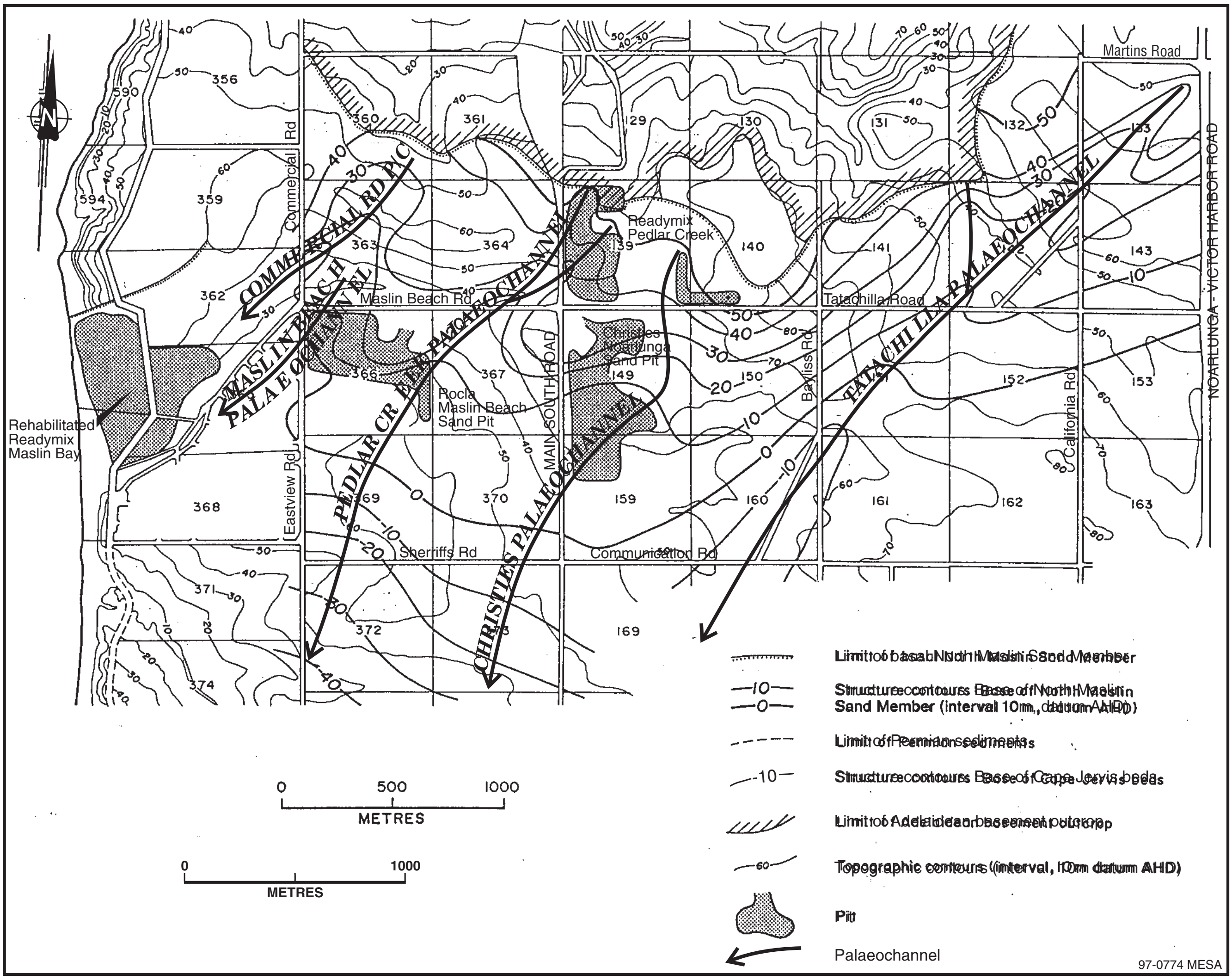

Fig. 13 *Maslin Bay palaeodrainage (after Pain 1988).*

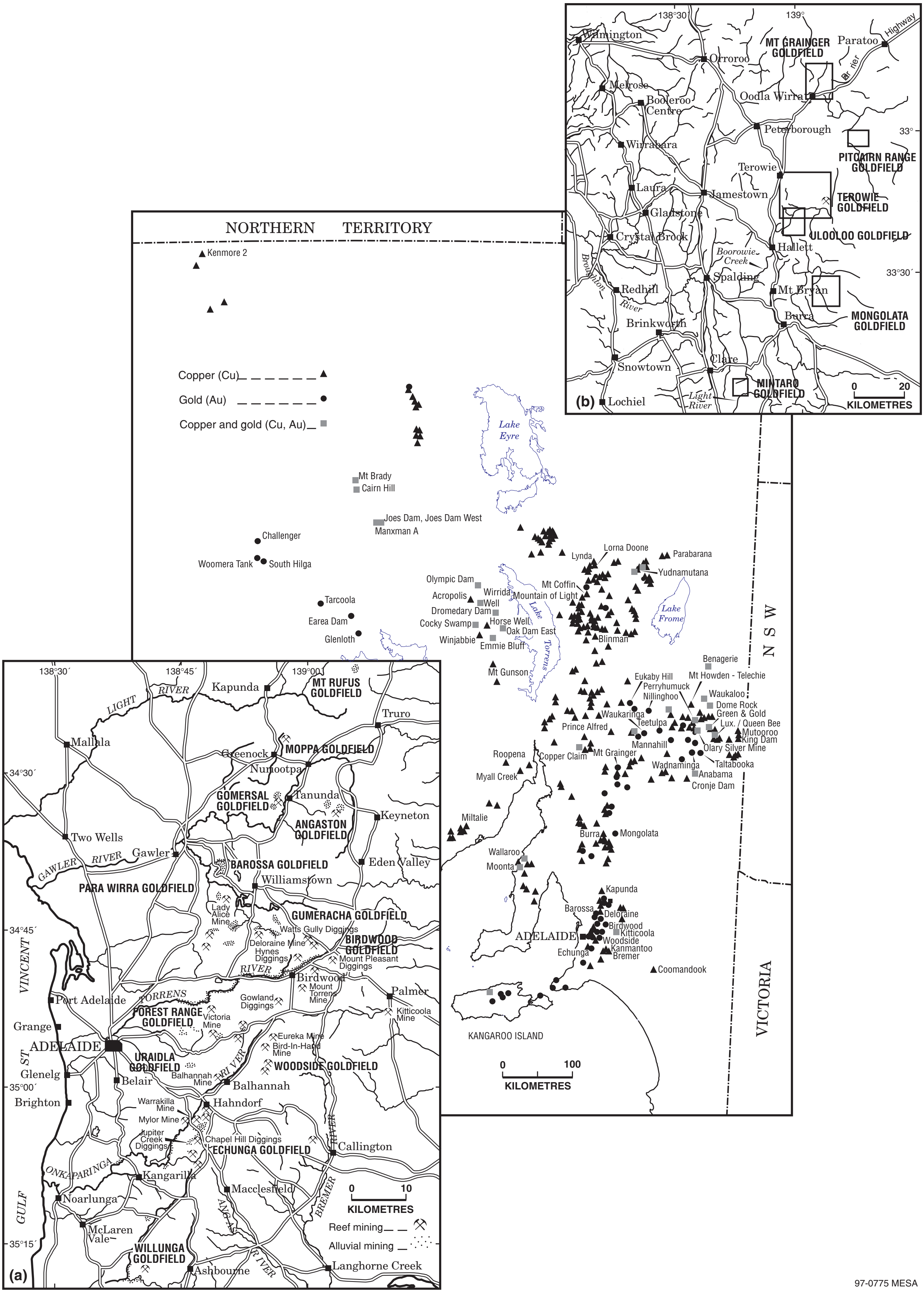

***Fig.14** Map showing gold and copper occurrences in South Australia (after Newton 1996). Insets show gold discoveries associated with the southern Mt Lofty Ranges **(a)** and northern Mt Lofty Ranges **(b)**.*

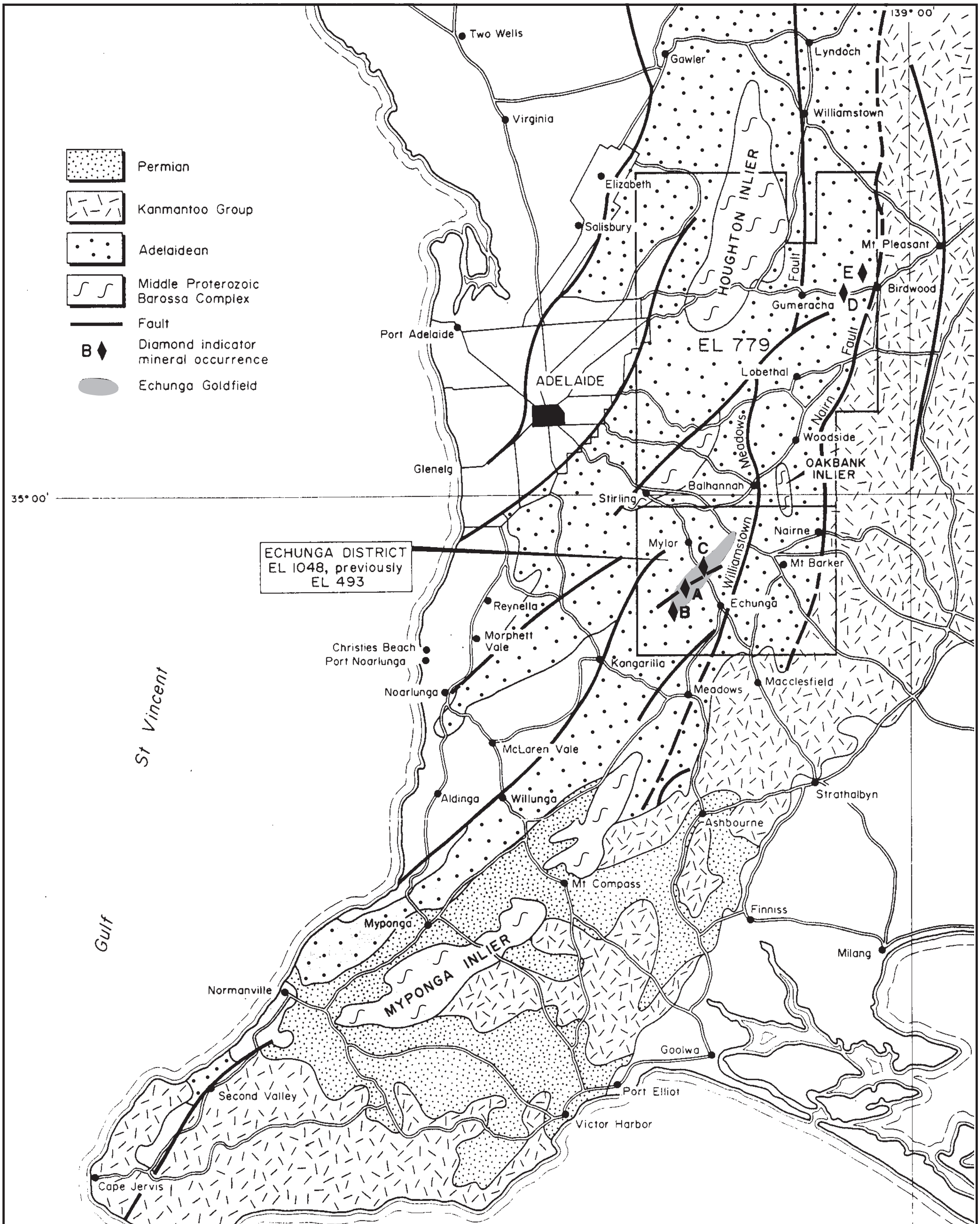

***Fig. 15** Diamond occurrences in the southern Mt Lofty Ranges with a possible kimberlite source located in the Gumeracha - Birdwood area (after Gerdes 1988).*

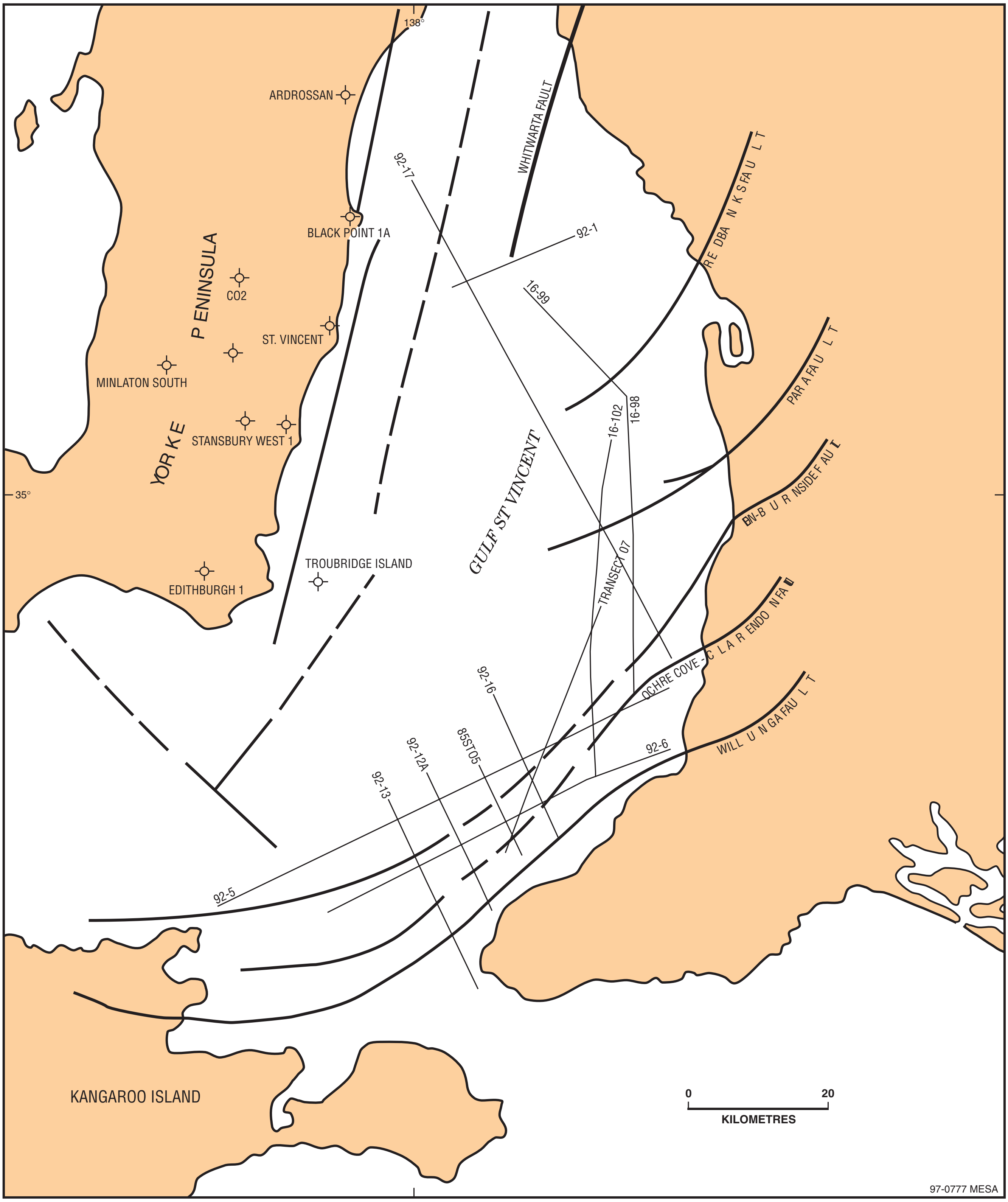

Fig. 16 *Offshore St Vincent Basin seismic lines selected for a future palaeodrainage mapping programme.*