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EL 1628

MALCOLM PLAINS

PROGRESS REPORTS TO LICENCE EXPIRY/SURRENDER FOR THE PERIOD 22/12/1989 TO 21/12/1993

Submitted by
Olliver Geological Services Pty Ltd
1993

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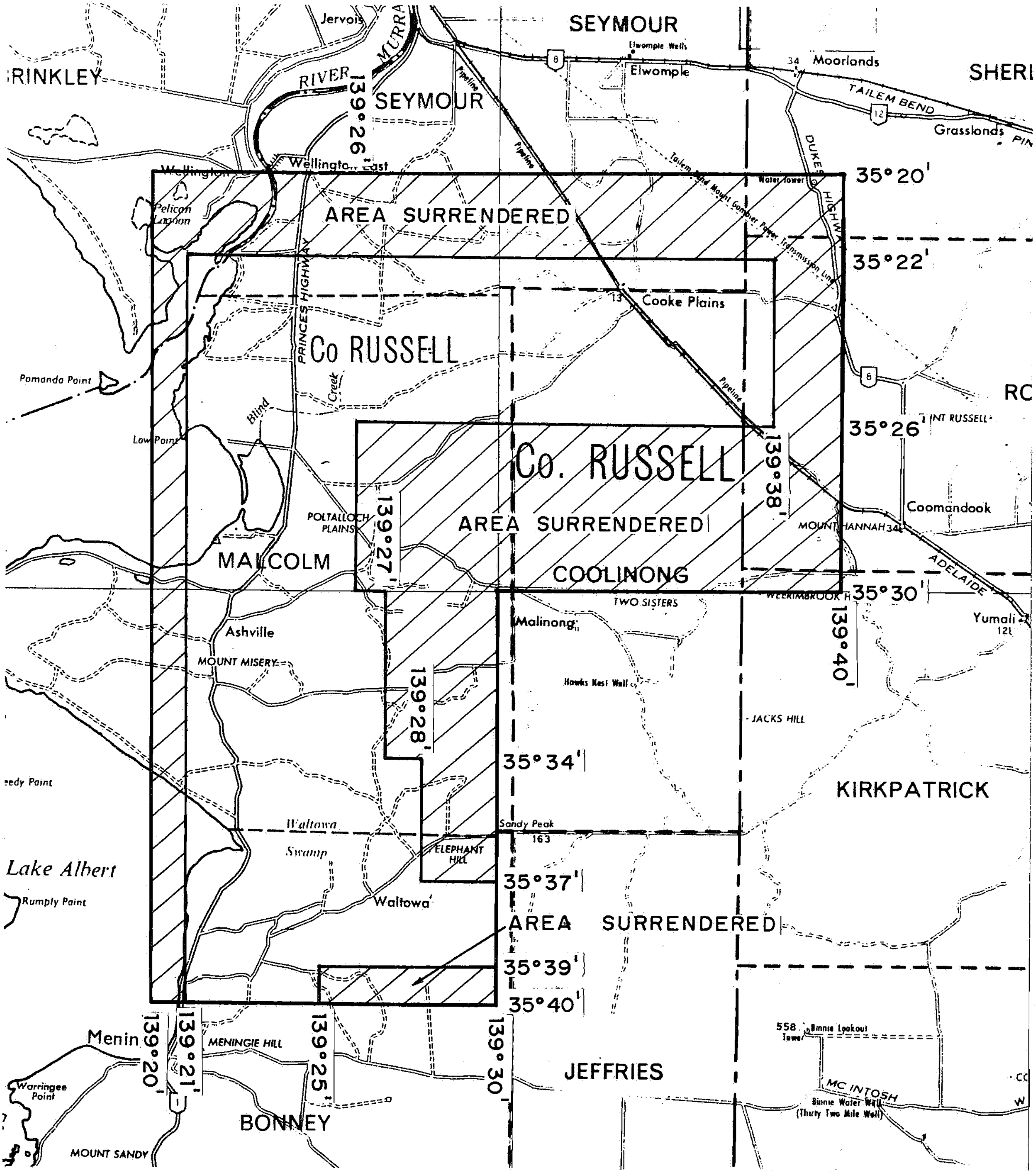
Government of South Australia
Primary Industries and Resources SA

SCHEDULE A



EXPIRED

SCALE 1:250,000

KILOMETRES 5 0 5 10 15 20 25 KILOMETRES

APPLICANT: EDDINGTON PTY. LTD.

DME 205/89

AREA: ~~839~~ 433 square kilometres (approx.)

1:250 000 PLANS: BARKER, PINNAROO

LOCALITY: MALCOLM PLAINS AREA – Approx. 25 km SOUTH of TAILEM BEND

DATE GRANTED: 22-12-89

DATE EXPIRED: 21-~~6-90~~ 12-90 91

EL No: 1628

ENVELOPE 8281

TENEMENT: EL 1628, Malcolm Plains

TENEMENT HOLDER: Olliver Geological Services Pty Ltd

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EL 1628 MALCOLM PLAINS

QUARTERLY REPORT NO. 1 TO 21 MARCH 1990

TENURE

EL 1628 was granted to Olliver Geological Services Pty Ltd on 22 December 1989 for six months. Primary target is filter grade diatomite in Cooke Plains Embayment, Waltowa Swamp and other smaller depressions. Secondary targets are gypsum and fracturing sand.

MARKET FOR DIATOMITE

A review is being compiled of diatomite in Australia including uses, specifications, processing, geology, production in Australia, South Australian occurrences, world sources and Australian imports/exports to identify markets for South Australian deposits.

UNIVERSITY RESEARCH

Sean Kennedy (Consultant Geologist) and the writer discussed previous post graduate research at Malcolm Plains with Professor Chris von der Borch (Flinders University). He has an on going program investigating Holocene sediments in the region with Liz Barnett (Post graduate Researcher) currently working west of Lake Alexandrina. Robert Hayball is about to undertake a study of the sapropel unit underlying the diatomite and will cooperate in the push tube sampling.

FIELD INVESTIGATIONS

The only field work has been a brief reconnaissance of the area by the writer.

PROPOSED ACTIVITY

Flinders University have provided push tube coring equipment and two days coring is scheduled for the week commencing 26 March 1990.

J.G. OLLIVER
Director
Olliver Geological Services Pty Ltd

11th April 1990

EL 1628 MALCOLM PLAINS

EXPENDITURE TO 21 MARCH 1990

TENEMENT FEES		
EL application	122.00	
EL rental	2 013.60	
State Taxes	4.00	2 139.60
GEOLOGICAL SERVICES		3 025.00
ADMINISTRATION		3 250.00
OFFICE COSTS		648.43
DATA ACQUISITION		71.50
FIELD OPERATIONS		NIL
TOTAL		9 134.53

EL1628 MALCOLM PLAINS

QUARTERLY REPORT NO. 2 TO 21 JUNE 1990

PART 1 BACKGROUND - GEOLOGY, PRODUCTION AND USES OF DIATOMITE IN AUSTRALIA.

PART 2 EXPLORATION ACTIVITIES FROM 22 MARCH TO 21 JUNE 1990.

by

JEFFREY G. OLLIVER
Director
Olliver Geological Services Pty Ltd

and

SEAN KENNEDY
Geological Consultant
S and C R Kennedy

July 1990.

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COLOUR PLATES

PLANS ACCOMPANYING REPORT

PART 1 - BACKGROUND - GEOLOGY, PRODUCTION AND USES OF DIATOMITE IN AUSTRALIA

DEFINITIONS

Diatomite is sedimentary rock composed mainly of opaline skeletal remains or frustules of minute single-celled aquatic organisms called diatoms. Unconsolidated material is called diatomaceous earth. Kieselguhr is an impure clay-rich variety. Impurities include other micro fossils, volcanic ash, clay and silica sand.

Diatomite is light weight with millions of irregularly shaped particles interlocking to produce 85-90% voids.

The commercial value of diatomite is due to its unique microscopic honeycomb structure which provides large internal surface area coupled with chemical inertness. Shape of individual diatoms ranges from thin needles to spindles, cylinders, discoid forms to ovate.

Diatoms are algae of class Bacillariophycea and order Bacillariaes. There are over 3000genera and 12 000 to 16 000 species and they flourish in either marine or freshwater.

Taxonomically, diatoms are divided into two broad categories

* centricae - discoid
* pennatae - elongate or filiform

Two valves are bound by a connecting band or girdle. Each valve is perforated by openings arranged in a consistent and distinctive pattern and comprise an inner and outer plate separated by ribs forming a chambered interior.

Valves vary from 5 to 1 000 microns in diameter but are usually 50 to 150 microns.

Rate of reproduction varies from 2 or 3 times per day to once a week.

CHEMISTRY

Diatomite is opal or hydrous silica SiO_2 n H_2O.

Silica is critical to the diatom not only forming cell walls but also for the basic life process. Without silica, cell development ceases.

In addition to combined water which varies from 3.5 to 8.0%, small amounts of Al_2O_3 are present with lesser Fe_2O_3 , Ca, Mg, Na and K.

Boron is reported to be an essential element.

DEPOSITIONAL ENVIRONMENT

Diatoms flourish in shallow lakes or the sea where soluble silica is abundant. Species are sensitive to depositional conditions such as water temperature and salinity.
Thick deposits are associated with volcanic ash.

Almost all known deposits in Australia occur with Tertiary volcanic rocks either in depressions in basalt or as inter beds.

For diatoms to proliferate, the following five conditions are required (Kadey, 1983)

* large shallow basin 35m or less deep to allow photosynthesis.
* abundant supply of soluble silica.
* abundant supply of nutrients.
* absence of toxic or growth-inhibiting constituents.
* minimal clastic sediment.

Other organisms which form with diatoms and are found in diatomite are

* silico-flagellates
* radiolaria
* siliceous sponges

USES

FILTER, FILTER AID

From 50 to 66% of all processed diatomite is used to separate suspended solids from fluids. Selection of the optimum diatomite for a particular application is related to flow rate - clarity relationship.

Processed diatomite powders are used to filter

* dry cleaning solvents
* pharmaceuticals
* beer, whisky and wine
* raw sugar liquor
* antibiotics
* swimming pool water
* fruit and vegetable juices
* lube, rolling-mill and cutting oil
* jet fuel
* organic and inorganic chemicals
* varnish and lacquer.

FILLER

The second largest application generally uses fines from production of filter grades in such materials as

* paint - for flatting effect and to improve intercoat adhesion.
* paper
* plastic
* rubber - also has semi reinforcing effect
* asphalt
* concrete - improve workability and reduce bleeding.

CHEMICALS

As a source of reactive silica in the manufacture of lime-silicate insulation and highly absorptive calcium silicate powder.

INSULATION

* fire bricks/thermal insulation in kilns
* fire proofing safes and cabinets
* acoustic insulator in wall boards

MILD ABRASIVE

Hardness is sufficient to produce abrasion on metal surfaces. Natural milled diatomite is ideal for silver polish and flux calcined material is used in automobile polishes.

LIQUID CARRIER

With ability to absorb 2.5 times its weight of water, diatomite powder is used in

* rug cleaner
* pesticide
* pitch control in paper manufacture
* handling and storage of sulphuric and phosphoric acid.

OTHERS

* chromatographic support
* catalyst carrier - nickel catalyst in hydrogenation
  - vanadium catalyst in manufacture of sulphuric acid
* anti-caking agent on ammonum-nitrate prill
* match head composition to control after glow
* welding rod
* battery box separator
* acetylene container
* stabilizer in explosive
* drilling mud additive

* conditioner of animal food
* light weight ceramics
* fertiliser - enhances liberation of fluorine from phosphate rock.

PROCESSING

Great care is required to ensure that the unique skeletal shape and structure is preserved. Hence, ball milling or grinding are unacceptable processes.

A typical processing plant is as follows

1. Primary crushing - usually by spiked roll crusher.

2. Simultaneous hammer milling and drying - suspended particles are carried in a stream of hot gas to remove impurities and to expel sorbed water.

   Product at the end of this stage is referred to as "natural milled".

3. "Calcination" - (really sintering) to expel combined water and to breakdown structure by incipient fusion. Particle size distribution is adjusted through fusion and agglomeration of fines to produce a range of "calcined" or "flux calcined" products.

   Simple "calcination" results in a pink colour owing to oxidation of iron.

   "Flux calcination" results in a white product.

   The effect of "calcination" on various properties is illustrated below

Property	Natural Milled	Calcined/Flux Calcined
Hardness (Moh Scale)	4.5 - 5.0	5.5 - 6.0
Specific gravity	2.0	2.3
Refractive Index	1.4 - 1.46	1.49

4. Acid treatment - for special filter grades.

Energy accounts for 25-30% of total cost of mining, processing, packaging and transport.

LABORATORY TESTING

Well defined specifications are not available. For filter grade, raw and calcined samples are tested for filtration rate and haze in direct comparison with commercial products. Laboratory investigation normally includes the following.

IDENTIFICATION

Palaeontological description of diatom species and size, shape and preservation.

CHEMICAL ANALYSIS

Diatom content and contaminants are determined by optical microscopy, X-Ray diffraction and chemical analysis for

SiO_2, Al_2O_3, Fe_2O_3, TiO_2, CaO, MgO, Na_2O, K_2O, loss on ignition, moisture content, organic matter, water soluble matter

Other analyses include

* pH of 10% water suspension.
* acid solubles to ASTM D719-63
* analysis for pigment to ASTM D719-63.

PHYSICAL PROPERTIES

* Block density
* Specific gravity
* Bulk density - wet and dry
  - crushed and raw
* Wet cake density
* Porosity

PARTICLE SIZING

* Sieve and sedimentometer
* Predominant size range
* Proportion retained on 325 mesh and 150 mesh.

COLOUR/BRIGHTNESS

* Colour
* TAPPI or GE Brightness - natural and fused
* Reflective index

GEL TIME

OIL ABSORPTION

* Gardner - Coleman to ASTM D1483-60
* Spatula rub out to ASTM D281-31

WATER ADSORPTION

FILTRATION

* Filtration rate of raw, calcined and flux calcined
* Haze or clarity by
    * laboratory filter
    * dicalite bomb filter

SPECIFIC SURFACE AREA

* nitrogen adsorption

THERMAL PROPERTIES

* Fusibility - Pyrometric Cone Equivalent (PCE) to ASTM C24

SETTLING RATE

* in petroleum spirits after 1 hour.

WORLD SOURCES

Although diatomaceous silica is widespread, commercial deposits are rare. A good portion of the Californian Coast is "diatomaceous in character" but high quality commercial diatomite is restricted to only 10 sq km (Kady, 1983)

Diatoms became abundant during the Cretaceous age (135 to 65 ma) but most commercial deposits are Miocene age (26 to 7 ma) or younger.

Regional metamorphism and/or chemical alteration will destroy the delicate nature of the diatom frustule converting the rock to useless opaline chert or porcellanite.

Most known world deposits are lacustrine although the few workable marine deposits tend to be larger.

USA is the dominant producer and user with seven companies operating eleven plants in four states producing about 700 000 tonnes/year.

World mine output approximates 2 million tonnes with Romania now replacing France and USSR as Europe's main supplier (Industrial Minerals 1987).

Diatomite at the most famous deposit at Lompoc in California USA is of marine origin and up to 300m thick. Dominant diatoms are rounded, honeycomb forms such as Coscinodiscus with numerous long needle frustules of Nitzschia and Synedra which are common in freshwater deposits (Crespin, 1946).

PRODUCTION IN AUSTRALIA

Most deposits in New South Wales, Victoria and Queensland have formed under freshwater lacustrine conditions during upper Pliocene - Pleistocene times associated with basaltic lava or pyroclastics. Lava flows altered the drainage system by filling valleys and damming rivers to form lakes and provided a plentiful supply of silica.

Mining began in a small way at Lillicur, Victoria in 1886 and near Lismore NSW in 1895. First recorded output in Queensland was in 1936 and in WA, Lake Gnangarra was opened in 1942 (Crespin 1946).

Davis Gelatine (Australia) Pty Ltd began using NSW diatomite for filtration in 1922. By 1944, CSR Co Ltd, Fletcher Chemical Co and numerous dry-cleaning companies were filtering with Australia diatomite (Crespin, 1946).

Australian production is compared with imports mainly from USA in Appendix A based on the Annual Reviews of the Australian Mineral Industry published by Bureau of Mineral Resources, Geology and Geophysics. Aert Driessen (Principal Commodity Geologist BMR) has advised that imports of diatomite do not appear to have been recorded before 1946. Production figures are those recorded by State governments and do not include small tonnages mined from outside mining tenements in Victoria before 1940.

Since 1970, Australian output has fluctuated between 1 288t in 1977 to 10 263t or more since 1978. Before 1942, Australian diatomite was regarded as unsuitable for filter purposes. In 1942 only 22% was processed for filtration. By 1945, the proportion had grown to 75% and was even higher in 1948.

During the 1950's and 1960's this proportion settled at about 50% but decreased steadily to 1984 when only some swimming pool filters were produced.

The apparent market in 1987 totalled 24 600t based on the following

* total recorded domestic production of 10 300t
* imports mainly from USA of 6 000t of crude diatomite valued at $2.38 million and 6 000t of activated diatomite valued at $2.26 million.
* exports of 2 300t mainly to New Zealand and Saudi Arabia.

Imports decreased substantially from 12 004t in 1987 to only 6 763t in 1988 but the basis of recording may have changed with the transfer of activities from BMR to ABARE.

Commercial Minerals Ltd quote $180-$200/t milled explant.

Average f.o.b. value of material imported from USA was $362-$398/t.

Data on each state are summarised from 1987 data (Towner, 1989). Details to 1960 are presented by Barrie (1965).

SOUTH AUSTRALIA

There has been no production, although 1 000t of spongolite used for building stone at Paringa, River Murray was attributed incorrectly to diatomite by Hiern (1975).

NEW SOUTH WALES

Major producer is Australian Diatomite Mining Pty Ltd (wholly owned subsidiary of Westralia Sands Ltd) with mine and calcining plant at Kyooma near Barraba. Output from 1984 to 1987 has varied from 6 173 to 8 306t.

Previous production had been obtained from Coonabaraban, Ballina - Lismore, Bunyan and Orange (Card & Dunn 1896and Herbert, 1975).

Melosira granulate (perforated cylinder) is the dominant form with lesser

* Neidium, Cymbella and Gomphonema (boat shape)
* Epitherma (bean pod)
* Pinnularia (ovate)
* Synedra (needle)

according to Crespin (1946 and 1947 - see fig. 1).

VICTORIA

Since 1985, Commercial Minerals Ltd has produced about 1 000t/year from Lillicur, 143 km northwest of Melbourne which is processed 70km away at Mount Egerton and used in the manufacture of phosphoric acid.

Other deposits have been mined at Moranding, Newham, Happy Valley, Redesdale, Talbot, Glengower, Portland and Mickleham (Crohn, 1952 and Kenley, 1975).

Dominant diatom forms (Crohn, 1952 and Crespin, 1946 and 1947) are

Cocconeis placentula (ovate)

Synedra ulna (needle)

Melosira granulata (cylinder)

Gomphonema accumnatum (boat shape)

Gomphonema intricatum (boat shape)

QUEENSLAND

Since 1986, a few hundred tonnes have been produced at Mount Sylvia, 140 km west of Brisbane.

Almost all Queensland's output has been freshwater diatomite from this area with cylindrical Melosira the dominant genus (Rolfe, 1975).

WESTERN AUSTRALIA

Although there is no recorded production to 1972, about 60 to 90t/year have been mined since 1942 (Crespin 1946) from various deposits for insulating bricks (Gibson, 1975).

Output in recent years from Sabys Peak near Gingin peaked at 1 060t in 1986.

At the Ninth Industrial Minerals International Conference in Sydney in March 1990, P.B. (Brian) Rakich of Mallina Holdings Ltd announced that filter grade diatomite was being developed at Hill River north of Perth. Following several years of investigations supported by the WA Government Laboratories, trial samples were tested satisfactorily by CUB and Swan Breweries.

Mallina expect to be producing commercial quantities in about two years.

Follow up checking by Western Australian contacts has cast doubt on the viability of the project which is in coastal swamps with environmental problems and difficulty in removing contaminating clay and organic matter.

These difficulties are ongoing as demonstrated by Mallina's announcements as summarised from BMR Annual Reviews.

1974 - BHP and Mallina are investigating diatomite deposits 30 km south east of Dongara and 45 km south of Geraldton.

1975 - Pilot plant erected with capacity of 1 500t/year. Option agreement obtained with Leichhardt Minerals Pty Ltd over Wanneroo deposit.

Late 1975 - Agreement lapsed with BHP.

1976 - Encouraging progress, full scale plant to be built in 1976-77.

1977 - Design work continued.

1978 - Investigations progressing.

1979 - Work still in progress, also investigating Eneabba deposit.

1980 - New 4 000t/year plant to be built at Narngula adjacent to attapulgite plant. Expect to commission in 1982.

1981 - Diatomite project deferred to concentrate on attapulgite.

1982 - No mention.
1983 - Joint venture discussions continue.

1984-87 - No mention.

Diatomite is in freshwater Holocene sediments with a different assemblage to eastern states Tertiary deposits and commonest diatoms are Pinnularia Amphora and Diploneis (ovate), Eunolia (rod like), Gomphonema, Navicula and Cymbella (boat) (Crespin, 1946).

SOUTH AUSTRALIAN DEPOSITS

At Eight Mile Swamp near Port MacDonnell in the South East, a bed of Holocene diatomite only 0.2m thick is associated with peat (Nichol, 1972). Diatom assemblage is similar that in western Victoria deposits, dominant form is needle-like Synedra.

During mapping of PINNAROO 1:250 000 sheet, diatomite at least 0.5m thick was discovered in a road rubble pit 6.5 km north of Parrakie in the Murray Mallee (Rogers, 1980).

Several pits to 0.5m deep, up to 30m wide and extending north westerly for about 200m expose pale grey light weight siltstone with columnar structure.

Samples collected in 1978 were estimated by Wayne Harris (former Senior Palynologist, SADME) to contain up to 80% diatomite.

Two applications DME 424/89 (Parilla) and 426/89 (Geranium) were lodged by Olliver Geological Services Ltd on 13 November 1989 for the area staddling the Lameroo-Pinnaroo road and extending westwards from the Victorian border for about 90 km (fig. 2). These applications cover the available ground with elongate hollows in Parilla Formation expected to contain diatomite-rich lacustrine or lagoonal sediments.

These applications are on hold pending SADME investigations on DME 383/89 which overlaps much of the area (fig. 3).

In 1958, N.H. Ludbrook (Palaeontologist, SADME) recorded abundant diatoms from 0.53 to 1.83m (21-72 inches) in a hole drilled in section 306 hundred Malcolm by CSIRO at Malcolm Plains (Ludbrook, 1958).

Diatomite was identified in slip-hammer cores during a study at Flinders University of Holocene sedimentation in the Cooke Plains Embayment (Altmann, 1976 and vonder Borch and Altmann, 1979). A total of 49 holes were cored to 3m mainly along three north-south traverses (fig. 4).

Nine Holocene sedimentary units were identified resting unconformably on Pleistocene calcrete.

Diatom frustules are concentrated in unit 3 but are present in all other units except

Unit 6 - carbonate
Unit 9 - evaporate

Unit 3 - diatomite comprises grey soft sticky clay with diatom content up to 70% and the following impurities

* fine fraction - kaolinite, illite.
* coarse fraction - quartz, feldspar, halite, gypsum.

Thickness of unit 3 varied up to a maximum of 2.1m near the centre of Traverse A (fig. 4).

Diatom-rich sediment was deposited in water ranging in salinity from essentially fresh to a little less than normal marine. Overall water was fresher in the west and more saline to the east.

Application for an Exploration Licence was lodged on 11 May 1989 covering Cooke Plains Embayment and Waltowa Swamp (fig. 5). EL 1628 was granted to Eddington Pty Ltd now Olliver Geological Services Pty Ltd on 22 December 1989 initially for six months and has been renewed for a further six months to 21 December 1990.

The only mining operation within EL 1628 is Cooke Plains gypsum on a lunnette dune on the eastern end of Cooke Plains Embayment (King, 1951).

FUTURE TRENDS

Many materials may substitute for diatomite. However,at current prices, diatomite is preferred particularly for filtration. World outlook for production and consumption is predicted to be continued steady growth at about 3% until the year 2000 (Industrial Minerals, 1987).

The threat in the future will be the development of synthetic fillers, synthetic membranes and more efficient and easier-to-manage ultra filtration systems - particularly for food and beverages.

If diatomite consumption is to expand, markets apart from filter and filler must be developed. Applications with potential are catalyst carriers and bacterial and enzyme support systems. However in the immediate future, the unique properties will ensure diatomite's continuing role in filtration.

With no domestic source of filter grade diatomite, the potential for value adding and opportunities to export to Asian and Pacific countries, diatomite is an appropriate industrial mineral target in Australia.

PART 2 - EXPLORATION ACTIVITIES FROM 22 MARCH TO 21 JUNE 1990

INTRODUCTION

As Prof. Chris von der Borch had advised that no samples remain from the core sampling in Cooke Plains Embayment by Altmann (1976) nor in Waltowa Swamp by another Honours student who failed to complete the course, resampling of both sites was required.

Slip hammer coring equipment was obtained from the School of Earth Sciences, The Flinders University of South Australia.

A total of 32 holes were completed by Sean Kennedy (Consultant Geologist, S and C.R. Kennedy) and field assistant during the following two field trips.

* 28-29 March 1990 - Cooke Plains Embayment - 5 holes (CP1-5)
  - Waltowa Swamp - 1 hole (WS1)
* 24-28 April 1990 - Cooke Plains Embayment - 18 holes (CP6-23)
  - Waltowa Swamp - 8 holes (WS2-9)

LOCATION AND ACCESS

EL 1628 of 839 sq km about 90 km south east from Adelaide extends from the shores of Lake Alexandrina and Lake Albert eastward for 15 to 30 km covering parts of

county Russell	-	hundreds Seymour, Malcolm, Coolinong and Bonney.
county Buccleuch	-	hundreds Sherlock, Roby and Kirkpatrick.
1:250 000 sheets	-	BARKER SI 54-13
	-	PINNAROO SI 54-14
1: 50 000 sheets	-	Wellington 6727 - 11
	-	Moorlands 6827 - 111
	-	Meningie 6726 - 1
District Council	-	Meningie apart from eastern most 5 km which is in Peake.
Planning Area	-	Murray Mallee.

A full range of services are available at Tailem Bend on the River Murray, 8 km to the north and Meningie, 2 km to the southwest.

These towns are linked by the sealed Princes Highway. Cooke Plains village with store and petrol pump is on the sealed Dukes Highway and the Adelaide - Melbourne railway line which traverse the north eastern corner of EL 1628. Access is provided by a network of unsealed roads and farm tracks although the latter become difficult to negotiate in swampy ground after moderate rainfall.

Most of Cooke Plains Embayment west of Cooke Plains village is owned by McFarlane Brinkley Pty Ltd (Murray McFarlane) of Brinkley Station and Waltowa Swamp is owned by J.B. (Barry) and P.C. McClure of Tatiara Station. Other land owners are

Peter Walker	-	Jockwa Station
Keith McFarlane	-	Wellington Lodge
John White	-	Galong Station

PHYSIOGRAPHY

Cooke Plains Embayment (fig 6) and Waltowa Swamp (fig 8) are former extensions of Lake Alexandrina and Lake Albert respectively when water level was higher than at present and are part of Murray Lakes Environmental Region of the Murray Mallee Province 2 of Laut et al (1977).

Cooke Plains Embayment forms part of Lake Alexandrina Environmental Association (2.1.2) with extensive lacustrine plain fringed with swamps and salt flats, and low rises and isolated dunes. Reedlands and chenopodioid shrublands are interspersed with pasture used for grazing livestock. The surface from 0 to 4m AHD consists of shallow poorly drained black cracking clay. Waltowa Swamp is a smaller similar environment within Mt. Misery Environmental Association (2.1.4) with undulating calcrete plain between and rising prominently from the shores of Lakes Alexandrina and Albert and overlain by sand dunes. Dunes are open parkland with local mallee remnants and plain is grassland used for grazing.

The surrounding country side is undulating plain on calcreted sand, outcrop of calcrete, isolated sand dunes and calcarenite plains with parkland, grassland and small areas of cereal crops.

Land use is mainly sheep, dairy and beef cattle and some cereal cropping.

GEOLOGICAL SETTING

EL 1628 is near the western margin of the Murray Basin which contains fairly shallow water Tertiary sediments on the Coastal Plain - a physiographic unit on PINNAROO 1:250 000 sheet (Rogers, 1980). The Coastal Plain is essentially a relatively flat surface 10 to 30m above sea level.

During a period of high rainfall from 5 000 to 8 000 years ago and the peak of marine transgression 6 000 years ago, Lake Alexandrina and Lake Albert extended further eastwards than present. During this period, estuarine, lagoonal and lacustrine sediments were deposited on Pleistocene calcrete in Cooke Plains Embayment (von der Borch and Altmann, 1979) and Waltowa Swamp.

These Holocene sediments are equated with St Kilda Formation in St Vincent Basin (Rogers, 1980). In Cooke Plains Embayment east of the Dukes Highway, evaporitic gypsum beds of Yamba Formation were formed in saline lakes and during later aridity were blown into gypsarenite lunette dunes (King, 1951).

DRILLING METHODS

EQUIPMENT

Difficulty was encountered in purchasing the correct size of PVC pipe for coring, as 32mm Class 9, the size previously used, was apparently unobtainable in Adelaide. 32mm Class 12 is unsuitable as the slip hammer does not fit inside. Eventually 10 six metre lengths of 40mm Class 12 were purchased and cut in half. It was necessary to alter the ring of the core recovery tool in order to accommodate this larger diameter pipe. The ring was cut through, opened up and an extra section was welded to it. it is now oval and can be used to recover both 32mm and 40mm pipe.

FIRST FIELD TRIP

The initial target was Altmann's core hole E21 in which 2m of diatomite had been intersected. The hole was sited as accurately as possible using Altmann's map, the 1:40 000 1974 aerial photograph and the Moorlands 1:50 000 topographic sheet.

An attempt was made to core this site but it was found that the 40mm Class 12 pipe would not penetrate below about 0.4m. This was attributed to resistance caused by the extra wall thickness and by the enlarged surface area of the pipe compared to the 32mm pipe. The coring was temporarily abandoned and a visit was made to Tailem Bend and Murray Bridge in search for PVC pipe of the correct specification. Eventually 5 six metre lengths of 32mm Class 9 were obtained from Daish Irrigation of Adelaide Road, Murray Bridge.

Coring recommenced at Altmann's E21 site, but it was found that the 32mm pipe would not penetrate below 0.4m. Finally, it was decided to core the first 0.3-0.4m using 40mm pipe, then switch to 32mm pipe below this depth. This approach proved successful and was subsequently adopted for all holes drilled.

The hole at Altmann's E21 site was designated as CP1. Holes were then drilled 100m west, 100m east and 100m south and were numbered CP2, CP3 and CP4. In the latter hole, the pipe containing the final core could not be extracted.

The next target was Altmann's E18 and E17, about 700m northwest of CP1. Here 1.5m of diatomite had been intersected by Altmann. This site is in the middle of a bare salt flat (the previous sites CP1 to CP4 were on samphire flats). The vehicle became bogged 100m out into the salt flat, still 500m short of the target. After extricating the vehicle, the attempt to reach this site was abandoned.

CP5 was then drilled about 1.5 km west-southwest of CP1. This site was reached by driving west along the northern side of the fence line until the first gate was reached. CP5 is approximately 100m northeast of the corner of the two fences.

SECOND FIELD TRIP

Attending this second trip on 18 April 1990 were Joe Kappelle and Ross Newton of Golden Plateau, Perth, together with Jeff Olliver and Sean Kennedy. The two areas of interest, Cooke Plains and Waltowa Swamp were visited, and three holes were dug by hand and sampled.

THIRD FIELD TRIP

Was made to EL 1628 from 24 to 28 April 1990 by Sean Kennedy and field assistant Peter Hornsby. Before the trip commenced, a sledge was constructed, to transport equipment between the vehicle and drill hole sites. However this sledge proved unsuitable and was only used for the first hole.

During this trip, the following land owners were met:-

Murray McFarlane, "Brinkley", Wellington (met previously)
Peter Walker, "Jockwa", Wellington
Keith McFarlane, "Wellington Lodge", Wellington
John White, "Galong", Cooke Plains
Barry & Trish McClure, "Tatiara", Meningie (met previously)

25 holes were drilled by the slip hammer method. These included two on the sites of holes dug by hand on 18 April 1990.

CORE RECOVERY AND LOGGING

The PVC pipe containing the core was cut open longitudinally, using a circular saw at the School of Earth Sciences, Flinders University. This core was then logged macroscopically. In addition, samples of the most promising material were investigated under the microscope, in order to determine the fraction and diversity of diatoms present.

Core recovery rates are erratic with sometimes as little as 25cm of core recovered from a 1.20m run. This discrepancy cannot be due to compression alone. It is suggested that, due to the tight fit of the slip hammer inside the PVC tubing, air is trapped and prevents the core from moving in as the tubing is hammered down. This could be remedied by cutting or drilling a small hole in the PVC pipe to bleed the air out, then sealing this before the pipe is extracted from the ground.

RESULTS OF DRILLING

Geological logs of the 32 core holes are contained in Appendix B with visual estimation of diatom content by Sean Kennedy using binocular microscope at selected depths.

COOKE PLAINS EMBAYMENT

Corehole locations are shown on figure 5 adapted from 1:50 000 topographic sheets and the sequence intersected is summarised in Table 1 and represented schematically on cross section figure 6.

Apart from holes CP1-4 which attempted to confirm the results of Traverse A-A' of Altmann (1975), the other 19 holes were located along the axis of the embayment hopefully to penetrate the thickest development of Holocene sediments.

Diatomite occured at the surface in the west in CP22, 23 and 20 and in the east generally under overburden of black soil, salt, black mud and yellow clay to a maximum of 1.15m in CP2.

Thickness varied from 0.20m in CP 21 to 1.79m in CP10 compared with a maximum of 2.0m in E21 on Traverse A-A' (Altmann, 1975).

WALTOWA SWAMP

Core hole locations are shown on figure 7 adapted from 1:50 000 topographic sheets and the sequence intersected is summarised in Table 2 and represented schematically on cross section figure 8.

Diatomite was indentified in all nine holes below overburden of black soil, salt and black mud to a maximum of 0.50m in WS3.
Thickness varied from 0.20m in WS9 to 1.85m in WS8.

TABLE 1

DRILLHOLE INTERSECTIONS COOKE PLAINS EMBAYMENT

Corehole	Black Soil	Salt	Black Mud	Yellow Clay	Diatomite from-to	thickness	Sapropel	Basal Clay	Calcrete
CP1	0-0.34	-	-	0.34-1.10	1.10-2.32	1.22	-	-	-
2	0-0.30	-	-	0.30-1.15	1.15-2.19	1.04	-	-	-
3	0-0.20	-	0.20-0.50	0.50-0.60	0.60-1.50	0.90	-	1.50-1.63	-
4	0-0.20	-	-	0.20-1.00	1.00-1.37	0.37	-	-	-
5	0-0.40	-	-	0.40-1.00	1.00-1.75	0.75	-	1.75-2.18	-
6	-	-	-	0 -0.25	0.25-2.13	0.88	-	-	-
7	-	-	-	-	0 -0.40	0.40	-	-	-
8	-	-	-	0 -0.40	0.40-0.90	0.50	-	0.90-1.29	-
9	-	-	-	0 -0.24	0.24-1.40	1.16	-	1.40-1.60	-
10	-	-	-	0 -0.09	0.09-1.88	1.79	-	-	-
11	-	-	0 -0.18	-	0.18-0.95	0.77	-	-	0.95-1.00
12	-	-	-	-	0.05-1.50	1.45	-	1.50-1.94	-
13	-	-	0 -0.40	-	0.40-2.10	1.70	2.10-2.20	2.20-2.26	-
14	-	-	0 -0.40	-	0.40-2.00	1.60	2.00-2.21	-	-
15	-	-	0 -0.10	-	0.10-0.82	0.72	-	0.82-1.18	-
16	-	0 -0.02	0.02-0.07	-	0.07-1.08	1.01	-	-	-
17	-	0 -0.05	0.05-0.25	-	0.25-0.60	0.35	-	0.60-0.79	-
18	-	-	0 -0.50	-	0.50-1.10	0.60	-	1.10-1.30	-
19	-	-	0 -0.20	-	0.20-0.90	0.70	-	0.90-1.25	-
20	-	-	-	-	0 -1.30	1.30	-	1.30-1.40	-
21	-	0 -0.04	0.04-0.30	-	0.30-0.50	0.20	0.50-0.54	0.54-1.64	-
22	-	-	-	-	0 -1.90	1.90	-	1.90-2.34	-
23	-	-	-	-	0 -0.80	0.80	-	0.80-1.18	-

TABLE 2

DRILLHOLE INTERSECTIONS - WALTOWA SWAMP

Corehole	Black Soil	Salt	Black Mud	Diatomite From To	Thickness	Sapropel	Sand	Sandy Clay
WS1	0-0.28	-	-	0.28-0.71	0.43	-	0.71-2.28	2.28-2.57
2	-	0-0.05	0.05-0.40	0.40-1.50	1.10	1.50-1.70	-	1.70-2.06
3	-	0-0.05	-	-		-	0.05-0.35	-
	-	0.35-0.40	-	0.50-1.42	0.92	1.42-2.20	0.40-0.50	-
	-	-	-	-		-	2.20-2.26	-
4	-	-	-	-		-	0 -0.20	-
	-	-	0.20-0.40	0.40-1.28	0.88	1.28-1.70	1.70-1.95	-
5	-	-	-	0 -1.40	1.40	1.40-1.60	1.60-2.09	-
6	-	0 -0.05	0.05-0.25	0.25-0.60	0.35	0.60-1.35	1.35-1.65	1.65-2.15
7	0-0.34	-	-	0.34-1.20	0.86	1.20-1.50	1.50-2.62	-
8	-	-	-	0 -1.85	1.85	-	1.85-2.00	-
9	-	0 -0.05	0.05-0.10	0.10-0.30	0.20	0.30-0.55	0.55-0.76	-

DIATOM ASSEMBLAGE

The following seven types of frustule were identified under binocular microscope by Sean Kennedy

* spicules - probably sponge
* dumbells
* spheres
* fans - may be broken spheres
* hexagons
* bone shaped cylinders
* footballs or boat shaped.

A small quantity was scraped by knife at the nominated depth from the tube of core and smeared onto a glass slide. "Diatom content" was estimated visually as recorded in the Appendix and on cross section fig. 7 and 9.

Palaeontological examination to identify the diatom species was discussed with

* Prof. Chris von der Borch
* Assistant Prof. Brian McGowran (Adelaide University)
* Neville Alley (Principal Palaeotologist, SADME)

and it was decided that Elizabeth Barnett (Post graduate student, Flinders University) who is researching similar diatom-bearing sediments west of Lake Alexandrina would undertake the work when she is available in mid July 1990.

An estimated 50% or more diatoms were recorded at the depths detailed in Table 3.

TABLE 3

DIATOM CONTENT MORE THAN 50%

Hole	Depth (m)	Diatoms
CP1	1.30	70% dumbells, spheres, spicules
CP3	1.30	60% spheres, spicules
CP5	1.65	70% spheres
CP11	0.40	60% spheres hexagons
CP15	0.25	70% hexagons
CP16	0.40	75% hexagons
CP17	0.26	85% hexagons
CP20	0.10	50% hexagons
CP21	0.35	65% hexagons
WS4	1.10	75% diverse fauna
WS8	1.00	50% spines

LABORATORY TESTING

The nine selected intervals in Table 4 were submitted to Amdel Ltd on 13 June 1990 to determine diatom content using

* electron microscopy
* x-ray diffraction
* chemical analysis by ICP

TABLE 4

SAMPLES TO BE TESTED

Core Hole	Interval (m)	Thickness (m)
CP 3	1.00 - 1.40	0.40
CP 5	1.15 - 2.19	1.04
CP12	0.60 - 1.50	0.90
CP16	0.07 - 0.80	0.73
CP20	0.02 - 1.30	1.28
CP23	0.00 - 0.60	0.60
WS 2	0.40 - 1.50	1.10
WS 4	0.20 - 1.28	1.08
WS 8	0.00 - 1.70	1.70

EXPENDITURE

Expenditure for the two quarters to 21 June 1990 is summarised on Table 5.

Laboratory testing of nine samples was in progress at Amdel Ltd on 21 June 1990.

TABLE 5

EL1628 MALCOLM PLAINS

EXPENDITURE TO 21 JUNE 1990

ITEM	3 MONTHS TO 21.03.90	3 MONTHS TO 21.06.90	TOTAL
Tenement fees	2 139.60	NIL	2 139.60
Geological Services	3 025.00	10 640.00	13 665.00
Administration	3 250.00	8 500.00	11 750.00
Office costs	648.43	649.57	1 298.00
Data acquisition	71.50	16.50	88.00
Field operations	NIL	2 243.23	2 243.23
TOTAL	9 134.53	22 049.30	31 183.83

CONCLUSIONS

A persistent diatom-bearing soft off white to grey clay has been confirmed near the base of the Holocene sediments in most coreholes drilled in Cooke Plains Embayment and Waltowa Swamp.

Thickness varies from 0.20m to 1.79m in the former and from 0.20m to 1.85m in the latter.

Seven different shaped frustules have been observed in varying abundance up to 85% of the sediment.

Results of laboratory testing of nine samples by Amdel Ltd and the palaeontological identification of fossil species are awaited before further investigations are decided.

Jeffrey G. Olliver
....
JEFFREY G. OLLIVER

Sean Kennedy.
....
SEAN KENNEDY

JULY 1990.

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APPENDIX A

DIATOMITE IN AUSTRALIA
PRODUCTION AND IMPORTS

YEAR	AUSTRALIAN PRODUCTION (Tonnes)	PROPORTION USED FOR FILTRATION	IMPORTS MAINLY FROM USA (Tonnes)
1896	40		
1897-99	Nil		
1900	474		
1901	305		
1902	437		
1903	406		
1904	Nil		
1905	49		
1906	284		
1907	173		
1908	152		
1909	813		
1910	566		
1911	432		
1912	895		
1913	178		
1914	1 041		
1915	427		
1916	239		
1917	904		
1918	163		
1919	248		
1920	1 406		
1921	209		
1922	489		
1923	523		
1924	573		
1925	509		
1926	926		
1927	1 229		
1928	1 382		
1929	1 924		
1930	1 260		
1931	1 084		
1932	1 355		
1933	2 870		
1934	3 409		
1935	3 062		
1936	2 822		
1937	3 241		
1938	3 751		
1939	3 355		
1940	4 085		
1941	5 326		
1942	4 310	22%	
1943	4 155		
1944	3 663		
1945	3 137	75%	
1946	5 036		594
1947	5 632		1 519

1948	4 509	80%	580
1949	4 128		1 295
1950	6 321		1 678
1951	8 869		1 453
1952	6 468		848
1953	4 511		2 214
1954	5 526		2 472
1955	5 123		4 900
1956	5 882		4 464
1957	6 321		3 918
1958	4 308	50%	3 796
1959	5 170		4 574
1960	4 734		4 216
1961	5 548		4 136
1962	7 429	50%	4 258
1963	5 926		4 438
1964	8 872		5 326
1965	7 026		5 531
1966	7 228		6 896
1967	8 474		4 400
1968	6 833		5 208
1969	2 412		8 433
1970	2 656		5 964
1971	1 927		8 680
1972	1 537		9 913
1973	4 602		9 676
1974	7 438		13 316
1975	5 543		8 468
1976	1 480		9 059
1977	1 288		9 587
1978	3 136		11 983
1979	3 592		10 657
1980	3 010		12 278
1981	2 073		12 312
1982	1 561		11 477
1983	7 921		9 884
1984	6 430	10%	11 115
1985	7 587		12 479
1986	9 048		10 637
1987	10 263	10%	12 004
1988	11 279		6 763

APPENDIX B - GEOLOGICAL LOGS OF PUSHTUBE CORE HOLES

Cooke Plains Embayment CP1-23
Waltowa Swamp WS1-9

HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
CP1	0.00 - 0.34	Black Soil		
	0.34 - 0.64	gypsum rich brown to yellow clay	0.40	spicules < 5%
	0.64 - 1.10	yellow clay with minor gypsum	0.85	spicules < 5%
	1.10 - 2.32	soft grey clay	1.30	dumb bells, spheres, spicules 70%
			2.12	spicules < 5%
CP2	0.00 - 0.30	Black Soil		
	0.30 - 0.80	gypsum rich brown to yellow clay	0.35	fans, spheres, spicules 20%
	0.80 - 1.15	brown clay with minor gypsum	1.10	spicules < 3%
	1.15 - 2.19	soft grey clay	1.35	spheres, spicules 20%
			2.00	spicules < 5%
CP3	0.00 - 0.20	Black Soil		
	0.20 - 0.50	brown, gypsum rich mud	0.40	spheres, spicules, fans 20%
	0.50 - 0.60	yellow and grey clay with minor gypsum		
	0.60 - 1.50	soft grey clay	0.65	spicules < 5%
			1.30	spheres, spicules 60%
	1.50 - 1.63	basal greenish clay	1.55	none visible
CP4	0.00 - 0.20	Black Soil		
	0.20 - 1.00	yellow and black clay	0.55	spicules < 5%
			0.80	spicules, spheres 10%
	1.00 - 1.37	soft grey clay	1.10	spicules < 5%
CP5	0.00 - 0.40	Black Soil		
	0.40 - 1.00	yellow and brown clay	0.75	spicules 5%
	1.00 - 1.75	soft grey clay	1.40	spicules, spheres 10%
			1.65	spheres 70%
	1.75 - 2.18	light grey sandy clay	2.10	spicules 5%

HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
CP6	0.00 - 0.03	grey gypsum rich clay		
	0.03 - 0.25	yellow, gypsum rich clay		
	0.25 - 2.00	grey to dark grey clay	0.45	spicules 15%
			1.04	spicules 20%
			1.75	spicules, spheres 15%
			1.95	spicules, spheres, fans 40%
	2.00 - 2.13	grey, sandy clay		
CP7	0.00 - 0.40	grey clay (hole dug by hand)	0.35	spicules, spheres 10%
CP8	0.00 - 0.25	brown clay and mud		
	0.25 - 0.40	mud and gypsum		
	0.40 - 0.70	grey clay	0.50	none visible
	0.70 - 0.90	very light grey clay	0.80	none visible
	0.90 - 1.29	greenish basal clay	1.20	none visible
CP9	0.00 - 0.16	light grey sandy clay	0.10	hexagons 30%
	0.16 - 0.24	yellow clay		
	0.24 - 0.90	light grey, gypsum rich clay	0.58	spicules 5%
	0.90 - 1.40	light grey clay with dark stringers	1.20	none visible
	1.40 - 1.60	greenish grey, sandy basal clay	1.50	none visible
CP10	0.00 - 0.09	black, stong smelling mud		
	0.09 - 0.60	grey clay, sandy in parts	0.45	spicules, spheres 10%
			0.55	spicules, spheres 40%
	0.60 - 1.00	dark grey clay	0.90	spheres 20%
	1.00 - 1.88	grey clay with gypsum	1.80	fans 25%

HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
CP11	0.00 - 0.05	algal mat		
	0.05 - 0.18	black, strong smelling mud		
	0.18 - 0.65	grey clay with sandy layers	0.40	spheres, hexagons 60%
	0.65 - 0.95	dark grey clay	0.80	spheres, "footballs" 25%
	0.95.- 1.00	calcrete		
CP12	0.00 - 0.05	light grey algal mat		
	0.05 - 0.20	light grey sandy clay	0.15	none visible
	0.20 - 0.60	light grey clay	0.55	none visible
	0.60 - 1.50	grey clay	1.05	fans, "footballs", spheres 40%
			1.30	fans, "footballs", spheres 40%
	1.50 - 1.94	greenish grey basal clay		
CP13	0.00 - 0.40	black, strong smelling mud		
	0.40 - 1.20	grey clay	0.70	spicules 15%
	1.20 - 2.10	dark grey clay	1.60	spicules 15%
	2.10 - 2.20	sapropel		
	2.20 - 2.26	grey sandy basal clay		
CP14	0.00 - 0.40	black, strong smelling mud		
	0.40 - 0.80	light grey clay	0.60	none visible
	0.80 - 2.00	dark grey clay	1.40	none visible
	2.00 - 2.21	sapropel		
CP15	0.00 - 0.10	black mud		
	0.10 - 0.28	light grey clay	0.25	hexagons 70%
	0.28 - 0.35	dark grey clay		
	0.35 - 0.47	greenish grey clay	0.45	fans 5%
	0.47 - 1.18	dark grey clay	0.70	fans, spicules 30%
			1.00	none visible

HOLE NO	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
CP16	0.00 - 0.02	salt		
	0.02 - 0.07	black, strong smelling mud		
	0.07 - 0.55	grey clay with sandy layers	0.40	hexagons 75%
	0.55 - 1.08	dark grey clay	0.80	hexagons 25%
CP17	0.00 - 0.05	salt		
	0.05 - 0.25	black, stong smelling mud		
	0.25 - 0.30	light grey sandy clay	0.26	hexagons 85%
	0.30 - 0.60	light grey clay	0.45	spicules 5%
	0.60 - 0.79	grey clay		
CP18	0.00 - 0.50	black, strong smelling mud		
	0.50 - 0.70	grey sandy clay		
	0.70 - 1.10	grey clay		
	1.10 - 1.30	dark grey clay	1.10	none visible
CP19	0.00 - 0.20	black, strong smelling mud		
	0.20 - 0.46	grey clay	0.30	hexagons 20%
	0.46 - 0.90	light grey to yellowish clay	0.60	hexagons 10%
	0.90 - 1.00	greenish grey clay	0.95	none visible
	1.00 - 1.25	dark grey clay	1.10	none visible
CP20	0.00 - 0.20	light grey sandy clay	0.10	hexagons 50%
	0.20 - 1.30	dark grey clay	0.70	none visible
	1.30 - 1.40	light grey sandy clay	1.35	none visible
CP21	0.00 - 0.04	salt		
	0.04 - 0.30	black, strong smelling mud		
	0.30 - 0.50	grey clay	0.35	hexagons 65%
	0.50 - 0.54	sapropel		
	0.54 - 1.64	grey green, sandy basal clay	1.35	none visible

HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
CP22	0.00 - 1.50	very light grey clay	0.50	none visible
			1.50	fans, spicules 20%
	1.50 - 1.90	light grey clay	1.90	spheres, fans 15%
	1.90 - 2.34	light grey to green clay	2.20	none visible
CP23	0.00 - 0.40	dark grey clay	0.20	spheres, hexagons 50%
	0.40 - 0.80	light grey sandy clay	0.60	none visib le
	0.80 - 1.18	dark grey clay	1.00	bone shaped cylinders 20%
WS1	0.00 - 0.28	black soil		
	0.28 - 0.71	light grey clay	0.60	spicules <5%
	0.71 - 2.28	grey to yellow c.gr. sand, wellsorted, subrounded to rounded	1.20	none visible
		with dark specks	1.88	none visible
	2.28 - 2.57	greenish grey m.gr. sand grading to green clay	2.40	none visible
WS2	0.00 - 0.05	salt		
	0.05 - 0.40	black, strong smelling mud		
	0.40 - 1.50	grey clay	0.60	spheres 30%
			1.30	spheres, spines, fans 30%
	1.50 - 1.70	sapropel		
	1.70 - 2.06	greenish grey sandy clay	1.90	none visible
WS3	0.00 - 0.05	salt		
	0.05 - 0.35	dark sand		
	0.35 - 0.40	salt		
	0.40 - 0.50	dark, coarse sand		
	0.50 - 1.42	dark grey to brown clay	0.70	"footballs" etc 10%
	1.42 - 2.20	sapropel		
	2.20 - 2.26	dark coarse sand		

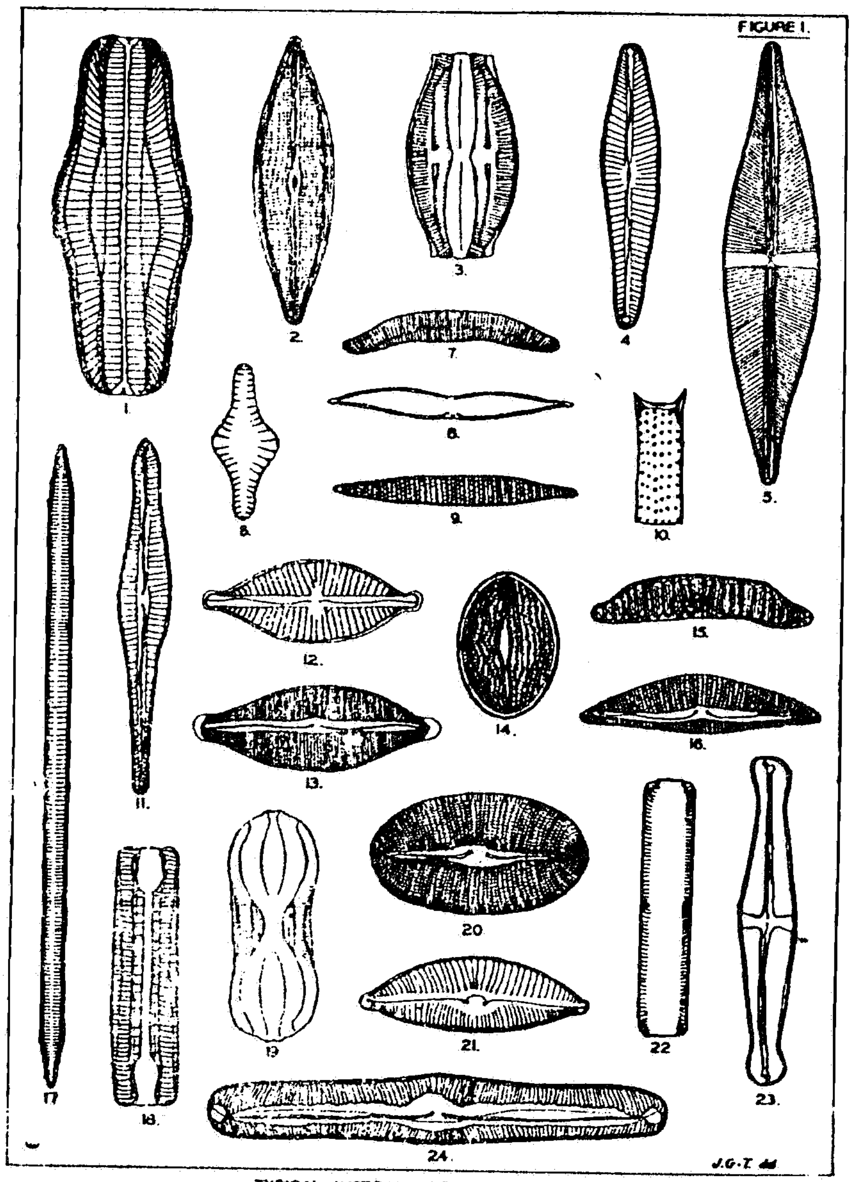
HOLE NO.	SAMPLE (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND
WS4	0.00 - 0.20	sand		
	0.20 - 0.40	black, strong smelling mud		
	0.40 - 1.28	grey clay	1.10	diverse fauna 75%
	1.28 - 1.70	sapropel		
	1.70 - 1.95	coarse grained sand		
WS5	0.00 - 1.20	grey clay	0.60	none
	1.20 - 1.40	light grey clay	1.30	diverse fauna 30%
	1.40 - 1.60	sapropel		
	1.60 - 2.09	coarse, white sand		
WS6	0.00 - 0.05	salt		
	0.05 - 0.25	black, strong smelling mud		
	0.25 - 0.60	green to grey clay	0.40	"footballs", fans, spheres etc 30%
	0.60 - 1.35	sapropel		
	1.35 - 1.65	dark grey coarse sand		
	1.65 - 2.15	grey to green clayey sand		
WS7	0.00 - 0.34	black to brown soil		
	0.34 - 1.20	yellow to grey clay	0.45	spheres 20%
			1.10	fans 20%
	1.20 - 1.50	sapropel		
	1.50 - 2.62	grey sand	2.00	none visible
WS8	0.00 - 1.15	light brown to grey clay	1.00	spines 50%
	1.15 - 1.85	grey clay	1.30	diverse fauna 40%
			1.70	spheres etc 30%
	1.85 - 2.00	coarse grained white sand		
WS9	0.00 - 0.10	salt and black mud		
	0.10 - 0.30	sandy grey clay	0.20	he xagons, spheres 40%
	0.30 - 0.55	sapropel		
	0.55 - 0.76	coarse grained grey sand		

PLATE 1 - PUSH TUBE CORING, COOKE PLAINS EMBAYMENT

Sean Kennedy operating coring device at
Hole CP12. April 1990

PLATE 2 - PUSH TUBE CORING, WALTOWA SWAMP

Peter Hornsby operating coring device at Hole WS9 on lake with thin salt crust over black mud. April 1990



TYPICAL AUSTRALIAN FRESH-WATER DIATOMS

1. ***Amphora*** sp. 1. Lillicur, Victoria. x 715.
2. ***Neidium*** sp. 1. Bed of Arrowsmith River, Arrino, W.A. x 715.
3. ***Amphora*** sp. 2. Little Badgerup, W.A. x 715.
4. ***Gomphonema*** sp. 1. Lillicur, Victoria. x 1270.
5. ***Stauroneis*** sp. 1. Lillicur, Victoria. x 715.
6. ***Tabellaria*** sp. 1. Mickleham, Victoria. x 1270.
7. ***Eunotia*** sp. 1. Lillicur, Victoria. x 435.
8. ***Glyphodesmis*** sp. 1. Little Badgerup, Waneroo district, W.A. x 435.
9. ***Eunotia*** sp. 2. 18"-24" layer, Ewart's Swamp, Grassmere, W.A. x 715.
10. ***Melosira*** sp. 1. Chalk Mountain, Bugaldi, N.S.W. x 1270.
11. ***Gomphonema*** sp. 2. 18"-24" layer, Ewart's Swamp, Grassmere, W.A. x 715.
12. ***Navicula*** sp. 1. 18"-24" layer, Ewart's Swamp, Grassmere, W.A. x 1270.
13. ***Navicula*** sp. 2. 18"-24" layer, Ewart's Swamp, Grassmere, W.A. x 715.
14. ***Cocconeis*** sp. 1. Lillicur, Victoria. x 640.
15. ***Epithema*** sp. 1. 18"-24" layer, Ewart's Swamp, Grassmere, W.A. x 435.
16. ***Cymbella*** sp. 1. Swamp, P. Vesty's property, Bullsbrook, W.A. x 435.
17. ***Synedra*** sp. 1. Lillicur, Victoria. x 410.
18. ***Amphora*** sp. 3. 18"-24" layer Ewart's Swamp, Grassmere, W.A. x 715.
19. ***Amphora*** sp. 4. Little Badgerup, Waneroo District, W.A. x 435.
20. ***Diploneis*** sp. 1. 18"-24" layer Ewart's Swamp, Grassmere, W.A. x 715.
21. ***Cymbella*** sp. 2. Lillicur, Victoria. x 640.
22. ***Amphora*** sp. 5. Lillicur, Victoria. x 410.
23. ***Stauroneis*** sp. 2. Little Badgerup, Waneroo District. W.A. x 715.
24. ***Pinnularia*** sp. 1 Lillicur, Victoria. x 410.

The figures have been drawn by Miss Joyce Gilbert-Tomlinson, of the Bureau of Mineral Resources, Canberra.

FROM CRESPIN (1946) : 28-29

FIG. 1

DEPARTMENT OF MINES AND ENERGY ADELAIDE

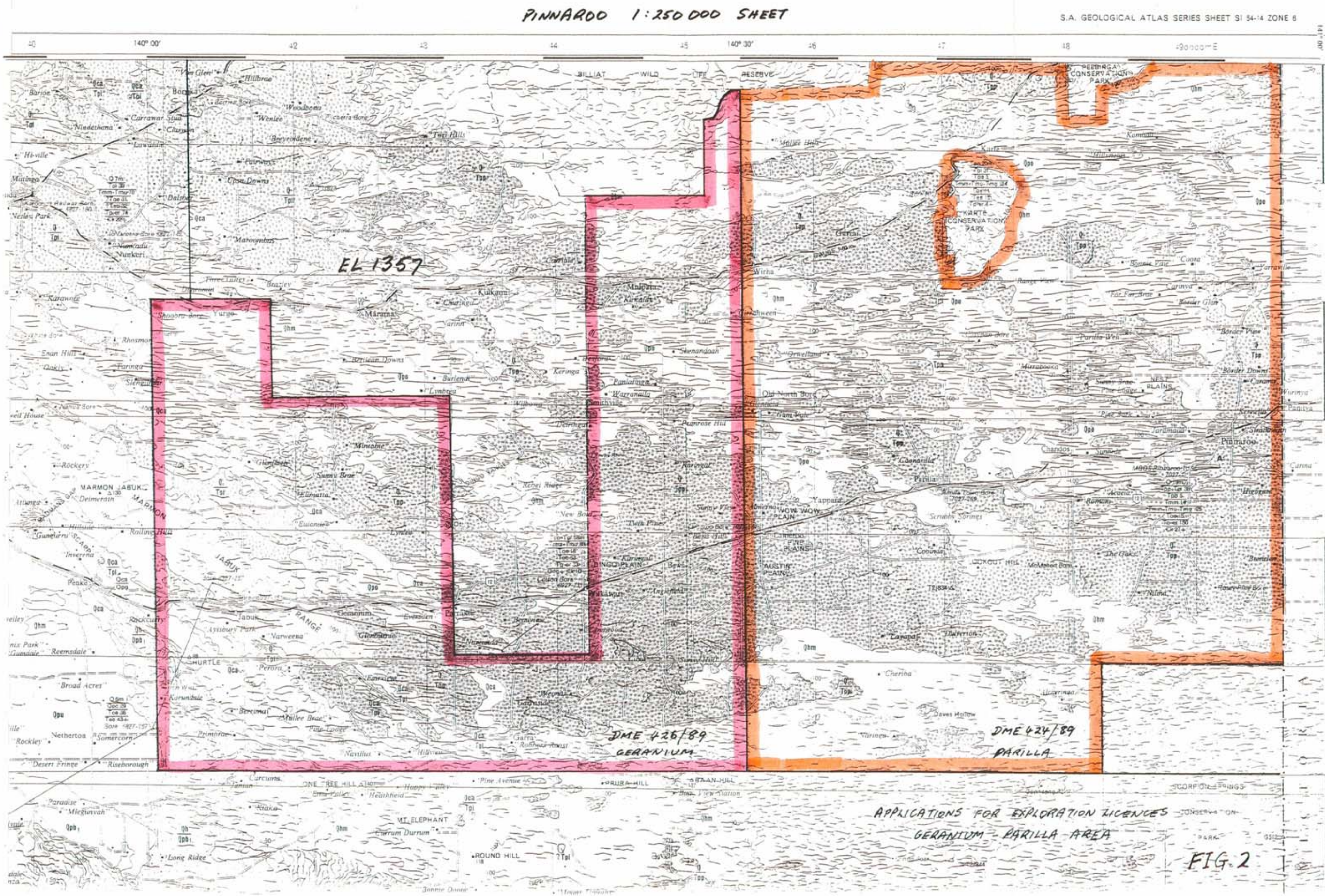
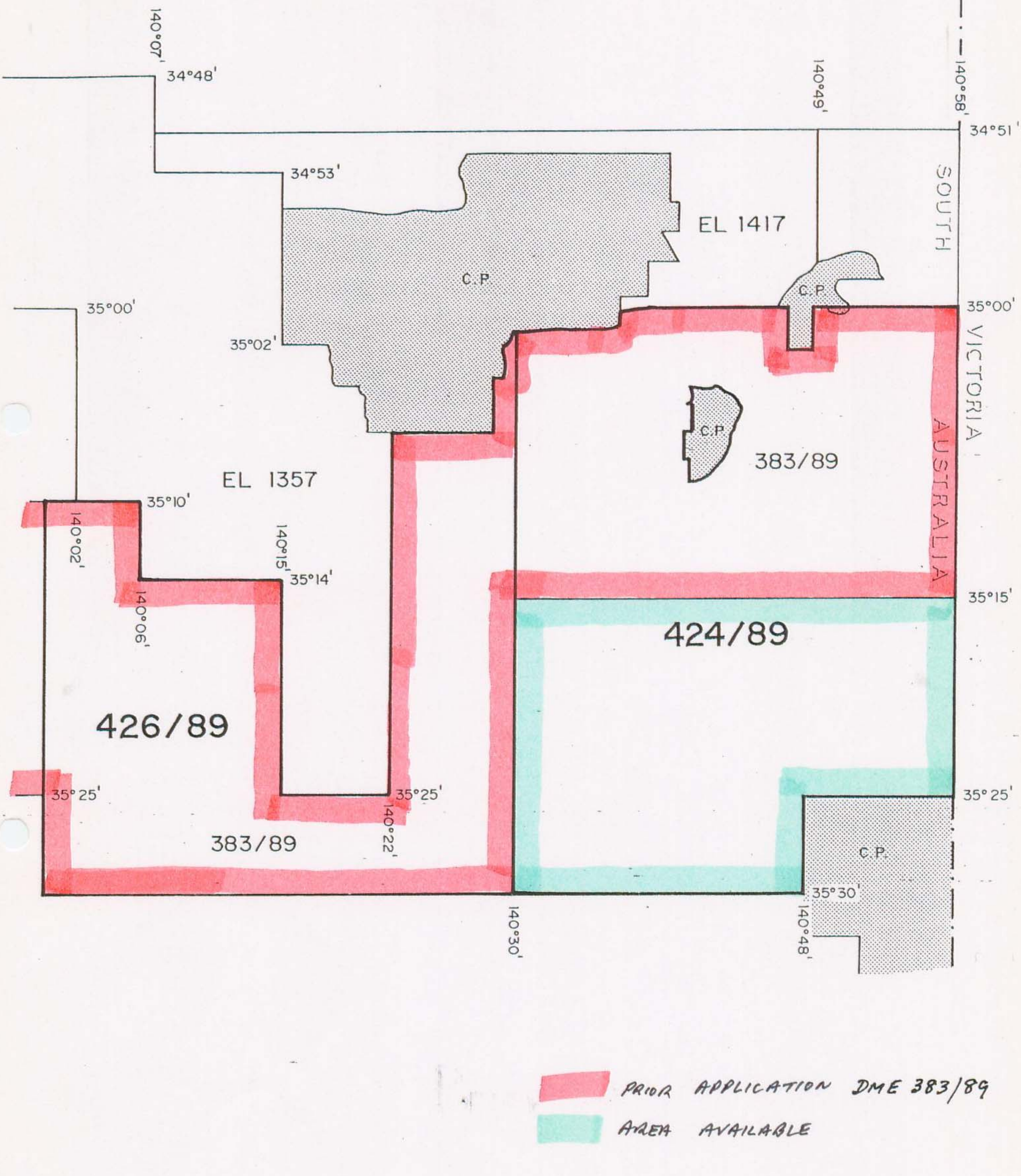


FIG. 2

045



APPLICATIONS FOR EXPLORATION LICENCES

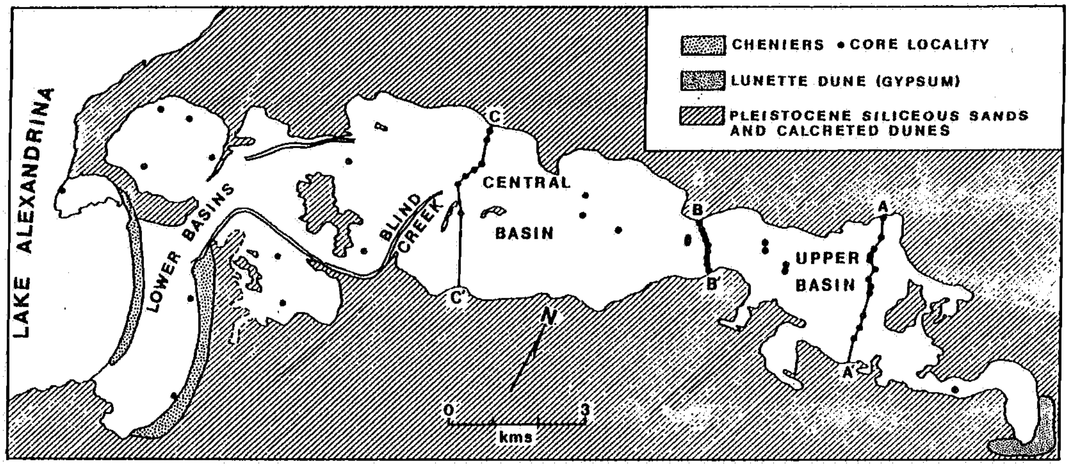
GERANIUM - PARILLA AREA

OVERLAP

1:500 000

FIG. 3

047



Details of the Cooke Plains Embayment, a former extension of Lake Alexandrina. Localities of all cores taken during this study are shown. Logs of cores collected along traverses A-A', B-B' and C-C' are illustrated in the cross-sections. The youngest gypsum lunette is shown at the eastern end of the Embayment. The embayment comprises the low lying swampy region shown without symbol.

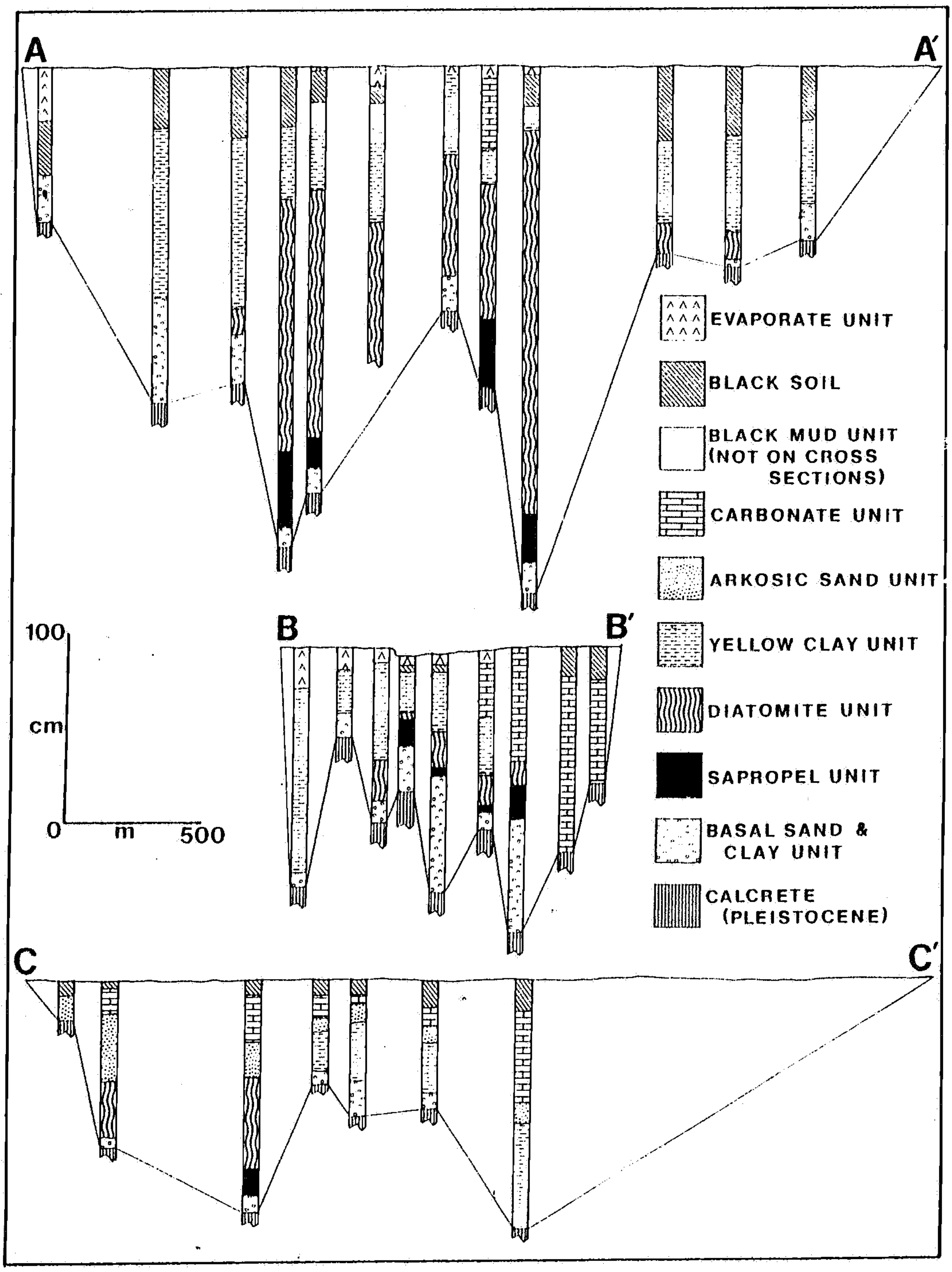
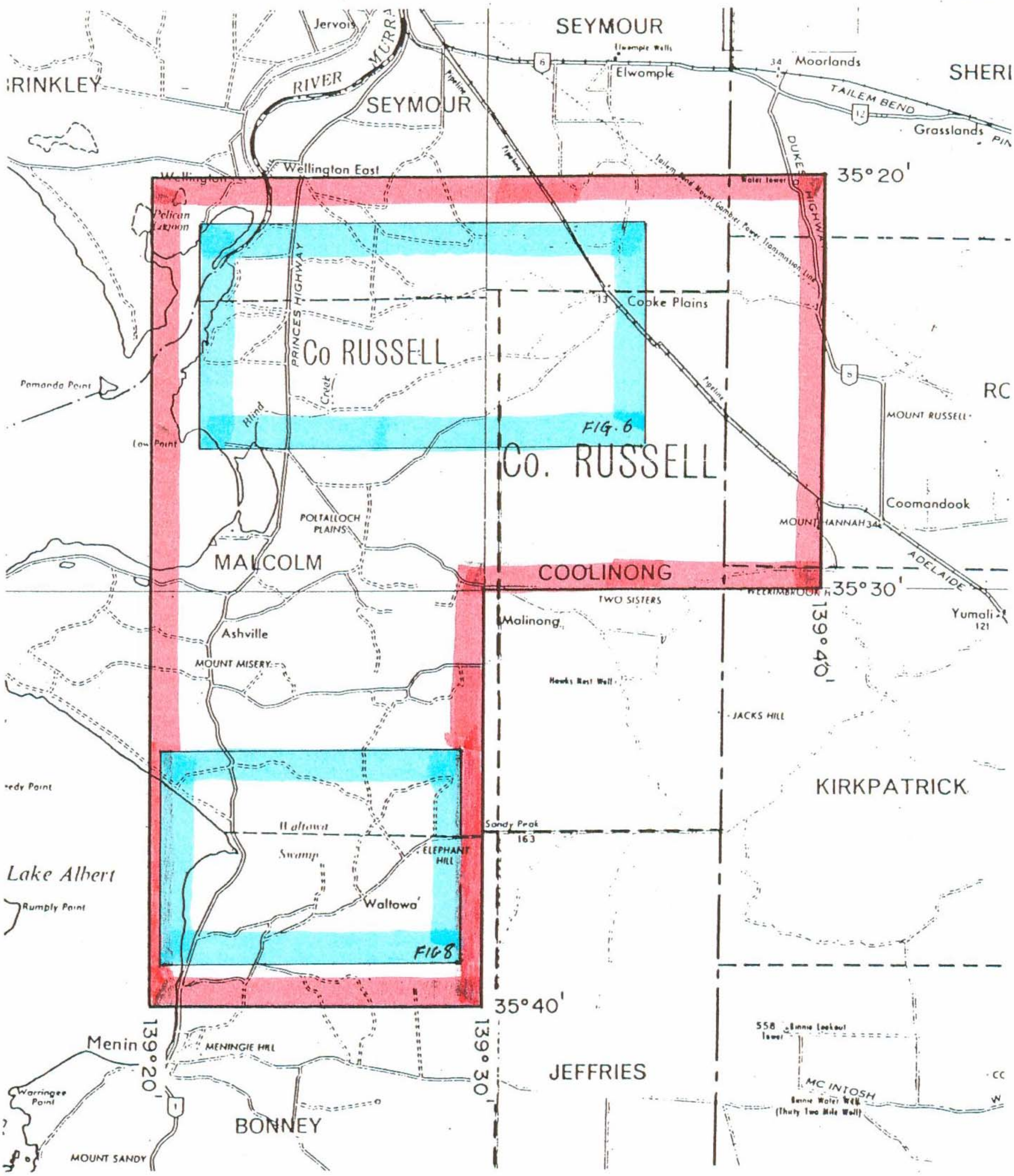


FIG. 4

Cross sections A-A', B-B' and C-C' of the Cooke Plains Embayment (See above for localities.) The Black Mud Unit is shown in its stratigraphic sequence in the legend, but was not intersected in these traverses.

SCHEDULE A
048



SCALE 1:250,000

KILOMETRES 5 0 5 10 15 20 25 KILOMETRES

FIG. 5

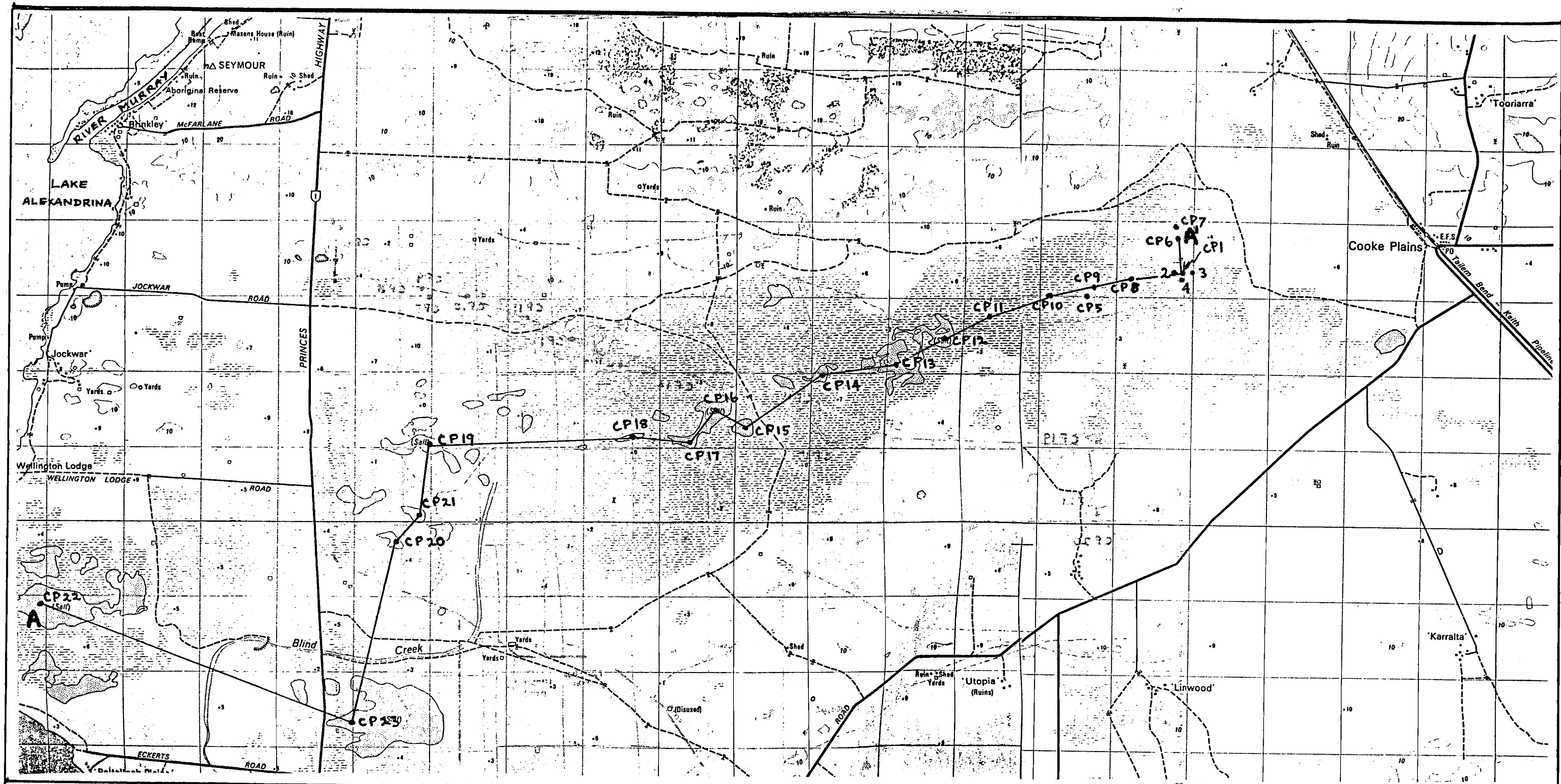
APPLICANT: EDDINGTON PTY. LTD.

DME 205/89 AREA: 839 square kilometres (approx.)

1: 250 000 PLANS: BARKER, PINNAROO

LOCALITY: MALCOLM PLAINS AREA – Approx. 25 km SOUTH of TAILEM BEND

DATE GRANTED: *22 DEC 1989* DATE EXPIRED: *21 DEC 1990* EL No: *1628*



OLLIVER GEOLOGICAL SERVICES PTY. LTD.

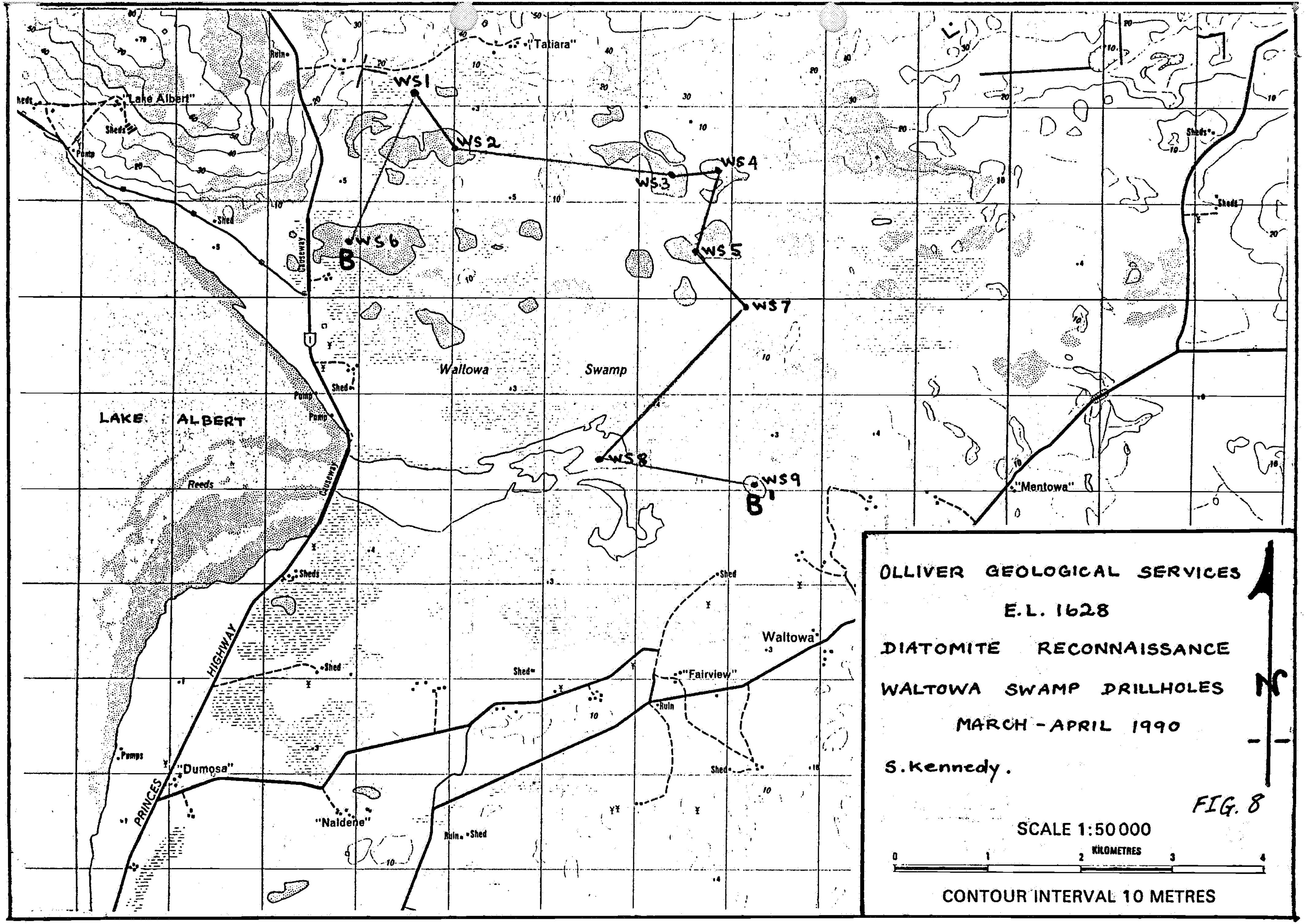
E.L. 1628 DIATOMITE RECONNAISSANCE

COOKE PLAINS EMBAYMENT DRILLHOLES

MARCH - APRIL 1990.

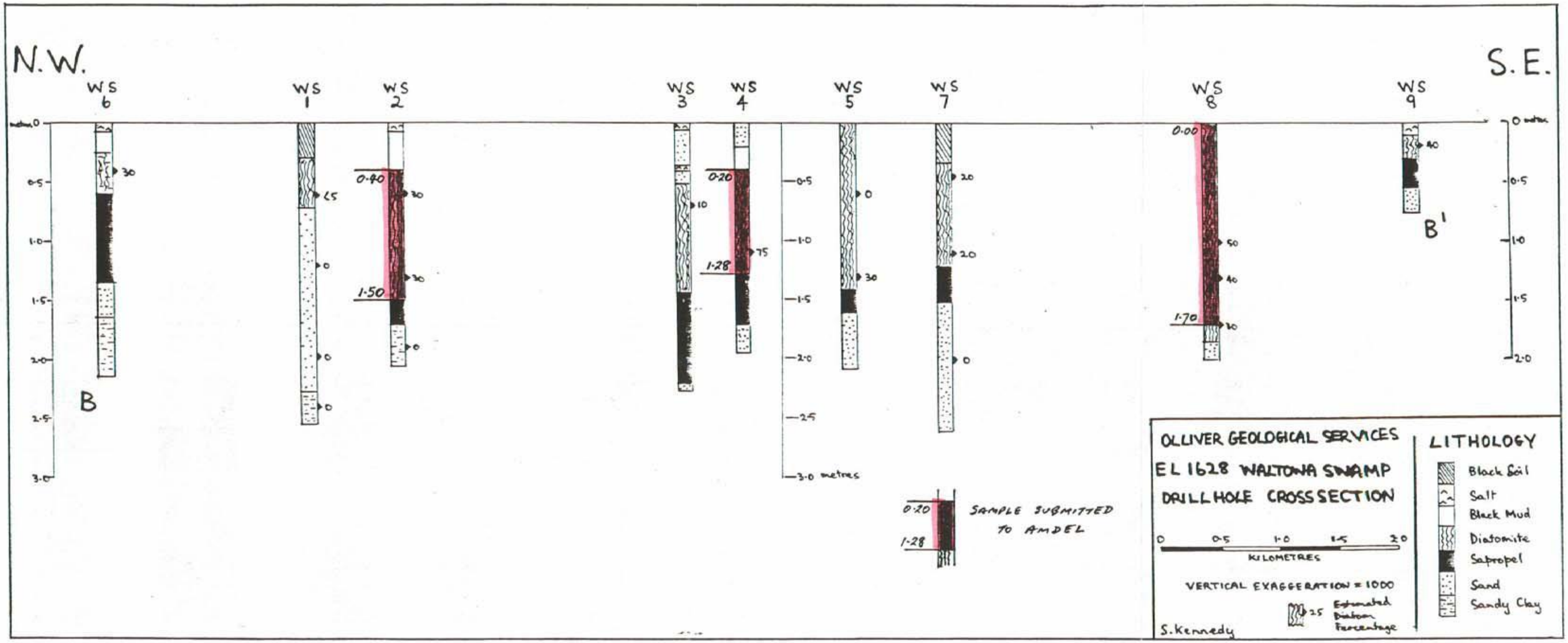
S. Kennedy.

FIG. 6



"Tatiara"
"Lake Albert"
Sheds
Pump
Shed
Ruin
Causeway
WS1
WS2
WS3
WS4
WS5
WS6
WS7
WS8
WS9
B
B'
Waltowa
Swamp
LAKE ALBERT
Reeds
Pumps
PRINCES HIGHWAY
"Dumosa"
"Naldene"
"Fairview"
Waltowa
"Mentowa"
OLLIVER GEOLOGICAL SERVICES
E.L. 1628
DIATOMITE RECONNAISSANCE
WALTOWA SWAMP DRILLHOLES
MARCH - APRIL 1990
S. Kennedy.
FIG. 8
N
SCALE 1:50 000
KILOMETRES
0 1 2 3 4
CONTOUR INTERVAL 10 METRES

050



N.W.
S.E.
WS 6
WS 1
WS 2
WS 3
WS 4
WS 5
WS 7
WS 8
WS 9
B
B'
SAMPLE SUBMITTED TO AMDEL
OLLIVER GEOLOGICAL SERVICES
EL 1628 WALTOWA SWAMP
DRILLHOLE CROSSSECTION
KILOMETRES
VERTICAL EXAGGERATION = 1000
Estimated Diatom Percentage
S.Kennedy
LITHOLOGY
Black Soil
Salt
Black Mud
Diatomite
Sapropel
Sand
Sandy Clay

FIG. 9

S.W.
N.E.
CP 22
CP 23
CP 20
CP 21
CP 19
CP 18
CP 17
CP 16
CP 15
CP 14
CP 13
CP 12
CP 11
CP 10
CP 9
CP 8
CP 1
CP 6
A
A'
3·0 metres
0·07
0·80
SAMPLE SUBMITTED TO AMDEL
OLLIVER GEOLOGICAL SERVICES
EL 1628 COOKE PLAINS
DRILLHOLE CROSSSECTION
0 0·5 1·0 1·5 2·0
KILOMETRES
VERTICAL EXAGGERATION = 1000
25 Estimated Diatom Percentage
S.Kennedy
LITHOLOGY
Black Soil
Salt
Black Mud
Yellow Clay
Diatomite
Sapropel
Basal Clay
Calcrete

FIG. 7

8281-1

EL 1628 MALCOLM PLAINS

QUARTERLY REPORT NO. 3 TO 21 SEPTEMBER 1990

TENURE

EL 1628 granted to Olliver Geological Services Pty Ltd on 22 December 1989 for six months was renewed for a further six months until 21 December 1990.

FIELD INVESTIGATIONS

There was no field work during the quarter.

AMDEL TESTING

The following nine samples of diatom-bearing sediment from push tube core holes were submitted to Amdel Ltd on 13 June 1990.

Core Hole	Interval (m)	Thickness (m)
Cooke Plains Embayment		
CP 3	1.00 - 1.40	0.40
CP 5	1.15 - 2.19	1.04
CP12	0.60 - 1.50	0.90
CP16	0.07 - 0.80	0.73
CP20	0.02 - 1.30	1.28
CP23	0.00 - 0.60	0.60
Waltowa Swamp		
WS 2	0.40 - 1.50	1.10
WS 4	0.20 - 1.28	1.08
WS 8	0.00 - 1.70	1.70

Amdel Report G 8622/90 is attached containing results of X-ray diffraction, chemical analysis and optical microscopy.

Few, if any, diatoms are reported in most samples.

SADME TESTING

The following three samples of "sapropel" were submitted to Mineral Resources Branch SADME to determine clay mineralogy.

Corehole	Interval (m)	Thickness (m)
CP14	2.0 - 2.21	0.21
WS 3	1.42 - 2.20	0.78
WS 6	0.60 - 1.35	0.75

A copy of the results are attached of a cursory examination by John Keeling (Senior Geologist).

In contrast to the Amdel report, moderate amounts of diatom fragments were noted.

FLINDERS UNIVERSITY TESTING

The following seven samples of diatom-bearing material were submitted to Elizabeth Barnett to

* identify genera and/or species
* estimate abundance of diatoms in the sediment.

Corehole		Depth (m)
Cooke Plains	CP 1	1.3
	CP 9	0.1
	CP12	1.05
	CP17	0.26
	CP23	1.00
Waltowa Swamp	WS 2	1.30
	WS 8	1.30

EXPENDITURE TO 21 SEPTEMBER

ITEM	6 MONTHS TO 21.06.90	3 MONTHS TO 21.09.90	TOTAL
Tenement fees	2 139.60	nil	2 139.60
Geological Services	13 665.00	2 060.00	15 725.00
Administration	11 750.00	1 500.00	13 250.00
Office costs	1 298.00	568.19	1 866.19
Data acquisition	88.00	nil	88.00
Field operations	2 243.23	nil	2 243.23
Laboratory testing	nil	1 800.00	1 800.00
TOTAL	31 183.83	5 928.19	37 112.02

....

J.G. OLLIVER

Amdel Limited
(Incorporated in S.A.)
31 Flemington Street,
Frewville, S.A. 5063

Telephone: (08) 372 2700

P.O. Box 114,
Eastwood, S.A. 5063

Telex: AA82520
Facsimile: (08) 79 6623

26 July 1990

Olliver Geological Services
Chalkhill Road
McLAREN VALE SA 5171

ATT: MR J.G. OLLIVER

REPORT G 8622/90

YOUR REFERENCE:	Letter from S. & C.R. Kennedy dated 13/6/90. Discussions with J.G. Olliver. Ref. Malcolm Plains diatomite project.
IDENTIFICATION:	CP3, CP5, CP12, CP16, CP20, CP23, WS2, WS4 and WS8.
MATERIAL:	Nine samples of "diatomites".
DATE RECEIVED:	13 June 1990
WORK REQUIRED:	Examination as possible diatomites. X-ray diffraction and chemical analysis.

Investigation and Report by: Dr Roger Brown

Keith Henley

Dr Keith J Henley
Manager, Geological Services

hy

EXAMINATION OF NINE SAMPLES AS POSSIBLE DIATOMITES

1. INTRODUCTION

Nine samples of prospective diatomites were received from S. & C.R. Kennedy on behalf of Olliver Geological Services, McLaren Vale. They were to be assessed for mineralogy and diatom content using X-ray diffraction and chemical analysis, with some optical microscopy as appropriate. Scanning electron microscopy was proposed if appropriate but this has not eventuated.

2. PROCEDURE

The samples were examined in a preliminary way visually and using stereomicroscopy.

The samples were mainly wet, often plastic, dark greyish or dark brown coloured muds, although some were pale or pale in patches due to the presence of major amounts of gypsum crystals. They were dried at 130°C, pre-crushed and riffled to produce representative subsamples. These were pulverised and split for XRD examination and analysis for free silica.

2.1 X-ray Diffraction

X-ray powder diffraction traces were recorded and interpreted in terms of the minerals present. Rough estimates of quartz content were made for subsequent comparison with the free silica analyses, which give results which include amorphous silica (as diatoms).

The mineralogy as determined by XRD is given in Table 1, which lists the minerals found, in approximate order of decreasing abundance, using the semiquantitative abbreviations given. Large amounts of indeterminate clays are reported in a number of samples. This is based on the observation of a lack of crystalline material, and the observation of non-basal clay diffraction peaks. The lack of any corresponding basal diffraction peak indicates a poorly-defined, poorly-crystalline clay of uncertain type, probably a smectite or interstratified smectite or a semi-amorphous clay material. A determination of clay types is not possible in these circumstances from a bulk sample. An examination of a separated and properly prepared clay fraction may allow a proper identification but this is not certain. The estimation of the amount of such material is hardly possible, and the semiquantitative estimates in the table are subject to very considerable error for this reason. The main observation to be made is that considerable amounts of such indeterminate clay material are present in many of the samples. It is suspected that there may also be amorphous organic material present in some samples.

2.2 Free Silica Analyses

The free silica analyses were carried out by a chemical method. The differences between these determinations and the approximate quartz figures from the XRD examination should give an indication of the presence of possible diatoms (as amorphous silica). This difference is not an accurate figure, but it can be expected to indicate samples in which a considerable proportion of diatoms is present, such as is presumably required for material to be of commercial interest.

The results are tabulated below.

Sample	Approximate quartz (XRD) %	Free silica (chem.) %
CP3	15	13.9
CP5	12	19.8
CP12	16	17.1
CP16	7	6.75
CP20	10	8.75
CP23	5	7.20
WS2	10	8.85
WS4	25	25.8
WS8	25	24.6

Only CP5 shows some indication of the presence of appreciable amorphous silica, and then only of the order on 5-10%.

2.3 Microscopic Observation

Examination of the dried, broken-up samples by means of the stereomicroscope was not rewarding in terms of obtaining information on the presence of diatoms. In general the dry samples were pale to mid-grey in colour, very fine grained and textureless, with a clay-like appearance. Occasional to abundant fragments and aggregates, representing gypsum crystals or halite, were often visible and their abundance was roughly in accord with the indications of the XRD examination. Gypsum in particular was prone to collect in areas or as aggregates, giving a paler appearance to areas of the sample or to the sample as a whole (after heating to 130°C gypsum crystals turn white because of conversion to hemihydrate). Some rare small gastropods were seen in CP23.

Some of the samples were examined at high magnification under the polarising microscope. The moist original samples were used, placed in water on a microscope slide and rubbed out to a thin layer under the cover slip. Samples CP5 (suggested by the analytical results) and WS8 were examined in most detail. Apart from quartz grains and a finely-divided background of clay particles, the main particles seen were clear, colourless isotropic tapered spicules, often or usually as broken fragments, about 15-20 μm in diameter and commonly about 50-150 μm long. These are familiar particles commonly seen in diatomaceous earths, and are assumed to be sponge spicules. Rare unbroken spicules are tapered at both ends and gently curved, i.e. rather banana-like.

Also present and rather rare were colourless fragments exhibiting a periodic structure, presumed to be diatom fragments. They were almost invariably ragged broken pieces up to about 50 μm in size, with irregular or curved edges and exhibiting rows of periodic perforations, usually slightly curved. In the case of WS8, which appeared to have suffered less damage, these presumed diatoms sometimes exhibited their unbroken form, which appeared to be roughly circular and about 150-200 μm in diameter, showing slightly curved rows of approximately radial perforations. Another much rarer diatom type was a delicate elongated comb-like structure difficult to observe satisfactorily.

Neither of these diatom types resemble in any way the elongated, segmented, perforated cyclindrical diatoms or the perforated "flying-saucer"-like diatoms familiar from commercial diatomaceous earths used for filter aids or insulation materials. These are believed to be imported.

There seems to be little prospect of separating out the observed rare diatom fragments from the fine-grained clay-rich matrix to concentrate them for scanning electron microscope examination. Discussion with Mr Olliver indicates that this is not required.

3. REMARKS

Estimates of amorphous silica indicate that its proportion is very low (say 0-10%). Most of the amorphous silica is evidently sponge spicules, and consequently the level of diatoms does not appear even to approach a commercial level. The high proportion of fine clay making up the matrix of most samples would appear to prevent beneficiation of the fine silica particles which in any case consist mainly of spicules and quartz particles.

TABLE 1: MINERALOGY OF NINE SAMPLES BY XRD

CP3		CP5		CP12		CP16		CP20	
IC	D	IC	D	IC	D	Gy	D	IC	D
Ha	A	Gy	A-SD	Q	A	Ha	SD	Ha	SD
Q	A	Ha	A	Ha	A	IC	A-SD	Q	A
Gy	A	Q	A	K	Tr-A	Q	A	Gy	Tr-A
K	Tr			F^-?	Tr			K	Tr
F?	Tr								

CP23		WS2		WS4		WS8	
Gy	D	IC	D	IC	D	IC	D
IC	SD	Ha	SD	Q	SD	Q	SD
Ha	A	Q	A	Ha	A	Ha	A
Q	Tr-A	Gy	A	M	A	M	Tr-A
F-^{1}?	Tr	K	Tr	Gy	Tr-A	K	Tr-A
				K	Tr-A	Py	Tr-A

Mineral Key

F	Feldspar (plag.)
F^-	K feldspar
Gy	Gypsum (hemihydrate following heating : reported as gypsum)
Ha	Halite
IC	Indeterminate clays - see text
K	Kaolinite
M	Mica/illite
Py	Pyrite
Q	Quartz

SEMIQUANTITATIVE ABBREVIATIONS:

D = Dominant. Used for the component apparently most abundant, regardless of its probable percentage level.

SD = Sub-dominant. The next most abundant component(s) providing its percentage level is judged above about 20.

A = Accessory. Components judged to be present between the levels of roughly 5 and 20%.

Tr = Trace. Components judged to be below about 5%.

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA
191 Greenhill Road, Parkside

TELEPHONE: (08) 274 7500
TELEGRAMS: Domex
TELEX: AA88692
FACSIMILE No. 272 7597
PLEASE ADDRESS ALL CORRESPONDENCE TO:
The Director-General
PO Box 151
Eastwood, S.A., 5063
In reply, please quote
EL 1628
JLK:LJT

28 August 1990

J G Olliver
PO Box 24
McLaren Vale SA 5171

Dear Jeff

RE: Sapropel Samples from Waltowa Swamp and Cooke Plains (EL 1628)

The above samples were given a cursory examination by J Keeling in the course of his current work on clay at CSIRO Division of Soils. The results detailed below, indicate that the samples comprise a high proportion of organic matter and water.

The mineral content is quartz and halite with minor clay, possibly a mixed layer smectite.

The approximate organic content was determined for dried samples by loss on ignition at 500°C. Enclosed are scanning electron micrographs of sample WS6 which show that in addition to quartz and halite, there are also moderate amounts of diatom fragments.

Summary of Results

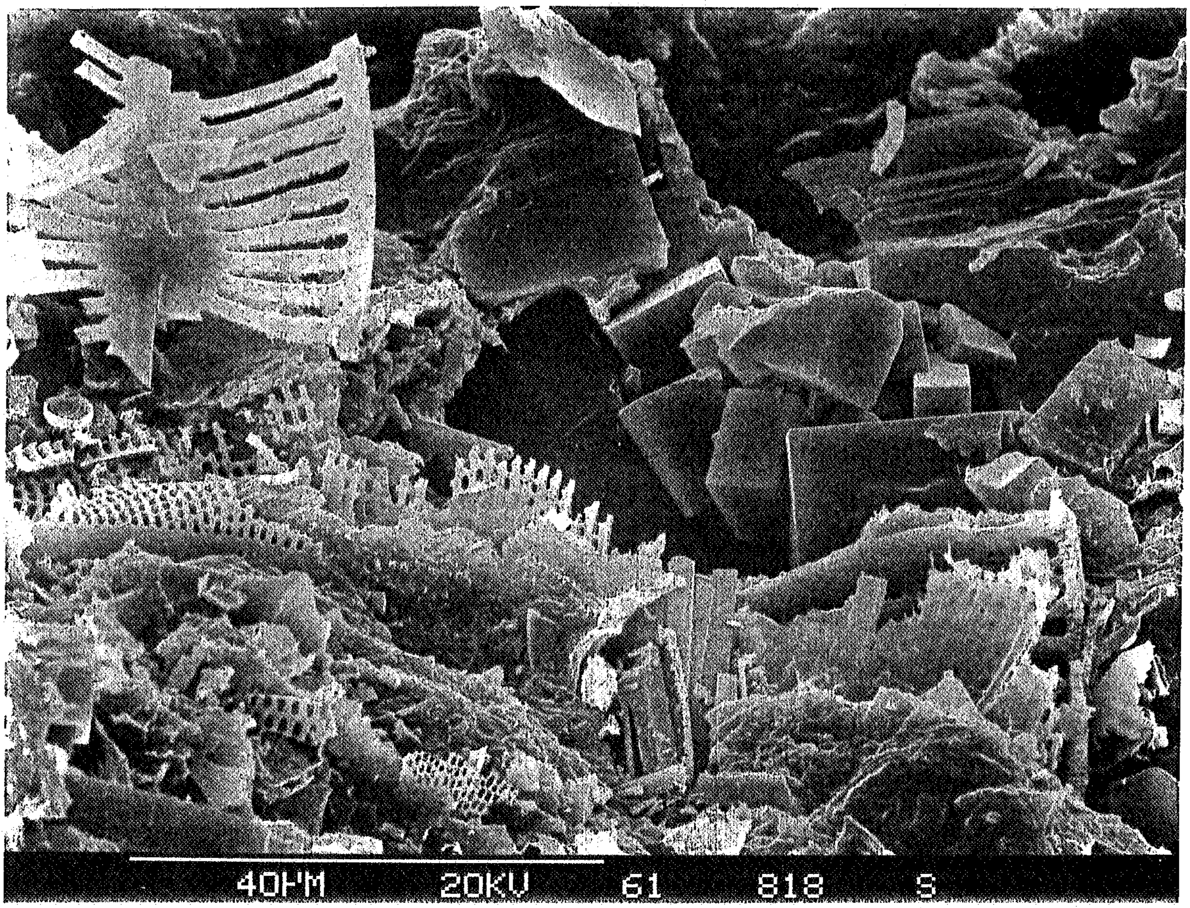
			Dried Sample (105°C)	
Sample	Depth (m)	Moisture Content (%)	Loss at 500°C (wt %)	Mineralogy (XRD)
WS3	1.42-2.2	41	41	qtz(D), halite (SD)
WS6	0.6-1.35	30	23	qtz(D), halite (SD)
CP14	2.0-2.21	45	16	qtz(D), halite (SD) smectite (minor)

Yours faithfully

for

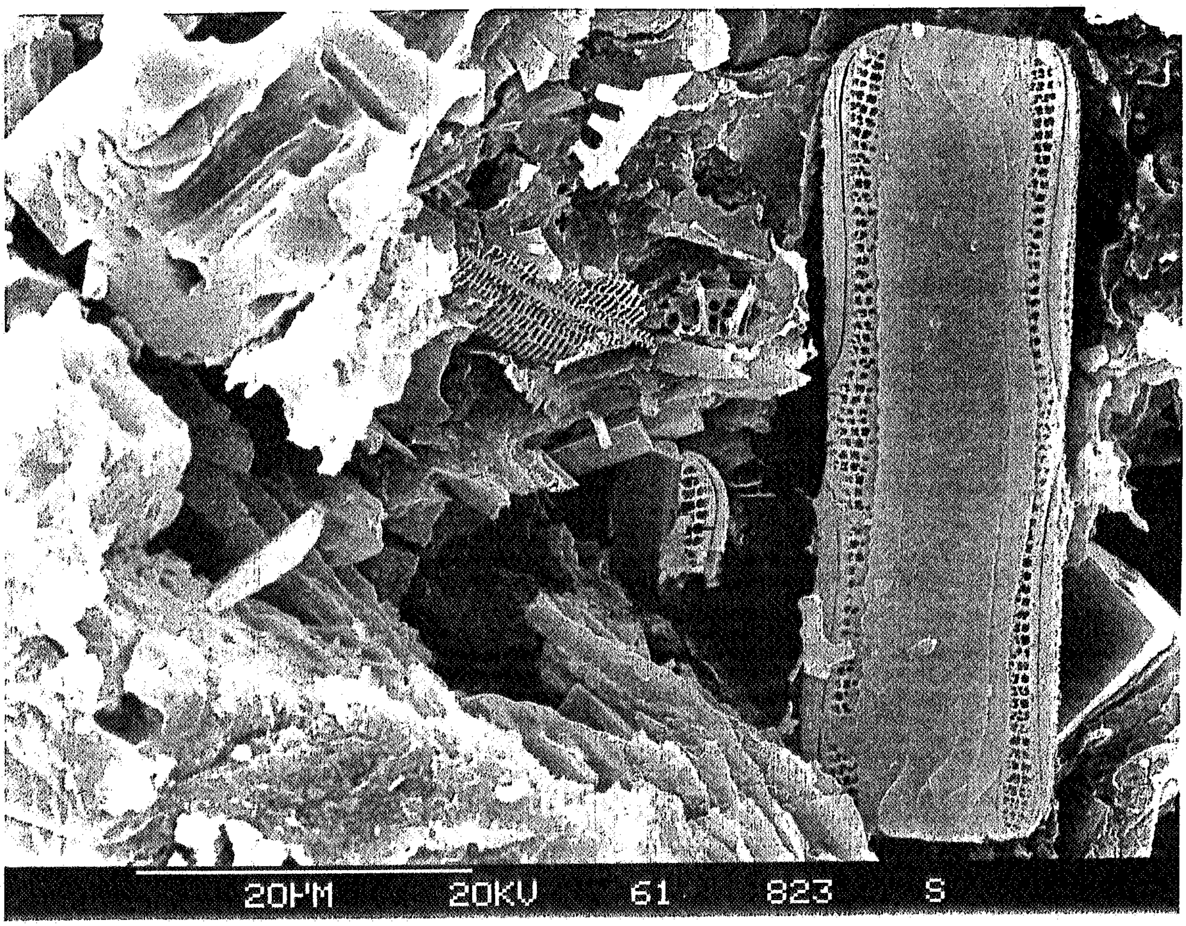
R K JOHNS
DIRECTOR-GENERAL

G01820



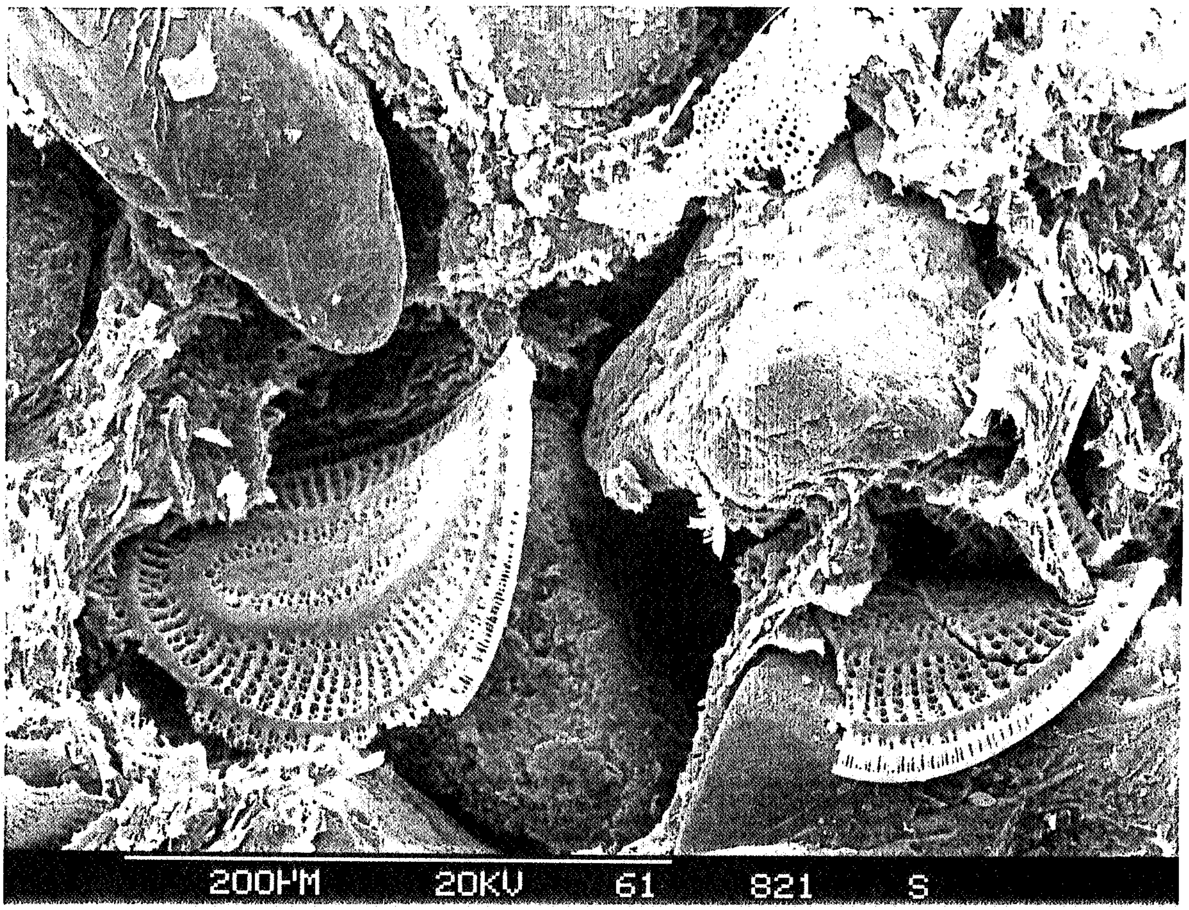
WS6
0.6 - 1.35m

Diatoms
and salt
crystals



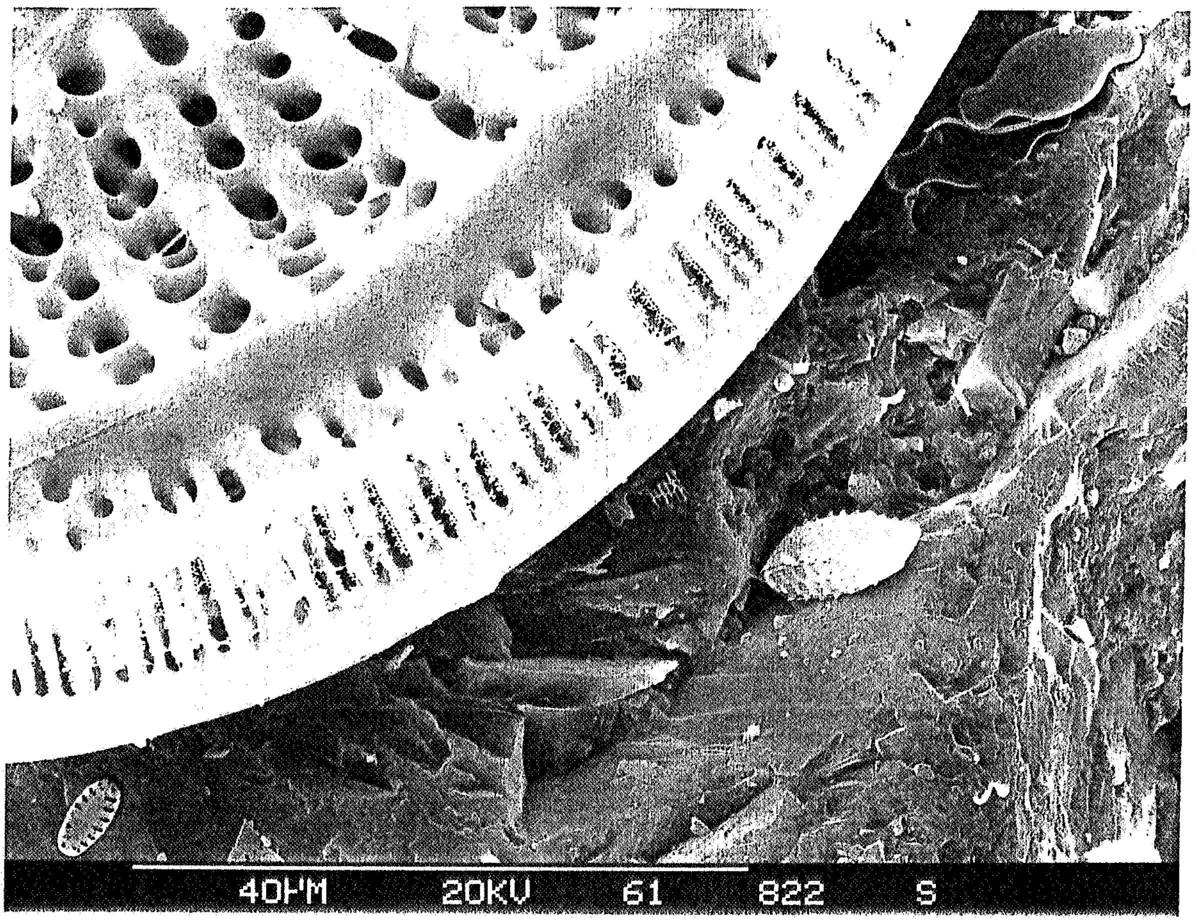
WS6
0.6 - 1.35m

Diatoms
and salt
crystals



WS6
0.6 - 1.35m

Quartz grains, diatoms + organic matter?



WS6
0.6 - 1.35m

Detail of 821 lower right

EL1628 MALCOLM PLAINS

QUARTERLY REPORT NO 4 TO 21 DECEMBER 1990

TENURE

EL1628 granted to Olliver Geological Services Pty Ltd on 22 December 1989 for six months was renewed for six months to 21 December 1990 and was renewed for a further twelve months to 21 December 1991.

FIELD INVESTIGATIONS

The fourth field trip was undertaken by Sean Kennedy (Consulting Geologist, S & CR Kennedy) and Peter Hornsby (Field Assistant) from 15 to 20 December 1990. A total of 36 holes (designated CP24-59) were drilled at Cooke Plains Embayment.

Coring and core recovery equipment from Department of Earth Services, Flinders University was not available. PVC pipe was hammered into the ground by hitting an aluminium dolly, which fitted in and over the pipe, with a small sledge hammer. This proved a most satisfactory method. A core recovery tool was borrowed from the Geology Department, University of Adelaide. In an attempt to reduce compression of the unconsolidated core, a hole was cut in the PVC pipe to bleed air out. However some compression still occurred.

LABORATORY TESTING

Report 111090 on identification of diatoms and estimate of abundance by Elizabeth Barnett (Post graduate Research Student, Flinders University) of seven selected core samples is attached together with SEM photographs by John Keeling reproduced from Quarterly Report No 3.

CONCLUSIONS

(1) Diatoms comprise up to 25% of the diatomite unit in parts of Cooke Plains Embayment and Waltowa Swamp. Contaminants are clay, organic matter and quartz silt with gypsum and halite common in near surface samples. The 'hexagons' in drill logs in Quarterly Report no. 2 are gypsum crystals. The estimate of up to 70% frustules by vonder Borch & Altmann (1979) was not confirmed.
Thickness ranges up to 1.79m at Cooke Plains and 1.85m at Waltowa Swamp.

(2) Diatom content can not be estimated using weight percent silica analysis. Biovolumes should be determined instead.

(3) The dominant diatoms Campylodiscus daemelianus and Hydalodiscus lentiginosus are relatively large discoid forms up to 200 microns and 60-100 microns diameter respectively.

(4) This Holocene assemblage is completely different from the Tertiary assemblage dominated by the cylindrical Melosira in eastern states diatomite which is not suitable for filter use.

(5) Diatoms are less fragmented in Waltowa Swamp probably due to the absence of fine quartz detritus. However, the higher clay content may pose beneficiation problems.

EXPENDITURE TO 21 DECEMBER 1990

ITEM	9 MONTHS TO 21.09.90	3 MONTHS TO 21.12.90	TOTAL
Tenement fees	2 139.60	nil	2 139.60
Geological services	15 725.00	3 885.00	19 610.00
Administration	13 250.00	1 500.00	14 750.00
Office Costs	1 866.19	242.34	2 108.53
Data Acquisition	88.00	-	88.00
Field Operations	2 243.23	1 511.10	3 754.33
Laboratory Testing	1 800.00	1 000.00	2 800.00
TOTAL	37 112.02	8 138.44	45 250.46

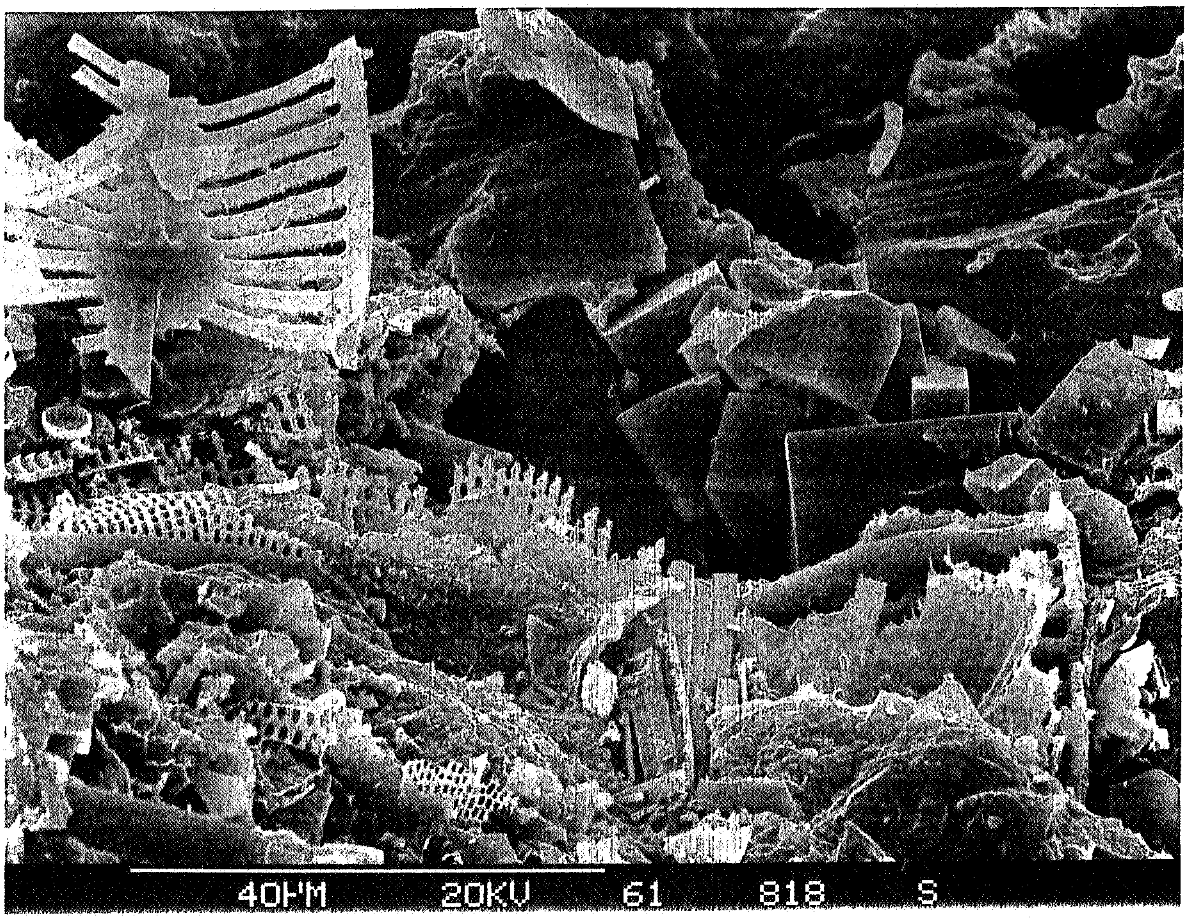
PROPOSED INVESTIGATIONS

Further work is warranted to try to locate diatom-rich areas as the largest diatomite deposit in similar swamps at Hill River WA is only 600m in diameter with a maximum thickness of 7m.

The following program is proposed for the next six months

- Complete Stage 2 push-tube coring with a further 20 holes at Waltowa Swamp.
- Split and geologically log core.
- Compile geological sections.
- Determine diatom content of critical holes.
- Stage 3 drilling of zones with more than 50% diatoms

JEFFERY G OLLIVER.

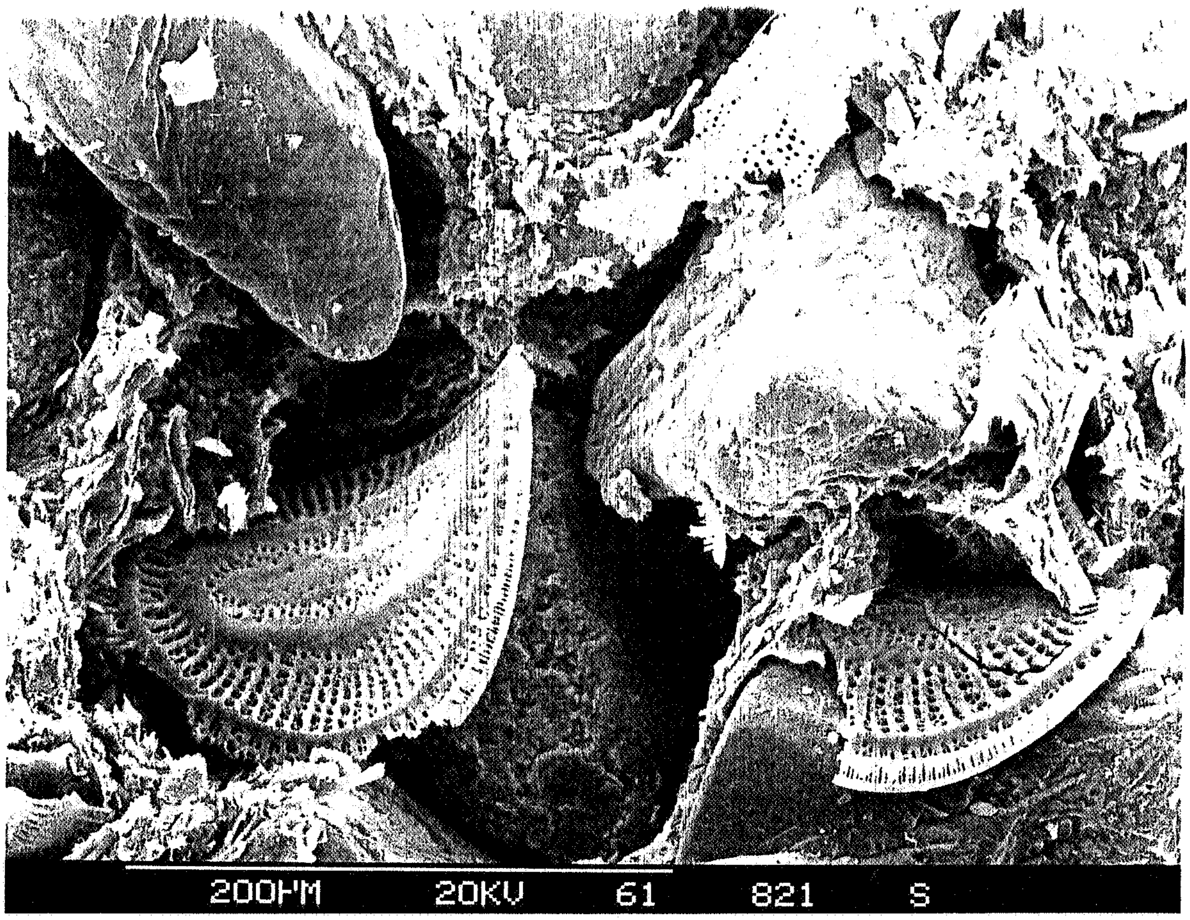


WS6
0.6 – 1.35m

Diatoms
and salt
crystals

plate 818 - Diatoms and salt crystals in WS6 0.6-1.35m

Navicula yarrensis (penate)
either Thalassiosira or Melosira (centrale)
fragments of campylodiscus

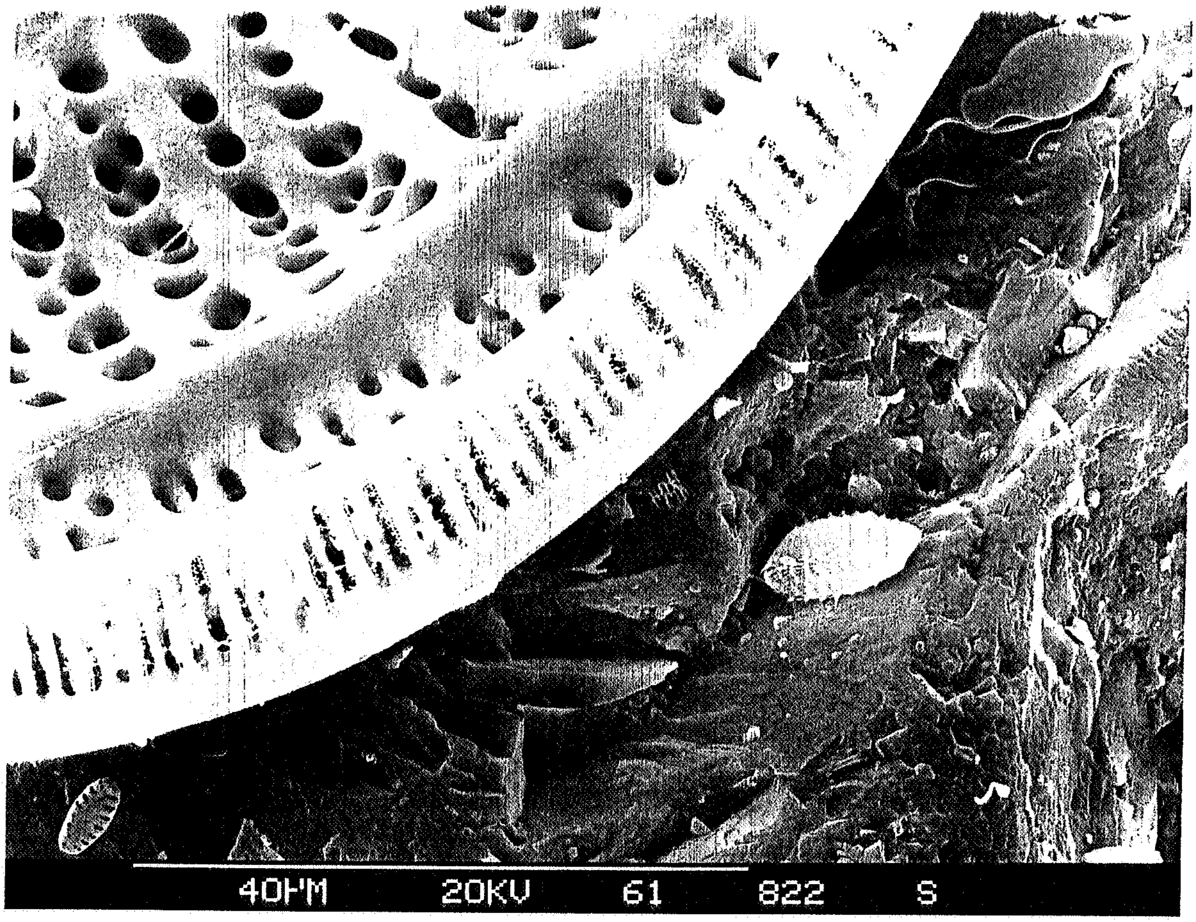


WS6
0.6 – 1.35m

Quartz
grains,
diatoms
+ organic
matter?

plate 821 – Quartz grains, diatoms and ? organic matter in WS6 0.6–1.35m

Campylodiscus – large discoid form



WS6
0.6-1.35m

Detail
of 821
Lower
Right

plate 822 - Enlargement of Lower Right of plate 821

Rim of Campylodiscus
Opephora martyi - centre right
Achnanthes exigua - top right
bottom left - too altered to determine.

REPORT 111090

IDENTIFICATION OF DIATOM GENERA OR SPECIES, AND ABUNDANCE ESTIMATES OF DIATOMS FOR SELECTED COOKE PLAINS AND WALTOWA SWAMP SAMPLES

Report by Elizabeth Barnett

EXECUTIVE SUMMARY

Sediment core samples from Cookes Plain and Waltowa Swamp have been analysed for diatom genus or species identification and abundance estimates. The samples included CP1, CP9, CP12, CP17, CP23, WS2 and WS8. Two samples, CP9 and CP17, that is, the near surface samples, contained no diatoms and were mostly composed of gypsum and halite.

Of the five samples with diatoms, the Waltowa Swamp samples were predominated by *Campylodiscus daemelianus* Grun. valves. *C.daemelianus* Grun. was also very common in the Cooke Plains samples although often fragmented. *Hyalodiscus lentiginosus* John was relatively common throughout most of the samples. The diatom assemblage in WS8 varied from WS2 and the CP samples. Although *C.daemelianus* Grun. was dominant, the assemblage contained numerous centrales such as *Thalassiosira weissflogii* (Grun) Fryxell and Hasle as well as a number of *Surirella* sp. and minor *Grammatophora oceanica* Ehr.

Geochemical opaline silica analyses were carried out to determine diatom abundance estimates in CP12 and WS2. These yielded low results since analyses were based on weight percent and not biovolume. Diatom abundance was therefore estimated from smear slides. This did not exceed 25% due to the presence of either clays and organic matter or quartz. On the basis of the number of whole *C.daemelianus* Grun. valves in the WS samples, Waltowa Swamp appears to be the more suitable area for diatomite recovery.

INTRODUCTION

Cooke Plains and Waltowa Swamp are located on the northeastern and east northeastern shores of Lakes Alexandrina and Albert, respectively. These areas most likely constitute previous embayments of the lakes during a pluvial period some 5,000 to 8,000 years BP., coinciding with Holocene marine transgression (von der Borch and Altmann, 1979). As such, the Holocene sediments in them represent a succession of facies resulting from initial inundation to eventual emergence and evaporation of lake waters. At depths between 1 to 2m a diatomite unit exists, probably laid down during maximum water depths in these embayments.

The two areas, shown in figures 1 and 2, have recently been sampled by S.Kennedy from Olliver Geological Services, McLaren Vale to determine the extent of the diatomite unit and the possible abundance of diatoms within it. Seven samples from Cooke Plains and Waltowa Swamp have been analysed here, in detail, to give information concerning not only abundance estimates of diatoms but also the different genera and species of diatoms in the unit. The samples included in this study are: CP1, CP9, CP12, CP17, CP23, WS2 and WS8.

LABORATORY METHODS

Diatom identification was achieved using thin smear slide preparations of the total sediment. A number of pretreatments can be used to aid in the identification of diatoms. These include removal of carbonates and salts with 10% HCl, removal of organic matter with 30% H_2O_2 and the removal of minerogenic matter by seiving coarse-grained minerals or decanting suspended clays. However, only relative diatom abundance can then be measured and not the total abundance with respect to total sediment. Therefore, the sediments were not pretreated. The smear slides were prepared by placing about 2mm of sediment collected on a small spatular onto a cleaned glass slide and mixing it with distilled H_2O. This was then evaporated to dryness on a hot plate and covered with Eukitt resin and a glass coverslip.

Diatom examination was carried out using a zeiss optical microscope at magnifications X80 and X320, complete with a graduated stage for continuous traverses and eyepiece graticule to measure valve sizes. Three traverses were

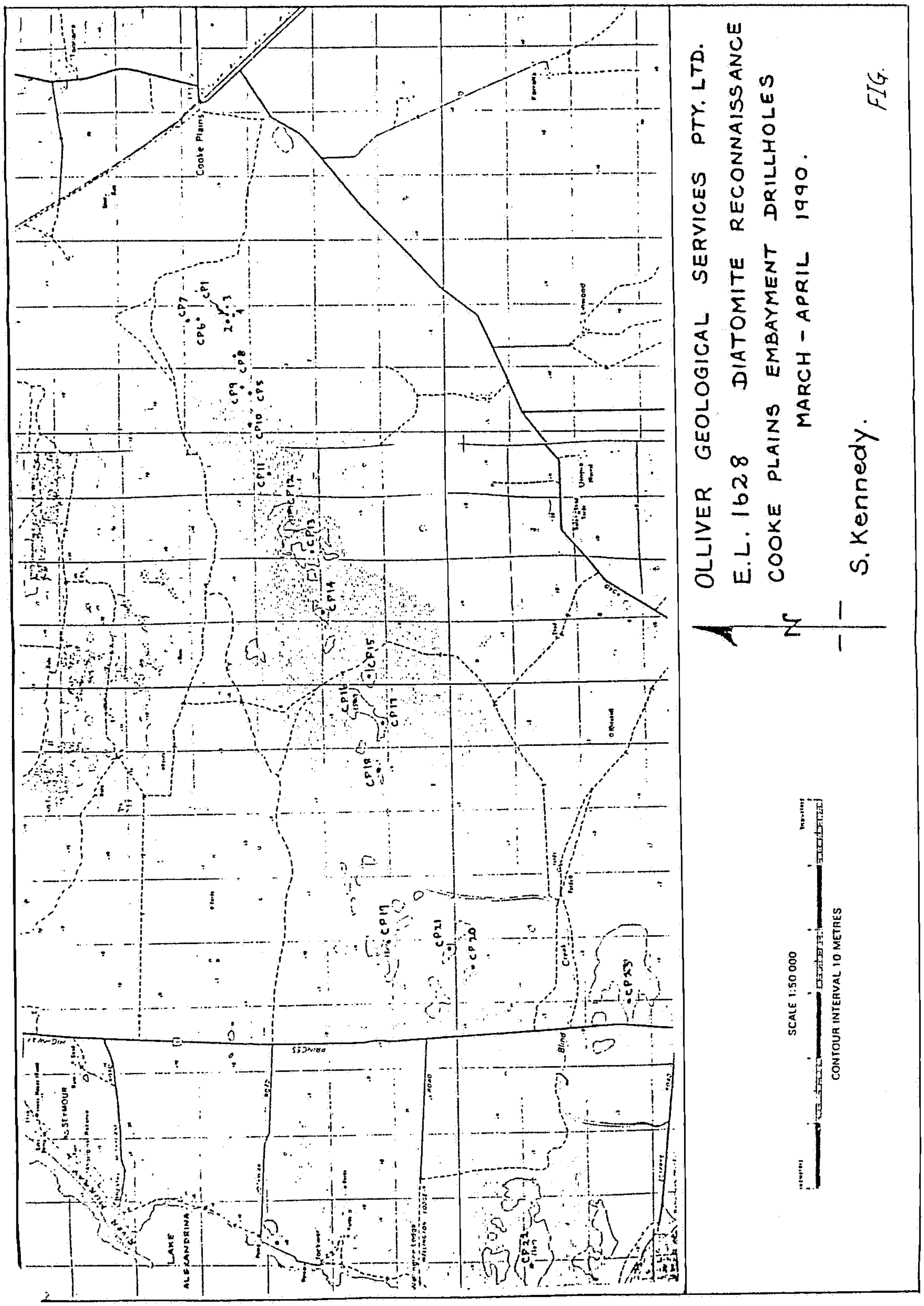


Figure 1. Location of Cooke Plains drillholes including CP1. CP9, CP17 and CP23.

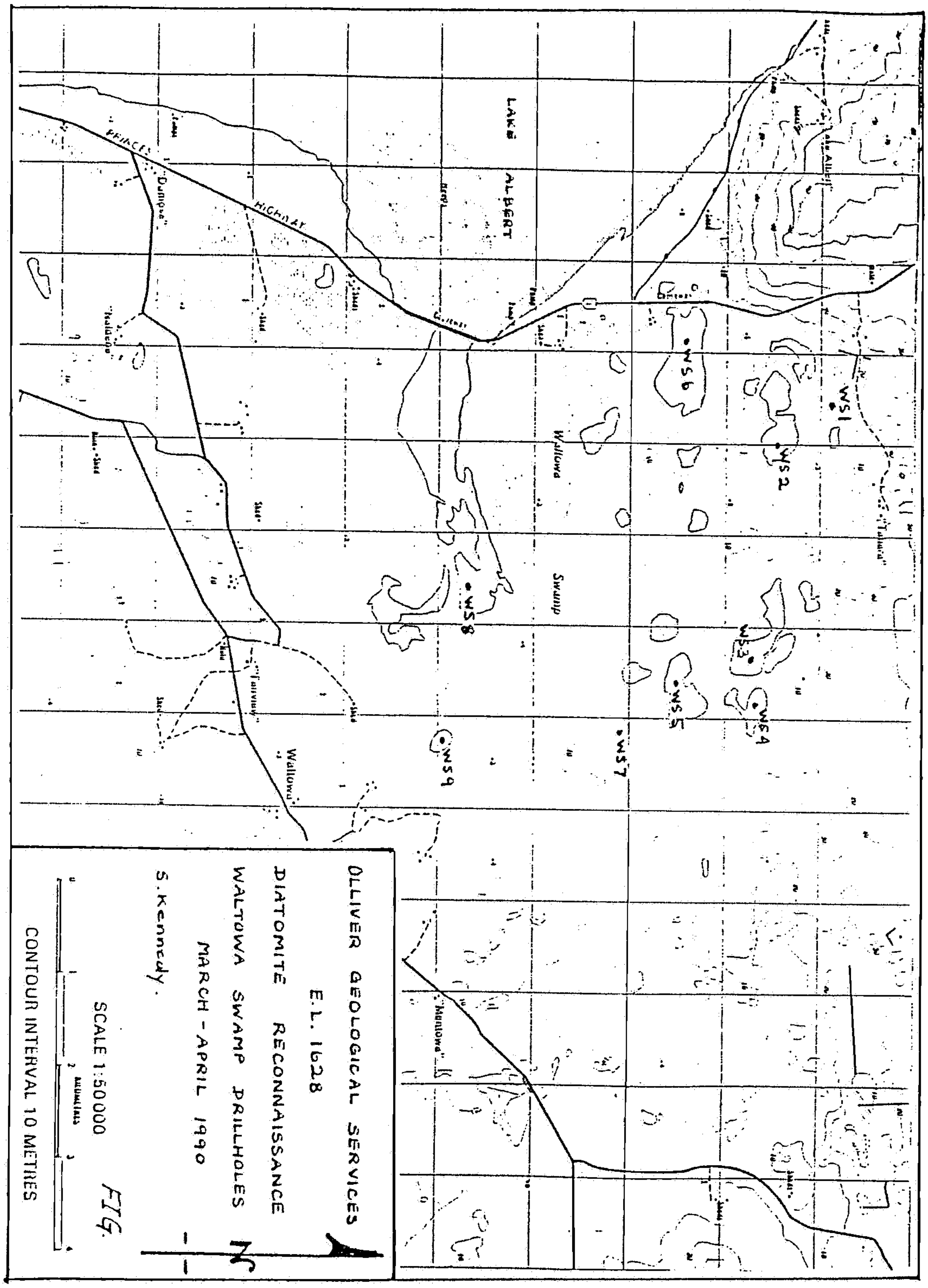


Figure 2. Location of Waltowa Swamp drillholes including WS2 and WS8.

completed for each slide including an edge and centre traverse to counter any selective sorting due to evaporation. It should be stressed that the counts for each slide depend on the initial amount of sediment used in the smear and as such cannot be compared between slides. Also, the technique can give only an estimate of diatom relative abundance and thus, diatom estimates are categorised semiquantitatively into dominant, very common, common, minor or rare.

To obtain a more quantitative estimate of diatom abundance, opaline silica concentration was measured in samples CP12 and WS2. Total opaline silica in these samples is a biogenic mixture of diatoms, sponge spicules and siliceous chrysophyte cysts, however, diatoms are the major constitutent. A small quantity of dry ground sediment was added to 5% Na_2CO_3 solution. At selected time intervals, the leaching solution was extracted and subsequently analysed for dissolved opaline silica by spectrophotometry using a silicomolybdate complex from the samples (Demaster, 1981; Parsons *et al*, 1984). The remaining sediment in the 5% Na_2CO_3 solution was treated in distilled H_2O, placed on a smear slide and observed under the microscope. Only remanents of *Campylodiscus daemelianus* Grun. were present indicating most of the opaline silica was dissolved.

Samples containing no diatoms, that is, CP9 and CP17, were dried, ground and X-ray diffracted at 1°/minute and 2/400. The XRD peaks were then analysed for common sedimentary minerals. CP9 contained gypsum, quartz, halite and minor muscovite and clays. CP17 also contained gypsum, halite and quartz.

GEOCHEMICAL ANALYSES

The opaline silica concentrations for CP12 and WS2 were 1.5 and 1.3% of the total sample, respectively. Figures 3a and b show percent opaline silica determined by the intersection of the silica concentration curve with the y-axis.

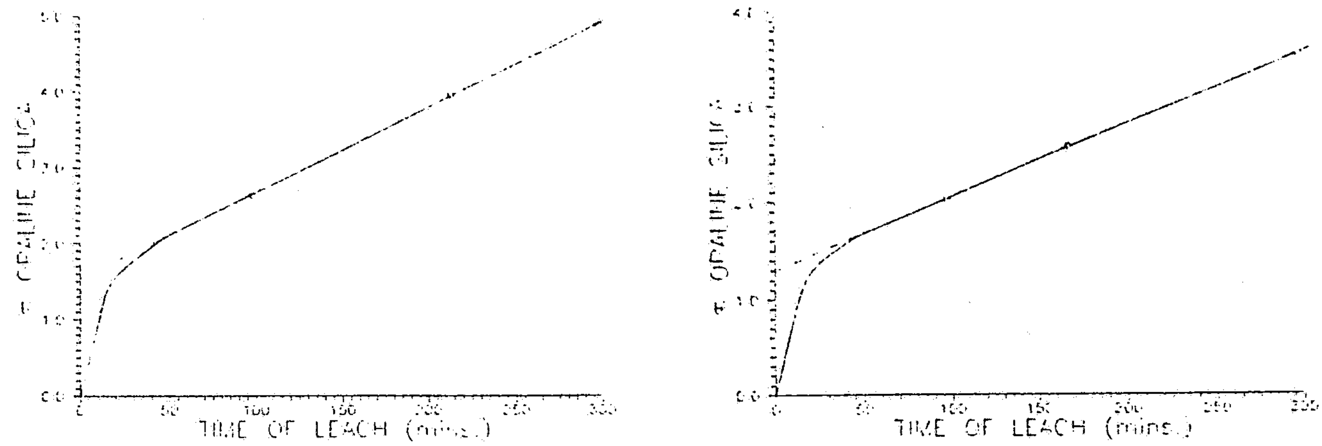


Figure 3a and b. Percent concentration of opaline silica measured by spectrophotometry. 1a, CP12; 1B, WS2.

Such low percent opaline silica reflects that the analyses were carried out on a silica weight percent basis and not on the diatom biovolume. Diatoms are extemely porous in nature and any subsequent analyses for diatom abundance estimates of the total sediment should estimate biovolume concentrations. However, little research for this has been done except to determine diatom accumulation rates with sediment depth (Battarbee, 1978).

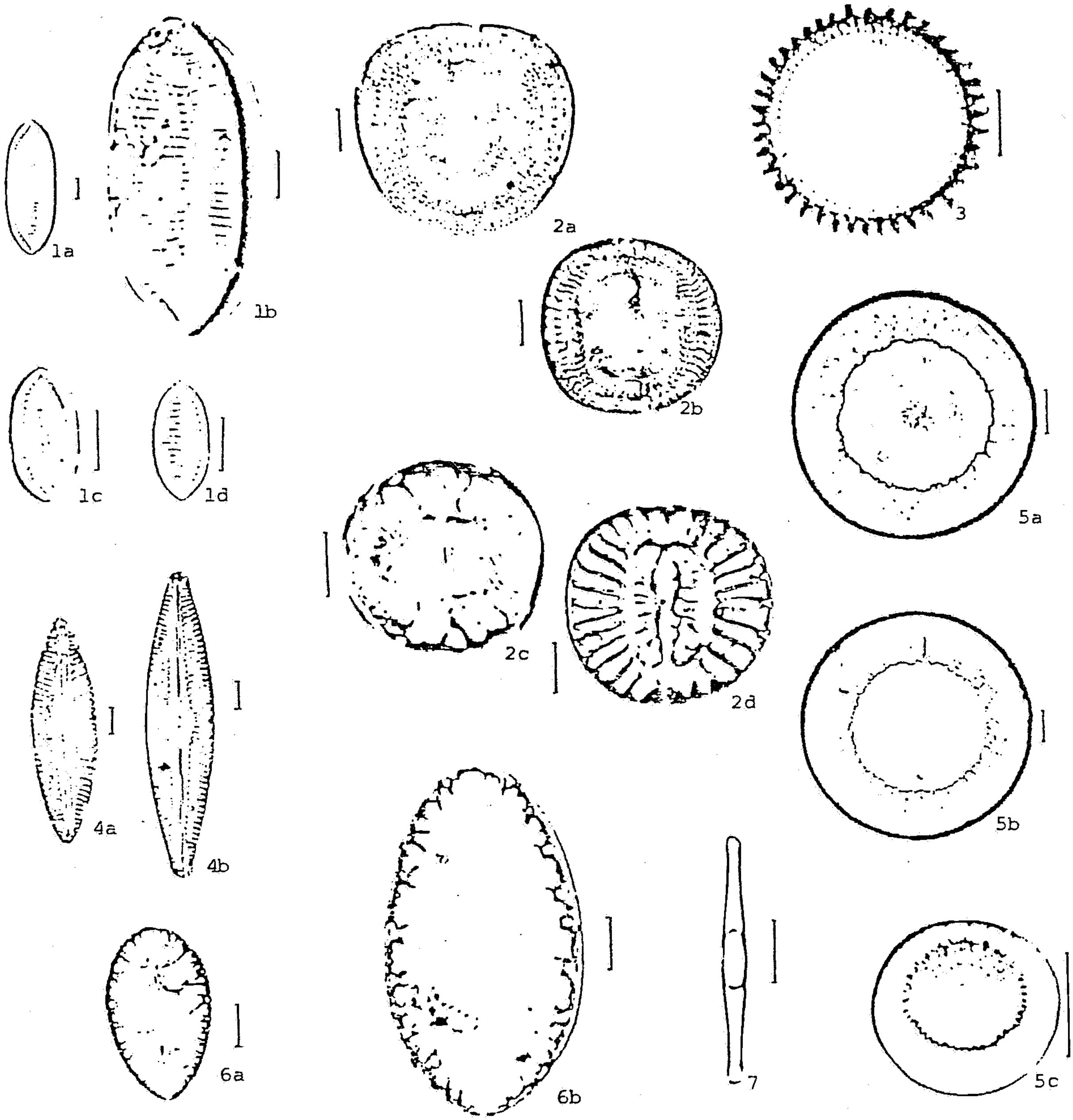
DESCRIPTION OF COOKE PLAINS AND WALTOWA SWAMP SAMPLES

Since geochemical analysis of the sediment did not provide quantitative information on diatom biovolume with respect to the total sediment, abundance estimates were carried out on the smear slides. The estimates are approximate and may vary with the amount of clay and organic matter present in each sample as most of this is less than 2μ, i.e., too small to identify the concentration.

The diatom assemblage is based on identification of individual genera or, if possible, species using Foged (1978) and John (1983), however, confirmation of some species would require SEM identification. Plate 1 taken from Foged (1978) illustrates some of the diatom species observed in the samples. The taxa referred to in the report and summarised in Table 1 are ordered according to the classification system by Hendey (1964). For each sample, a list of the diatoms present is arranged in order from most abundant to least.

PLATE 1
Compiled from John (1983)

(Scale = 10μ, except 2a and b where scale = 20μ)



Figures:
1a-d *Nitzschia tryblionella* var.*victoriae* Grun., 2a and b *Campylodiscus daemelianus* Grun., 2c and d *Camplodiscus clypeus* Ehr., 3 *Melosira sulcata* (Ehr.) Kütz., 4 *Navicula yarrensis* Grun., 5a and b *Hyalodiscus lentiginosus* John., 5c *Hyalodiscus scoticus* (Kütz) Grun., 6a and b *Surirella fluviicygnorum* n. sp., 7 *Grammatophora oceanica* Ehr.

CP1: 1.30m

Smear slide description:

Fine sand to silt-sized quartz grains, minor muscovite and opaque fragments account for between 35 and 45% of the total sediment. Clays including organic matter and possible salts are estimated to be up to 35%. Sponge spicules are relatively common at 5 to 10%. Diatoms appear to cover approximately 10 to 15% of the slide.

DIATOMS

The most common diatom is *Campylodiscus daemelianus* Grun. Whole valves up to 200μ are present although most valves are broken with fragments to less than 10μ. Some *C.clypeus* (Ehr.) or *C.adriaticus* Grun. fragments are also present. *Hyalodiscus lentiginosus* John and *H.scoticus* (Kütz) Grun. valves between 60 and 100μ and fragments appear common although algal clusters or cysts are similar to the *Hyalodiscus* umbilicus. A number of small centrales ranging from <10 to 30μ are present. These probably represent *Melosira* sp., *Thalassiosira* sp. or *Coscinodisus* sp. Of minor occurrence are *Nitzschia punctata* (W.Smith) Grun and *Rhopalodia gibberula* (Ehr.). Other rare diatoms include *Melosira* sp., *Thalassiosira weissflogii* (Grun.) Fryxell and Hasle, *Cyclotella* sp., fragments of *Cosinodiscus* (e.g., *C.janishii*) and *Navicula yarrensis* Grun., and *Mastogloia* sp.. These diatoms range in size from >30μ to <100μ.

Diatom Relative Abundance (counts per slide)

1. *Campylodiscus daemelianus* and *C.clypeus* valves or fragments (>50),
2. *Hyalodiscus lentiginosus* and minor *H.scoticus* (20),
3. Centrales including *Melosira, Thalassiosira or Coscinodiscus* (10),
4. *Nitzschia punctata* (7),
5. *Rhopalodia gibberula* (4),
6. fragments of *Navicula yarrensis* (2),
7. *Melosira* e.g., *M.sulcata* (1), *Thalassiosira weissflogii* (1), *Cyclotella* (1), fragment of *Coscinodiscus*,e.g. *C.janishii* (1), *Mastogloia*,e.g. *M.pumila* (1).

CP9: 0.1m

Smear slide description:

Large hexagonal or lenticular crystals of gypsum account for at least 50% of the sediment. Fine sand to silt-sized quartz grains, minor opaque minerals including rutile, and clays are estimated to be greater than 25%. Halite makes up the remaining 20 to 25% of the total sediment. No diatoms are present at this locality depth.

CP12: 1.05m

Smear Slide Description:
Clays and organic matter constitute between 60 and 70% of the slide. The organic matter contains plant material, e.g., cellulose fragments and pods. Framboidal pyrite also present is possibly associated with bacterial activity. Silt-sized quartz grains compose less than 15% of the sediment. Sponge spicules are minor although present. Diatoms account for approximately 20% of the slide.

DIATOMS
Numerous valves up to 200μ and fragments of *Campylodiscus daemelianus* Grun. occur throughout the slide. A number of *C.clypeus* (Ehr.) or *C.adriaticus* Grun. are also present. *Hyalodiscus lentiginosus* John or *H.scoticus* (kütz) Grun. are common although many are fragmented and may in fact be algal cysts. Also common are valve or girdle-orientated *Epithemia zebra* (Ehr.) Kütz., and valves of *Navicula yarrensis* Grun. These range in size from about >20μ and >50 to 120μ, respectively. At least 3 different species of *Nitzschia* are represented. These include *N.closterium* (Ehr.) W.Smith, *N.punctata* (W.Smith) Grun. and *N.tryblionella* var. *victoriae* Grun. The latter is slightly larger than the others, ranging up to approximately 60μ. A minor number of *Mastogloia elliptica* (Ag.) Cl. and fragments of *Synedra ulna* (Nitz.) Ehr. are present. Of rare occurrence are *Melosira* sp., *Thalassiosira lacustris* (Grun.) Hasle, *Achnanthes* sp., *Cocconeis* sp., *Diploneis* sp., *Cymbella* sp., *Amphora* sp. *and Surirella* sp..

Diatom Relative Abundance (counts per slide)
1. *Campylodiscus daemelianus*, *C.clypeus* or *C.adriaticus* includ. fragments (>50),
2. *Hyalodiscus lentiginosus or H.scoticus* (20),
3. *Epithemia zebra*, valve and girdle view (19),
4. *Navicula yarrensis* (16),
5. *Nitzschia closterium* (2), *N.punctata* (2), *N.tryblionella* var *victoriae* (3),
6. *Mastogloia elliptica* (or e.g., *M.pseudoexigna*) (4),
7. *Thalassiosira lacustris* (3),
8. fragments of *Synedra ulna* (3),
9. *Melosira sp.* (2),
10. *Achnanthes* (1), *Cocconeis* (1), *Diploneis* (1), *Cymbella* (1), *Amphora* (1), *Surirella* (1).

CP17: 0.26m

Smear slide description:
Large crystals amd groundmass of gypsum account for over 75% of the slide. The remaining 25% or less consists of halite needles, silt-sized quartz, framboidal pyrite and opaque minerals. No diatoms are present at this locality depth.

CP23: 1.00m

Smear slide description:
Up to 70% of the sediment is composed of clay and organic matter although percentage clay is difficult to estimate on a smear slide. The organic matter includes macrophyte and algal fragments as well as cellulose plant remains and minor opaque organics. Silt-sized quartz accounts for less than 5%. Sponge spicules are fairly common but amount to less than 2 to 3%. Diatoms could account for over 25% of the sediment.

DIATOMS
Campylodiscus daemelianus Grun. is very common in this diatom assemblage. It occurs as fragments as well as valves up to 200μ. *C.clypeus* (Ehr.) fragments are also present. *Hyalodiscus lentiginosus* John and a number of like-umbilici of *Hyalodiscus* are common. These are generally less than 120μ. Not as abundant but also quite common is *Nitzschia tryblionella* var. *victoriae* Grun. up to $>45\mu$, followed by *Epithemia zebra* (Ehr.) Kütz and *Nitzschia punctata* (W.Smith). Other diatoms including *Coscinodiscus centralis* (Ehr.), smaller centrales, *Cocconeis* sp., *Navicula yarrensis*, *Amphora ventricosa* (Greg.) and *Rhopalodia gibberula* (Ehr.) (or *R.musculus*) occur in minor numbers only. *Diploneis* sp., *Mastogloia elliptica* (Ag.) Cl and *Nitzschia*, e.g., *N.scalaris* are rare. Some other rare diatoms need SEM identification. These could possibly be *Fragularia* sp. and *Navicula* or *Anomoeneis* or *Gomphonema* spp. Most of these less abundant diatoms range in size from 10 to 50μ except for some larger *N.yarrensis* and *C.centralis.*

Diatom Relative Abundance (counts per slide)
1. *Campylodiscus daemelianus* and minor *C.clypeus* (>50),
2. *Hyalodiscus lentiginosus* and possible *H.scoticus* (32),

3. *Nitzschia tryblionella* var. *victoriae* (14) and *N.punctata* (10),
4. *Epithemia zebra* (12),
5. *Cocconeis* (7),
6. *Navicula yarrensis* (5),
7. *Coscinodiscus centralis* (4), small centrales (4), *Amphora ventricosa* (4), *Rhopalodia gibberula* (4),
8. *Diploneis* (2), *Mastogloia elliptica* (1), *Nitzschia*, *e.g. N.scalaris* (1).

WS2: 1.30m

Smear slide description:

Approximately 60 to 70% of the sediment is clay and organic matter. Minor cellulose plant material and opaque fragments are associated with the organics. Less than 10% of the sediment is silt-sized quartz with rare rutile. Sponge spicules and fragments are only minor. Diatoms appear to account for between 20 and 25% of the total sediment.

DIATOMS

Mostly whole valves of *Campylodiscus daemelianus* Grun. predominate throughout the slide. A number of fragments and occasional valves of *C.clypeus* (Ehr.) are also present. These range up to 200μ in size. Fairly common are whole or fragmented *Navicula yarrensis* Grun. as well as *Hyalodiscus lentiginosus* John or some algal cysts. These are relatively large diatoms ranging in size from 50 to 120μ. Of minor abundance *is Melosira sulcata* (Ehr.) Kütz up to 30μ. *Cocconeis* sp. and *Diploneis* sp. are minor to rare and also approximately 30μ in size. Other rare diatoms include *Thalassiosira weissflogii* (Grun) Fryxell and Hasle., *Neidium* (e.g., *N.affine*), *Rhopalodia gibberula* (Ehr.), *Nitzschia tryblionella* var. *victoriae* Grun. and possible *Synedra* sp.

Diatom Relative Abundance (count per slide)
1. *Camplyodiscus daemelianus* and *C.clypeus* (>50 and dominant),
2. *Navicula yarrensis* frustules and fragments (22),
3. *Hyalodiscus lentiginosus* (14),
4. *Melosira sulcata* (8),
5. *Cocconeis* sp. and *Diploneis* sp.(4),
6. *Thalassiosira weissflogii* (2),
7. *Neidium* sp. (e.g., *N.affine*) (1), *Rhopalodia gibberula* (1), *Nitzschia tryblionella* var. *victoriae* Grun. (1) and *Synedra* sp. (1)

WS8: 1.30m

Smear slide description:
As much as 60 to 70% of the sediment consists of clays and organics matter. Some of the organic matter includes cellulose and opaque material. The presence of framboidal pyrite is most likely associated with the organic matter. Approximately 10% of the sediment consists of silt-sized quartz and minor rutile and muscovite. Diatoms could account for between 20 and 25% of the total sediment.

DIATOMS
The diatom assemblage is predominated by *Campylodiscus daemelianus* Grun. with *C.clypeus* (Ehr.) also present. Whole valves are common and range up to 200μ. Centrale diatoms are common; centrales less than 30μ including *Thalassiosira weissflogii* (Grun.) Fryxell and Hasle are numerous. Larger centrales greater than 30μ, i.e., *T.weissflogii* (Grun.) Fryxell and Hasle and *T.lacustris* (Grun.) Hasle are numerous as well. *Hyalodiscus lentiginosus* John occurs throughout the slide. *Surirella* sp. up to 100μ size is quite common. Of minor occurrence are *Melosira sulcata* (Ehr.) Kütz, *M.distans*, *Grammatophora oceanica* Ehr., *Cocconeis* sp., fragments of *Navicula yarrensis* Grun., *Mastogloia elliptica* (Ag.) Cl. and *Rhopalopdia gibberula* (Ehr.). Of rare occurrence is *Nitzschia punctata* (W.Smith) Grun.

Diatom Relative Abundance (count per slide)
1. *Camplyodiscus daemelianus* and *C.clypeus* (> 50 and dominant),
2. *Thalassiosira weissflogii* or *T.lacustris* (44),
3. Centrales (20),
4. *Hyalodiscus lentiginosus* (20),
5. *Surirella* sp. (15),
6. *Melosira sulcata* (6) and *M.distans* (3),
7. *Cocconeis* (4) and *C.placentula* (2),
8. *Grammatophora oceanica* (3), *Mastogloia elliptica* (3), *Rhopalodia gibberula* (3) and fragments of *Navicula yarrensis* (3),
9. *Nitzschia punctata* (2)

Table 1. Diatom Relative abundance in Cooke Plains and Waltowa Swamp Samples.

GENUS	CP1	CP12	CP23	WS2	WS8
Melosira	R	R		R-M	M-C
Hyalodiscus	C	C	C	M-C	C
Thalassiorisa	R	R	R	R	C-VC
Cyclotella	R				
Coscinodiscus			M		
Centrales	M		M	R	C
Grammatophora					R-M
Synedra		R-M	R	R	
Achnanthes		R			
Cocconeis		R	M	R	R-M
Navicula	R	C	M	M-C	R
Diploneis		R	R	R	
Mastogloia	R	R-M	R		R-M
Neidium				R	
Cymbella		R			
Amphora		R	M		
Epithemia		M-C	M-C		
Rhopalodia	M		R	R	R-M
Nitzschia	M	M	C	R	R-M
Campylodiscus	VC	VC	VC	D	D
Surirella		R			C

Key: R = 1 or 2, M = <10, C = 10 to 50,
VC = >50 and D = dominant diatom genus

DISCUSSION

The most prolific diatom in the samples from the diatomite unit deposited in Cooke Plains and Waltowa Swamp is *Campylodiscus daemelianus* Grun.. Typically, it ranges in size from minute fragments to whole valves up to 200μ and is the largest diatom in the assemblage. It is a benthic diatom which can tolerate sand and clay-rich sediments possibly on account of its size. In the Waltowa Swamp samples, *C.daemelianus* predominates the diatom assemblage and numerous whole valves are present. In contrast, in the Cooke Plains samples, the valves are often fragmented. This may be due to an increase in silt, at least in CP1 and CP12, causing fragmentation either during settling of bottom sediments or even in smear slide preparation.

Hyalodiscus lentiginosus John is usually an epiphytic or planktonic diatom which is also common throughout the diatom unit. It is a relatively large centrale diatom ranging in size from 60 to 100μ. It occurs in highest numbers in CP23 but is less abundant in WS2. Chrysophyte cysts can appear similar to *H.lentiginosus* fragments under low magnification so only whole valves can give reliable representation.

Many other genera are present in the diatomite unit although none are as ubiquitous as *Campylodiscus* or *Hyalodiscus*. Each sample recorded a different assemblage although CP12 'and CP23 contained similarities. *Navicula yarresis* Grun., common in CP12, and *Nitzschia triblionella* var *victoriae* Grun., common in CP23, are moderately large diatoms ranging from approximately 50 to 120μ. *Epithemia zebra* (Ehr.) Kütz although relatively common to both samples is smaller that 40μ, and so by size alone cannot contribute significantly to diatom abundance unless in vast numbers. Many centrales such as *Thalassiosira weissflogii* (Grun.) Fryxell and Hasle or *Melosira* sp. are also smaller than 40μ, however, these genera can occur in algal blooms. WS8 may contain evidence of such a bloom with small centrales (<30μ) and *T.weissflogii* (Grun.) Fryxell and Hasle and *T.lacustris* (Grun.) common. Also common in WS8 but rare or absent in other samples is *Surirella* sp.. This is often a benthic diatom which occurs in fresh to brackish waters. However, of more brackish to marine water environments is *Grammatophora oceanica* Ehr., similarly found in WS8 in minor abundance. The diatom assemblages analysed in the samples represent brackish water environments with the possible exception of WS8 containing both brackish and freshwater diatoms.

Total diatom abundance in the diatomite unit is difficult to estimate. Geochemical analyses of opaline silica content give only percent weight and do not take into account porosity and biovolume of the diatom valves. Abundance estimates were therefore carried out on the prepared smear slides. Diatom abundances analysed ranged from less than 15% in CP1 to greater than 25% in CP23. WS2 and WS8 both contained 20 to 25% diatoms. These estimates are in contrast to that of 70% diatom frustules given by von der Borch and Altmann (1979). The decrease in diatoms in CP1 and CP12 is probably due to the increased silt content compared to clays in the WS and CP23 samples.

Separation of diatoms from minerogenic matter would probably be simpler in silt-rich rather than clay-rich sediments by repeated seiving. However, diatoms could be separated from clays as well as other mineral particles possibly by decanting clays and by floatation in heavy liquids.

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EL1628 MALCOLM PLAINS

QUARTERLY REPORT NO 5 TO 21 MARCH 1991

TENURE

EL1628 granted to Olliver Geological Services Pty Ltd on 22 December 1989 for six months was renewed for six months to 21 December 1990 and was renewed for a futrher twelve months to 21 December 1991.

FIELD INVESTIGATIONS

Fifth Field Trip - was undertaken by Sean Kennedy (Consulting Geologist S & CR Kennedy) and Peter Hornsby (Field Assistant) from 13 to 15 February 1991. The following 20 holes (WS 10 - 29) were drilled in Waltowa Swamp and two smaller salt lakes to the north.

Waltowa Swamp	-	10-24	mainly to follow up a promising intersection in WS8
Lihou Swamp	-	25-26	
Warne's Swamp	-	27-29	

Sixth Field Trip - was undertaken by Sean Kennedy and the writer from 5 to 7 March 1991. The sites of all previous drill holes were checked, Cooke Plains gypsum workings were inspected and operations discussed with Marcus Paterson (Mine Manager) and the following nine holes (WS30 to 37) were drilled.

Cooke Plains East	-	CP 60
Waltowa Swamp	-	4 holes - WS30 - 33
Warnes Swamp	-	3 holes - WS34 - 36
Lihou Swamp	-	1 hole - WS37

INSPECTION OF SAMPLES

PVC pipe and core samples have been sawn in half at Flinders University, core logged lithologically and diatom content estimated microscopically at selected intervals by Sean Kennedy for

- 37 holes - CP24-59 drilled at Cooke Plains in December 1990 and CP60 in March 1991.
- 15 holes WS10-24 and 30-33 in Waltowa Swamp.
- 5 holes WS27-29, 34-36 in Warnes Swamp.
- 3 holes WS25-26, 37 in Lihou Swamp.

Thin section slides prepared by Elizabeth Barnett with known diatomite content in Report no 111090 are used as standards.

EL1628 MALCOLM PLAINS

EXPENDITURE TO 21 MARCH 1991

ITEM	12 Months to 21.12.90	3 Months to 21.03.91	TOTAL
Tenement Fees	2 139.60	1 112.51	3 251.75
Geological Services	19 610.00	11 125.00	30 735.00
Administration	14 750.00	3 500.00	18 250.00
Office Costs	2 108.53	767.80	2 876.33
Data Acquisition	88.00	89.75	177.75
Field Operations	3 754.33	1 916.15	5 670.48
Laboratory Testing	2 800.00	nil	2 800.00
TOTAL	45 250.46	18 510.85	63 761.31

CONCLUSIONS

Diatom content is not high enough at Cooke Plains Embayment to warrant further work. Hand auger holes by CSR in 1981 were sufficient to discount the chance of viable gypsum east of the Dukes Highway.

WORK IN PROGRESS

(1) Elizabeth Barnett will examine the following nine samples from Waltowa Swamp to identify genera and/or species and estimate abundance of diatoms.

Hole WS	Depth
10	1.65
11	1.00
	2.00
12	0.70
14	1.00
18	1.00
20	0.60
30	1.40
	2.00

(2) High grade gypsarenite from Lihou and Warnes Swamps will be sampled and submitted to Classic Laboratories for chemical analysis.

Jeffrey G Olliver

JEFFREY G OLLIVER

EL 1628 MALCOLM PLAINS

QUARTERLY REPORT NO.6 TO 21 JUNE 1991

TENURE

EL 1628 granted to Olliver Geological Services Pty Ltd on 22 December 1989 for six months was renewed for six months to 21 December 1990 and was renewed for a further twelve months to 21 December 1991.

FIELD INVESTIGATIONS

There were no field operations during the quarter.

PALAEONTOLOGICAL REPORT

Elizabeth Barnett has advised from Colorado USA that she has completed her microscopic study of nine core samples from Waltowa Swamp. Her report is expected in Adelaide in early July.

GYPSUM

A total of 11 half core samples from the 5 holes (WS27-29, 34-36) in Warnes Swamp and 10 samples from 3 holes (WS25, 26 & 37) in Lihou Swamp were submitted to Classic Laboratories Ltd for chemical analyses. Results are summarised in Table 1 from the attached Report 1AD 1158.

Gypsum content is calculated by multiplying H_2O @ 220C by 4.778.

Hole locations are shown on Figure 1.

Based on the initial 5 holes, an estimated 3 million tonnes are indicated in Warnes Swamp to an average depth of 1.4m. Maximum thickness was 1.80m in WS34 which was the only hand auger hole. Raw gypsum content averages 84.3% $CaSO_4.2H_2O$ which should yield 89.5% $CaSO_4.2H_2O$ with removal of salt.

Highest salt-free intersection was 96.1% in WS27 from 0.10 to 1.09m.

The grade of Warnes Swamp is similar to the Streaky Bay deposit and superior to Cooke Plains and Morgan as shown in Table 2.

EXPENDITURE

Item	15 MONTHS To 21.03.91	3 MONTHS To 21.6.91	TOTAL
Tenement Fees	3 251.75	-	3 251.75
Geological Services	30 735.00	2 565.50	33 297.50
Administration	18 250.00	1 500.00	19 750.00
Office Costs	2 876.33	398.87	3 275.20
Data Acquisition	177.75	159.00	336.75
Field Operations	5 670.48	-	5 670.48
Laboratory Testing	2 800.00	2 586.65	5 386.65
TOTAL	63 761.31	7 207.02	70 968.32

WORK IN PROGRESS

Cooke Plains Embayment - geological sections compiled and summary report on drilling to be prepared.

Waltowa Swamp - await Elizabeth Barnett's report before compiling report on drilling.

Warnes Swamp - 60 holes are planned on a grid pattern to prove reserves. Cores will be taken by push tube to maximum penetration then hand auger will be used to try to deepen the hole. An enlarged aerial photograph has been ordered.

Lihou Swamp - further holes - perhaps 20 are required.

The lake surfaces need to dry out before drilling can take place.

J.G. OLLIVER
Exploration Consultant
Malcolm Plains Diatomite Project

WARNES GYPSUM DEPOSI

TABLE 1

CHEMICAL ANALYSIS (%) 5 HOLES - 11 SAMPLES

WS	M from	M to	thick	Raw Gypsum	CaCO3	SiO2	MgO	NaCl	Saltfree Gypsum
27	0.10	1.09	0.99	89.3	4.25	1.00	0.99	7.06	96.1
	1.09	1.40	0.31	86.5	6.71	1.06	1.30	7.06	93.1
	Average		1.30	88.6	4.84	1.02	1.06	7.06	95.4
28	0.20	0.87	0.67	82.7	5.15	1.11	1.30	8.75	90.6
	0.87	1.25	0.38	85.5	6.67	1.15	1.38	8.24	93.2
	Average		1.05	83.7	5.70	1.12	1.33	8.57	91.5
34	0.20	1.00	0.80	80.7	5.79	1.16	0.87	3.66	83.8
	1.00	1.50	0.50	89.8	6.15	1.06	0.91	2.92	92.5
	1.50	2.00	0.50	87.9	8.03	1.13	0.75	2.42	90.1
	Average		1.80	85.2	6.51	1.12	0.85	3.11	88.0
35	0.00	0.55	0.55	82.2	10.4	3.48	2.18	7.24	88.6
	0.55	1.26	0.71	81.2	6.35	1.72	1.03	5.55	86.0
	Average		1.26	81.6	8.12	2.49	1.53	6.29	87.1
36	0.02	0.49	0.47	81.7	3.55	1.17	0.78	5.22	86.2
	0.49	1.62	1.13	82.2	5.00	0.98	0.80	5.14	86.7
	Average		1.60	81.2	4.57	1.04	0.79	5.16	86.6
	Range		1.05-1.80	80.7-89.8	3.55-10.4	1.00-3.48	0.75-2.18	2.42-8.75	83.8-96.1
	AVERAGE		1.40	84.3	5.9	1.3	1.1	5.7	89.5

LIHOU GYPSUM DEPOSIT

CHEMICAL ANALYSIS (%) 3 HOLES - 10 SAMPLES

WS	M from	M to	thick	Raw Gypsum	$CaCO_3$	SiO_2	MgO	NaCl	Saltfree Gypsum
25	0.00	0.21	0.21	78.8	10.6	2.50	1.55	10.07	87.6
	0.21	0.77	0.56	80.3	15.5	1.24	0.82	3.76	83.4
	0.77	1.79	1.02	42.8	46.6	4.54	2.58	6.26	45.7
	1.79	2.10	0.31	51.6	37.6	3.14	2.36	7.03	55.5
	Average top		0.77	79.9	14.2	1.58	1.02	5.48	84.5
	Total		2.10						
26	0.00	0.33	0.33	87.4	3.56	1.67	1.38	10.42	97.6
	0.33	1.18	0.75	70.7	16.7	2.18	1.68	8.20	77.0
	1.18	1.40	0.22	67.4	25.3	3.32	1.78	10.67	75.5
	Average		1.30	74.4	14.8	2.24	1.62	9.18	82.0
32	0.20	0.82	0.62	76.4	13.0	2.64	1.56	5.80	81.1
	0.82	1.12	0.30	66.4	27.6	3.06	1.86	4.66	69.6
	1.12	1.13	0.01	58.3	32.3	3.18	2.02	5.68	61.8
	Average		0.93	73.0	17.9	2.78	1.66	5.43	77.2

CLASSIC LABORATORIES LTD
Incorporated in WA; a wholly owned subsidiary of Amdel Ltd
ACN 009-076-555
Osman Place, Thebarton, South Australia 5031
Telephone: (08) 43 5722 Facsimile: (08) 234 0321

Mr Sean Kennedy
11 Cheviot Avenue
LOWER MITCHAM
SA 5062

FINAL ANALYSIS REPORT

Your Order No: LET 22.4.91 Our Job Number : 1AD1158

Samples received : 22-APR-1991 Results reported : 24-MAY-1991
No. of samples : 21
Report comprises a cover sheet and pages G1, I1 to I2, W1

This report relates specifically to the samples tested in so far as that the samples as supplied are truly representative of the sample source.

Note:
If you have any enquiries please contact Miss Anne Reed quoting the above job number.

Approved Signatory:

John Waters
Technical Manager - Adelaide

CC Mr J G Olliver SA

Report Codes:
N.A. - Not Analysed.
L.N.R. - Listed But Not Received.
I.S. - Insuffecent Sample.

Distribution Codes:
CC - Carbon Copy
EM - Electronic Media
MM - Magnetic Media

"RELIABLE ANALYSES AT COMPETITIVE COST"

CLASSIC LABORATORIES LTD

Page G1

Client #

Report 1AD1158

Sample ID	SO3 as CaSO4	CO2 as CaCO3	Excess Ca as CaO	H2O @ 44C	H2O @ 220C ×4.778 →	CALCULATED GYPSUM
Code	GRAV 2	GRAV 4		GRAV 8	GRAV 8	
Results in	%	%	%	%	%	
WS 25						
0.00-0.21	58.6	10.6	<0.05	26.4	16.5	78.8
0.21-0.77	62.6	15.5	<0.05	16.3	16.8	80.3
0.77-1.79	27.2	46.6	0.30	23.7	8.95	42.8
1.79-2.10	38.0	37.6	<0.05	24.3	10.8	51.6
WS 26						
0.00-0.33	64.6	3.56	0.25	24.7	18.3	87.4
0.33-1.18	56.1	16.7	<0.05	22.9	14.8	70.7
1.18-1.40	45.0	25.3	<0.05	27.2	14.1	67.4
WS 27						
0.10-1.09	69.1	4.25	<0.05	16.0	18.7	89.3
1.09-1.40	66.3	6.71	<0.05	16.2	18.1	86.5
WS 28						
0.20-0.87	66.4	5.15	<0.05	19.5	17.3	82.7
0.87-1.25	64.4	6.67	0.25	19.0	17.9	85.5
WS 34						
0.20-1.00	72.0	5.79	<0.05	4.55	16.9	80.7
1.00-1.50	70.2	6.15	<0.05	4.94	18.8	89.8
1.50-2.00	68.8	8.03	<0.05	2.08	18.4	87.9
WS 35						
0.00-0.55	59.9	10.4	<0.05	23.8	17.2	82.2
0.55-1.26	68.1	6.35	<0.05	20.1	17.0	81.2
WS 36						
0.02-0.49	72.5	3.55	<0.05	19.5	17.1	81.7
0.49-0.62	70.4	5.00	0.85	19.2	17.2	82.2
WS 37						
0.20-0.82	60.4	13.0	0.35	23.5	16.0	76.4
0.82-1.12	48.6	27.6	0.35	19.1	13.9	66.4
1.12-1.13	41.9	32.3	1.40	21.6	12.2	58.3

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Analysis code ICP 5 Report 1AD1158 Page I1

NATA Certificate Results in %

Sample	CaO	Fe2O3	Na2O	Al2O3	TiO2	K2O	MnO
WS 25 0.0-0.21	29.2	0.100	4.34	0.260	0.020	0.140	<0.010
WS 25 0.21-0.77	34.4	0.040	1.61	0.060	0.020	0.050	<0.010
WS 25 0.77-1.79	38.1	0.110	3.10	0.100	0.010	0.090	0.020
WS 25 1.79-2.10	36.4	0.240	3.18	0.160	0.020	0.100	0.060
WS 26 0.0-0.33	28.4	0.090	4.42	0.190	0.030	0.120	<0.010
WS 26 0.33-1.18	32.0	0.080	3.70	0.090	0.010	0.100	0.020
WS 26 1.18-1.40	32.1	0.100	4.60	0.080	0.010	0.120	0.040
WS 27 0.10-1.09	30.4	0.040	2.92	0.080	0.030	0.090	<0.010
WS 27 1.09-1.40	30.1	0.070	2.86	0.070	0.050	0.090	0.020
WS 28 0.20-0.87	29.7	0.040	3.68	0.070	0.020	0.100	0.020
WS 28 0.87-1.25	30.2	0.060	3.58	0.070	<0.010	0.100	0.030
WS 34 0.20-1.00	31.4	0.050	1.48	0.110	0.020	0.090	0.010
WS 34 1.00-1.50	31.9	0.070	1.23	0.070	0.010	0.070	0.020
WS 34 1.50-2.00	32.8	0.070	1.06	0.080	0.010	0.060	0.010
WS 35 0.0-0.55	30.2	0.130	3.22	0.260	0.070	0.110	0.030
WS 35 0.55-1.26	30.8	0.060	2.40	0.090	0.030	0.090	0.010
WS 36 0.02-0.49	30.8	0.080	2.18	0.140	0.020	0.090	0.020
WS 36 0.49-1.62	31.6	0.050	2.22	0.090	0.010	0.060	0.010
WS 37 0.20-0.82	32.2	0.060	2.58	0.100	0.050	0.090	0.010
WS 37 0.82-1.12	35.7	0.100	2.26	0.080	0.010	0.060	0.020
WS 37 1.12-1.73	36.5	0.120	2.80	0.100	0.010	0.080	0.040
Detn limit	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)

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Analysis code ICP 5 Report 1AD1158 Page I2

NATA Certificate Results in %

Sample	P2O5	MgO	SiO2	LOI
WS 25 0.0-0.21	0.030	1.55	2.50	32.9
WS 25 0.21-0.77	0.030	0.820	1.24	27.9
WS 25 0.77-1.79	0.030	2.58	4.54	38.3
WS 25 1.79-2.10	0.030	2.36	3.14	36.8
WS 26 0.0-0.33	0.030	1.38	1.67	32.8
WS 26 0.33-1.18	0.030	1.68	2.18	32.0
WS 26 1.18-1.40	0.030	1.78	3.32	36.9
WS 27 0.10-1.09	0.020	0.990	1.00	28.8
WS 27 1.09-1.40	0.030	1.30	1.06	28.5
WS 28 0.20-0.87	0.030	1.30	1.11	31.1
WS 28 0.87-1.25	0.030	1.38	1.15	30.3
WS 34 0.20-1.00	0.020	0.870	1.16	25.1
WS 34 1.00-1.50	0.030	0.910	1.06	24.8
WS 34 1.50-2.00	0.040	0.750	1.13	25.2
WS 35 0.0-0.55	0.040	2.18	3.48	31.0
WS 35 0.55-1.26	0.030	1.03	1.72	26.7
WS 36 0.02-0.49	0.030	0.780	1.17	27.1
WS 36 0.49-1.62	0.020	0.800	0.980	26.3
WS 37 0.20-0.82	0.030	1.56	2.64	29.1
WS 37 0.82-1.12	0.040	1.86	3.06	30.9
WS 37 1.12-1.73	0.020	2.02	3.18	33.9
Detn limit :	(0.010)	(0.010)	(0.010)	(0.010)

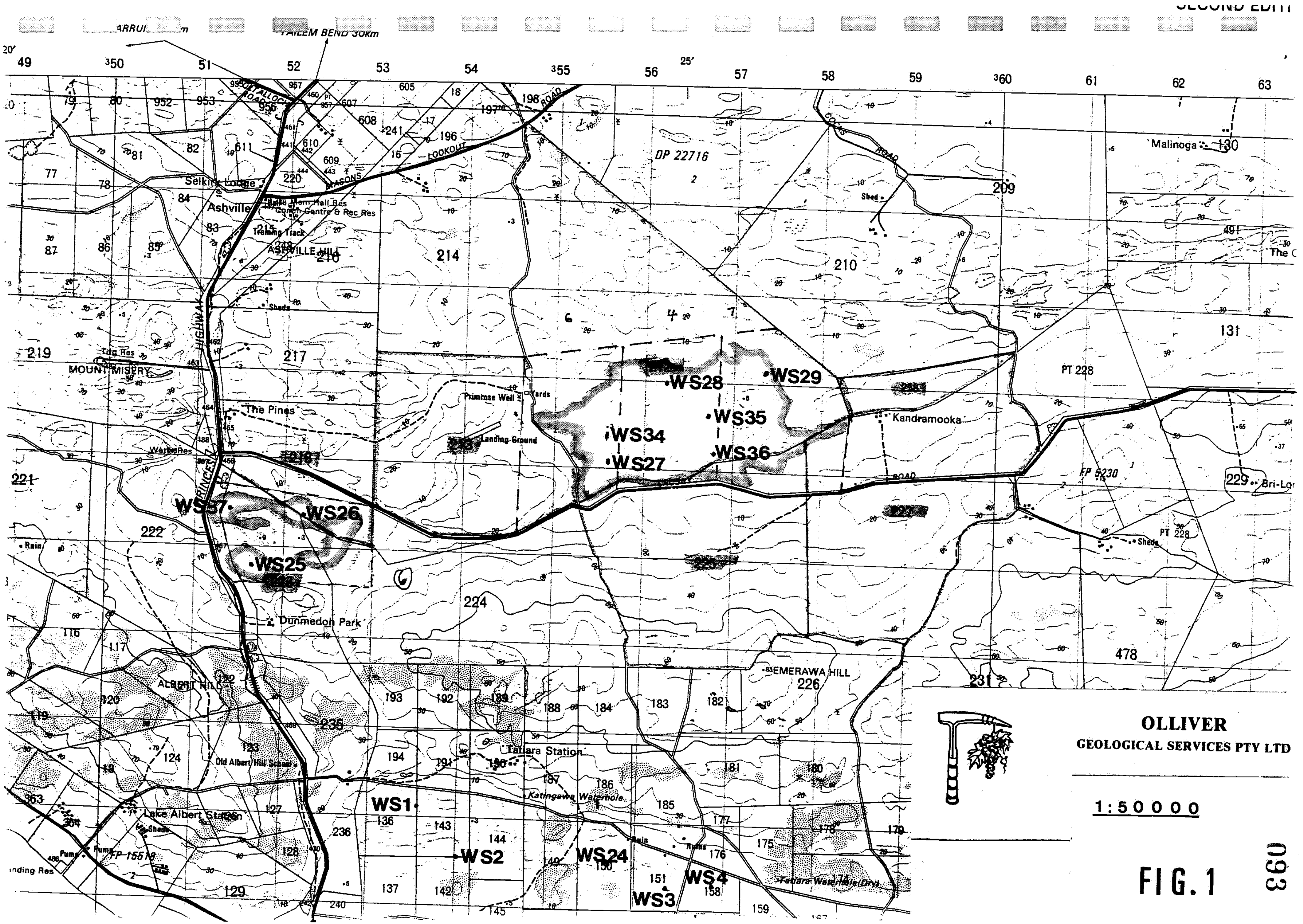
SECOND EDITI
TAILEM BEND 30km
PRINCES HIGHWAY
LOOKOUT ROAD
MASONS
COCKS ROAD
DP 22716
Malinoga
Selkirk Lodge
Ashville
ASHVILLE HILL
Training Track
Shed
Sheds
MOUNT MISERY
The Pines
Primrose Well
Yards
Landing Ground
Kandramooka
PT 228
FP 5230
Bri-Lor
Dunmedoh Park
EMERAWA HILL
ALBERT HILL
Old Albert Hill School
Tatiara Station
Katingawa Waterhole
Lake Albert Station
Tatiara Waterhole (Dry)
FP 15518
Ruins
Pump
WS1
WS2
WS3
WS4
WS24
WS25
WS26
WS27
WS28
WS29
WS34
WS35
WS36
WS37
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FIG.1

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TABLE 2

GYPSUM DEPOSITS - SOUTH AUSTRALIA

COMPARISON OF GRADE (%)

Deposit	Type	Gypsum Raw	Gypsum Salt-Free	CaCo3	Insol	Salt
L. Fowler	Dune-Main	92.9	93.5	1.1	3.9	0.7
	North	85.2	86.0	2.4	9.8	1.0
Cooke Plains	Dune	84.0	-	2.8	11.2	-
Morgan	Dune	75.6	-	4.7	17.4	0.2
L. Mac-Donnell	Selenite	94.5	95.4	3.5	0.2	0.9
Kangaroo Is Salt L.	Selenite	92.0	-	4.5	-	-
Marion L.	Gypsarenite	92.0	92.8	5.6	0.1	0.9
	Selenite	94.2	94.7	4.4	0.2	0.5
Snow L	Gypsarenite	76.3	80.1	11.5	0.6	4.8
Spider L	"	91.6	94.0	4.6	0.5	2.6
Streaky Bay L.Purdilla	"	87.8	89.7	8.7	-	2.1
L.Torna	"	85.9	87.9	10.7	-	2.3
Warnes L	"	84.3	89.5	5.9	0.1	5.7

EL 1628 MALCOLM PLAINS

QUARTERLY REPORT NO. 7 TO 21 SEPTEMBER 1991

TENURE

EL 1628 of 839 km^2 granted to Olliver Geological Services Pty Ltd on 22 December 1989 for six months was renewed for six months to 21 December 1990 and was renewed over a reduced area of 433 km^2 for a further twelve months to 21 December 1991

COOKE PLAINS EMBAYMENT

A summary report on investigations is attached. The diatomite unit is too low grade to be of further interest.

FIELD INVESTIGATIONS

SEVENTH FIELD TRIP - undertaken by Sean Kennedy and Jeff Olliver on 5 August 1991. Warnes and Lihou gypsum lakes are flooded and grid core drilling will not be possible until the end of summer. Waltowa Swamp which has large areas of samphire was still accessible and further holes were planned to the south of the best intersections in WS14.

EIGHTH FIELD TRIP - undertaken by Sean Kennedy and Peter Hornsby (Field Assistant) from 18 to 22 September 1991. Activities were discussed with landowners at Waltowa Swamp and sites were inspected with Robert Day and Reg Newchurch, representatives of Ngarrindjeri Lands and Progress Association. Core drilling was completed at Waltowa Swamp with a further 20 holes (WS 38 to 57).

INSPECTION OF SAMPLES

PVC Pipe and core samples have been sawn in half, core logged lithologically and diatom content estimated microscopically at selected intervals by Sean Kennedy.

PALAEONTOLOGICAL REPORT

Report 62091 by Elizabeth Barnett on nine samples from Waltowa Swamp is attached. Diatom content of 40-50% in WS 8,14 and 20 was followed up by the last 20 holes.

PERTH TRIP

Further data were obtained on the diatomite deposits of Mallina Holdings Ltd - Beechboro Holdings Pty Ltd north of Perth. The long awaited processing plant originally expected to open in March 1991, has still not been constructed - engineering studies continue including plant design, and environmental and mine studies.

Most diatoms are elongate to acicular, there are no discoid forms like Waltowa Swamp and large robust frustules are rare.

EXPENDITURE

ITEM	18 MONTHS To 21.06.91	3 MONTHS To 21.09.91	TOTAL
Tenement Fees	3 251.75	nil	3 251.75
Geological Services	33 297.50	9 680.00	42 977.50
Administration	19 750.00	3 000.00	22 750.00
Office Costs	3 275.19	1 070.19	4 345.38
Data acquisition	336.75	13.60	350.35
Field Operations	5 670.48	1 732.24	7 402.72
Laboratory Testing	5 386.65	1 000.00	6 386.65
Aboriginal Liaison	nil	200.00	200.00
TOTAL	70 968.32	16 696.03	87 664.35

WORK IN PROGRESS

Cooke Plains Embayment - completed

Waltowa Swamp - Appraise drilling results and compile summary report.

Gypsum Lakes - await end of summer for grid drilling.

....
J.G. OLLIVER
Exploration Consultant

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EL1628 MALCOLM PLAINS

SUMMARY REPORT - EXPLORATION FOR DIATOMITE IN COOKE PLAINS EMBAYMENT

by

JEFFREY G. OLLIVER
Director
Olliver Geological Services Pty Ltd

and

SEAN KENNEDY
Geological Consultant
S. and C.R. Kennedy

July 1991

CONTENTS

EXPLORATION FOR DIATOMITE IN COOKE PLAINS EMBAYMENT

EL 1628 MALCOLM PLAINS

INTRODUCTION

EL 1628 of 839km2 was granted to Olliver Geological Services Pty Ltd on 22 December 1989 for six months and was renewed for six months to 22 December 1990. A further renewal was granted over a reduced area of 433 km2 (see figure 1) for twelve months to 21 December 1991.

Cooke Plains Embayment about 90km southeast of Adelaide is a swampy depression extending 25km eastwards from Lake Alexandrina to the Cooke Plains Gypsum Deposit (figure 2).

Target is filter-grade diatomite in Holocene sediments deposited during the last marine transgression which peaked about 6 000 years ago.

Altmann (1976) and von der Borch & Altmann (1979) recorded up to 70% diatoms in the diatomite unit up to 2.1m thick.

Location, access, physiography, geological setting, drilling methods and results of the first 21 drill holes were described in Quarterly Report no.2 to 21 June 1990 (Olliver and Kennedy, 1990)

DRILLING PROGRAM

A total of 60 holes was drilled using push tube coring methods with minor hand augering during the following field trips:-

Date	No. of holes	Designation
28-29 March 1990	5	CP1-5
24-28 April 1990	18	CP6-23
15-20 December 1990	36	CP24-59
5-7 March 1991	1	CP60

Depth varied from 0.31m in CP51 to 2.47m in CP24. Locations are shown on figure 2 as well as 31 hand auger holes drilled east of Cooke Plains township by CSR in 1981 to test for gypsum (CSR, 1983).

SAMPLE TESTING

Drillcore was logged geologically by Sean Kennedy and diatom content estimated under the microscope (Appendix A). For holes CP24-60, thin section slides prepared by Barnett (1990) for her palaeontological study were used as standards. Contents for holes CP1-23 reported herein have been adjusted from those appended to Quarterly Report no.2 (Olliver and Kennedy, 1990) to incorporate later information.

The following laboratory testing has been completed.

- Barnett (1990) - diatom genera or species were identified and abundance of diatoms was estimated for the following five samples in Quarterly Report no.4

CP	Depth (m)
1	1.30
9	0.10
12	1.05
17	0.26
23	1.00

- Amdel Ltd - mineral composition was determined based on optical microscopy, X-ray diffraction and chemical analyses of the following six samples in Quarterly Report no.3

CP	Intersection (m)
3	1.00 - 1.40
5	1.15 - 2.19
12	0.60 - 1.50
16	0.07 - 0.80
20	0.02 - 1.30
23	0.00 - 0.60

- John Keeling (SADME) - determined clay mineralogy of a sample of sapropel from 2.00 -2.21m on CP14.

RESULTS OF DRILLING

The following Holocene sedimentary sequence as summarised in Table 1 from Appendix A from oldest to youngest has been recognised resting on calcrete basement.

1. Basal unit - grading from green to light or dark grey clay sandy in places to grey to dark grey clayey sand to relatively clean medium grained sand.

2. Sapropel - black organic matter with minor clay.

3. Diatomite.

4. Gypsiferous clay - yellow to brown and occasionally grey or green with varying amounts of fine to coarse gypsum crystals - sandy in places.

5. Black mud - strong smelling.

6. Salt.

7. Black soil.

8. Algal mat.

The lower four units grade vertically and laterally into adjacent units.

DIATOMITE EVALUATION

The diatomite unit is soft off-white to grey clay with thin darker bands and, in places, thin sandy layers and occasional patches of gypsum crystals.

Diatomite is at the surface in CP20,22,23,54 and 57 in the west, but elsewhere is generally overlain by algal mat, soil, salt, black mud and yellow to brown gypsiferous clay to a maximum of 1.15m in CP2.

Thickness ranges from nil in CP31,37,49,52,53 and 58 to 1.90m in CP22 compared to the maximum of 2.0m in E21 of Altmann (1976).

In the centre, west of the Princes Highway from CP46 and 47 to CP39 and 40, two diatomite subunits are separated by gypsiferous clay.

There was also no diatomite east of Cooke Plains in drill holes AH1-31 (CSR, 1983) and CP60.

However, although the diatomite unit is persistent, diatoms are restricted to the following zones from east to west.

- CP1-7, 10-12,24,29 and 32 - about 3.5 km long. Diatom content varies from 5-15% to 25-30% in CP11 with thickness from 0.30m to 1.79m.
- CP15 and 39 - 5-30% diatoms over 0.72-0.96m.
- CP42,44,45 - 10-30% diatoms over 0.16-0.28m.
- CP48 - 15% diatoms over 1.01m.
- CP50 - 10% diatoms over 0.25m.
- CP23 - 0-25% diatoms over 0.80m.
- CP22,54,56,57 west of Princes Highway - 5-25% diatoms over 1.19-1.90m.

The estimate of up to 70% diatoms reported by von der Borch & Altmann (1979) was not confirmed.

The dominant diatoms are Campylodiscus echineis (Ehr.) (corrected by Barnett, 1991 from C. daemelianus reported previously) and Hydalodiscus lentiginosus. Both are relatively large discoid forms up to 200 microns and 60-100 microns in diameter respectively although often fragmented.

TABLE 1

DRILL HOLE INTERSECTIONS - COOKE PLAINS EMBAYMENT

Hole CP	Algal Mat	Black Soil	Salt	Black Mud	Yell to Br Gyp.Clay	Diatomite From	To	Thickness	Est %	Sapropel	Basal Clay	Sand	Calcrete
1	-	0-.34	-	-	.34-1.10	1.10	2.32	1.22	10-15	-	-	-	-
2	-	0-.30	-	-	.30-1.15	1.15	2.19	1.04	10	-	-	-	-
3	-	0-.20	-	.20-.50	.50-.60	.60	1.50	.90	15	-	1.50-1.63	-	-
4	-	0-.20	-	-	.20-1.00	1.00	1.37	.37	5	-	-	-	-
5	-	0-.40	-	-	.40-1.00	1.00	1.75	.75	5-25	-	1.75-2.18	-	-
6	-	-	-	-	0-.25	.25	2.13	.88	5-10	-	-	-	-
7	-	-	-	-	-	0	.40	.40	5	-	-	-	-
8	-	-	-	-	0-.40	.40	.90	.50	nil	-	.90-1.29	-	-
9	-	-	-	-	0-.24	.24	1.40	1.16	nil	-	1.40-1.60	-	-
10	-	-	-	0-.09	-	.09	1.88	1.79	5-25	-	-	-	-
11	-	-	-	0-.18	-	.18	.95	.77	25-30	-	-	-	.95-1.00
12	0-.05	-	-	-	-	.05	1.50	1.45	0-20	-	1.50-1.94	-	-
13	-	-	-	0-.40	-	.40	2.10	1.70	nil	2.10-2.20	2.20-2.26	-	-
14	-	-	-	0-.40	-	.40	2.00	1.60	nil	2.00-2.21	-	-	-
15	-	-	-	0-.10	-	.10	.82	.72	5-30	-	0.82-1.18	-	-
16	-	-	0-.02	.02-.07	-	.07	1.08	1.01	nil	-	-	-	-
17	-	-	0-.05	.05-.25	-	.25	.60	.35	nil	-	.60-.79	-	-
18	-	-	-	0-.50	-	.50	1.10	.60	nil	-	1.10-1.30	-	-
19	-	-	-	0-.20	-	.20	.90	.70	nil	-	.90-1.25	-	-
20	-	-	-	-	-	0	1.30	1.30	nil	-	1.30-1.40	-	-
21	-	-	0-.04	.04-.30	-	.30	.50	.20	nil	.50-.54	.54-1.64	-	-
22	-	-	-	-	-	0	1.90	1.90	15-20	-	1.90-2.34	-	-

TABLE 1

DRILL HOLE INTERSECTIONS - COOKE PLAINS EMBAYMENT

Hole CP	Algal Mat	Black Soil	Salt	Black Mud	Yell to Br Gyp.Clay	Diatomite From	To	Thickness	Est %	Sapropel	Basal Clay	Sand	Calcrete
23	-	-	-	-	-	0	.80	.80	0-25	-	.80-1.18	-	-
24	-	-	-	-	0-.48	.48	2.27	1.79	10-20	-	2.27-2.47	-	-
25	-	-	-	-	0-.40	.40	1.65	1.25	nil	-	1.65-1.91	-	-
26	-	-	-	-	0-.76	.76	1.01	.25	nil	-	.76-1.01	-	1.01-1.02
27	-	-	-	0-.08	.08-.60	.60	1.00	.40	Tr	-	1.00-1.18	-	-
28	-	-	-	-	0-.30	.30	.87	.57	Tr	-	-	-	-
29	-	-	-	-	0-.60	.60	.90	.30	10	-	-	-	-
30	0-.02	-	-	.02-.10	.10-.40	.40	1.07	.67	nil	1.07-1.17	1.17-1.22	-	-
31	0-.05	-	-	-	.05-.72	-	-	-	-	-	-	-	.72-.74
32	0-.04	-	-	-	.04-.50	.50	1.50	1.00	10	1.50-1.80	1.80-1.92	-	-
33	0-.06	-	-	.06-.40	.40-.55	.55	1.54	.99	nil	1.54-1.69	-	1.69-1.88	-
34	0-.05	.05-.28	-	.28-.44	-	.44	.65	.21	nil	-	-	.65-.97	-
35	-	-	-	-	-	0	.60	.60	nil	-	-	.60-.85	.85-.87
36	-	-	-	-	0-.20	.20	1.00	.80	Tr	1.00-1.31	-	1.31-2.18	-
37	-	-	-	-	0-.65	-	-	-	-	-	-	-	.65-.74
38	-	-	-	0-.08	.08-.60	.60	1.07	.47	nil	1.07-1.30	-	-	-
39	-	-	-	0-.35	-	.35	.42	.07	-				
	-	-	-	.42-.46	-	.46	1.30	.84	10	1.30-1.65	1.65-.169	-	-
40	-	-	-	-	-	0	.12	.12	-				
				.12-.31	.31-.56	.56	1.55	.99	Tr	-	-	-	-
41	-	-	-	-	0-.71	.71	1.30	.59	nil	1.30-1.46	-	1.46-2.19	-
42	-	-	-	0-.05	.05-.60	.60	.81	.21	10	.81-.91	-	-	.91-.92

TABLE 1

DRILL HOLE INTERSECTIONS - COOKE PLAINS EMBAYMENT

Hole CP	Algal Mat	Black Soil	Salt	Black Mud	Yell to Br Gyp.Clay	Diatomite From	To	Thickness	Est %	Sapropel	Basal Clay	Sand	Calcrete
43	-	-	-	-	-	0	.30	.30	-				
					.30-.52	.52	1.01	.49	Tr	1.01-1.09	1.09-1.35	-	-
						0	.60	.60	-				
44	-	-	-	-	.60-.76	.76	.92	.16	15	.92-.97	.97-1.09	-	1.09-1.10
45	-	-	0-.05	-	.05-.22	.22	.45	.23					
					.45-.57	.57	.85	.28	30	.85-1.02	1.02-1.17	-	1.17
46	-	-	0-.23	-	-	.23	.38	.15	-				
			-	-	.38-.83	.83	1.32	.49	Tr	1.32-.155	-	1.55-1.57	-
47	-	-	-	-	-	0	.33	.33	-				
					.33-.71	.71	1.04	.33	Tr	1.04-1.21	-	1.21-1.25	-
48	-	-	-	0-.44	-	.44	1.45	1.01	Tr-15	1.45-1.91	-	1.91-1.95	-
49	-	-	-	0-.04	.04-.41	-	-	-	-	-	-	0.41-0.44	-
50	-	-	-	0-.06	.06-.70	.70	.95	.25	10	0.95-1.31	-	1.31-1.62	1.62
51	-	-	-	-	0-.12	.12	.18	.06	nil	-	-	-	.18-.31
52	-	-	-	-	-	0	.07	.07	-	-	-	.07-.42	-
53	-	-	-	-	-	0	.07	.07	-	-	-	.07-.51	-
54	-	-	-	-	-	0	1.54	1.54	10	1.54-1.74	1.74-1.87	-	-
55	-	-	-	0-.25	-	.25	1.44	1.19	nil	-	-	1.44-2.05	-
56	0-.05	-	-	.05-.24	-	.24	1.43	1.19	5	-	1.43-1.60	-	1.60-1.63
57	-	-	-	-	-	0	1.20	1.20	25	-	-	1.20-1.46	-
58	-	-	-	-	0-.24	-	-	-	nil	-	.24-.61	-	-
x59	-	-	-	-	0-.22	.22	1.20	.98	15	1.20-2.03	2.11-2.26	2.03-2.11	-
60	-	0-.25	-	-	.25-.72	-	-	-	nil	-	-	-	.72-.80

x CP59 is 5.5km south south west of CP58 beyond limit of Figure 2

CONCLUSIONS

Cooke Plains Embayment contains a fairly persistent soft light grey diatomite-bearing clay near the base of the Holocene sequence.

The diatom assemblage is dominated by Campylodiscus and to a lesser extent, Hyalodiscus mainly as broken fragments.

No further work is warranted as diatoms are absent in some holes, elsewhere only 10-15% and occasionally up to 30%.

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APPENDIX A

GEOLOGICAL LOGS OF CORE HOLES
COOKE PLAINS EMBAYMENT CP1-60

HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
CP1	0.00 - 0.34	Black Soil		
	0.34 - 0.64	gypsum rich brown to yellow clay	0.40	spicules <5%
	0.64 - 1.10	yellow clay with minor gypsum	0.85	spicules <5%
	1.10 - 2.32	soft grey clay	1.30	dumb bells, spheres 10-15% spicules 5-10%
			2.12	spicules <5%
CP2	0.00 - 0.30	Black Soil		
	0.30 - 0.80	gypsum rich brown to yellow clay	0.35	fans, spheres 10% spicules 10%
	0.80 - 1.15	brown clay with minor gypsum	1.10	spicules <3%
	1.15 - 2.19	soft grey clay	1.35	spheres 10% spicules 10%
			2.00	spicules <5%
CP3	0.00 - 0.20	Black Soil		
	0.20 - 0.50	brown, gypsum rich mud	0.40	spheres, fans 10% spicules 10%
	0.50 - 0.60	yellow and grey clay with minor gypsum		
	0.60 - 1.50	soft grey clay	0.65	spicules <5%
			1.30	spheres 15% spicules 15%
	1.50 - 1.63	basal greenish clay	1.55	none visible
CP4	0.00 - 0.20	Black Soil		
	0.20 - 1.00	yellow and black clay	0.55	spicules <5%
			0.80	spicules 5% spheres 5%
	1.00 - 1.37	soft grey clay	1.10	spicules <5%
CP5	0.00 - 0.40	Black Soil		
	0.40 - 1.00	yellow and brown clay	0.75	spicules 5%
	1.00 - 1.75	soft grey clay	1.40	spicules 5% spheres 5%
			1.65	spheres 20-25%
	1.75 - 2.18	light grey sandy clay	2.10	spicules 5%

HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
CP6	0.00 - 0.03	grey gypsum rich clay		
	0.03 - 0.25	yellow, gypsum rich clay		
	0.25 - 2.00	grey to dark grey clay	0.45	spicules 15%
			1.04	spicules 20%
			1.75	spicules 10% spheres 5%
			1.95	spicules 20% spheres, fans 10%
	2.00 - 2.13	grey, sandy clay		
CP7	0.00 - 0.40	grey clay (hole dug by hand)	0.35	spicules 5% spheres 5%
CP8	0.00 - 0.25	brown clay and mud		
	0.25 - 0.40	mud and gypsum		
	0.40 - 0.70	grey clay	0.50	none visible
	0.70 - 0.90	very light grey clay	0.80	none visible
	0.90 - 1.29	greenish basal clay	1.20	none visible
CP9	0.00 - 0.16	light grey sandy clay	0.10	gypsum xals, no diatoms
	0.16 - 0.24	yellow clay		
	0.24 - 0.90	light grey, gypsum rich clay	0.58	spicules 5%
	0.90 - 1.40	light grey clay with dark stringers	1.20	none visible
	1.40 - 1.60	greenish grey, sandy basal clay	1.50	none visible
CP10	0.00 - 0.09	black, stong smelling mud		
	0.09 - 0.60	grey clay, sandy in parts	0.45	spicules 5% spheres 5%
			0.55	spicules 10% spheres 10%
	0.60 - 1.00	dark grey clay	0.90	spheres 20%
	1.00 - 1.88	grey clay with gypsum	1.80	fans 25%

HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
CP11	0.00 - 0.05	algal mat		
	0.05 - 0.18	black, strong smelling mud		
	0.18 - 0.65	grey clay with sandy layers	0.40	spheres 30%
	0.65 - 0.95	dark grey clay	0.80	spheres, footballs 25%
	0.95.- 1.00	calcrete		
CP12	0.00 - 0.05	light grey algal mat		
	0.05 - 0.20	light grey sandy clay	0.15	none visible
	0.20 - 0.60	light grey clay	0.55	none visible
	0.60 - 1.50	grey clay	1.05	fans, footballs , spheres 20%
			1.30	fans, footballs , spheres 20%
	1.50 - 1.94	greenish grey basal clay		
CP13	0.00 - 0.40	black, strong smelling mud		
	0.40 - 1.20	grey clay	0.70	spicules 15%
	1.20 - 2.10	dark grey clay	1.60	spicules 15%
	2.10 - 2.20	sapropel		
	2.20 - 2.26	grey sandy basal clay		
CP14	0.00 - 0.40	black, strong smelling mud		
	0.40 - 0.80	light grey clay	0.60	none visible
	0.80 - 2.00	dark grey clay	1.40	none visible
	2.00 - 2.21	sapropel		
CP15	0.00 - 0.10	black mud		
	0.10 - 0.28	light grey clay	0.25	abund gyp xals, no diat
	0.28 - 0.35	dark grey clay		
	0.35 - 0.47	greenish grey clay	0.45	fans 5%
	0.47 - 1.18	dark grey clay	0.70	fans, spicules 30%
			1.00	none visible

HOLE NO	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
CP16	0.00 - 0.02	salt		
	0.02 - 0.07	black, strong smelling mud		
	0.07 - 0.55	grey clay with sandy layers	0.40	no diat, abund gyp xals
	0.55 - 1.08	dark grey clay	0.80	no diat, some gyp xals
CP17	0.00 - 0.05	salt		
	0.05 - 0.25	black, stong smelling mud		
	0.25 - 0.30	light grey sandy clay	0.26	no diat, abund gyp
	0.30 - 0.60	light grey clay	0.45	spicules 5%
	0.60 - 0.79	grey clay		
CP18	0.00 - 0.50	black, strong smelling mud		
	0.50 - 0.70	grey sandy clay		
	0.70 - 1.10	grey clay		
	1.10 - 1.30	dark grey clay	1.10	none visible
CP19	0.00 - 0.20	black, strong smelling mud		
	0.20 - 0.46	grey clay	0.30	no diat, some gyp
	0.46 - 0.90	light grey to yellowish clay	0.60	" " " "
	0.90 - 1.00	greenish grey clay	0.95	none visible
	1.00 - 1.25	dark grey clay	1.10	none visible
CP20	0.00 - 0.20	light grey sandy clay	0.10	no diat, some gyp
	0.20 - 1.30	dark grey clay	0.70	none visible
	1.30 - 1.40	light grey sandy clay	1.35	none visible
CP21	0.00 - 0.04	salt		
	0.04 - 0.30	black, strong smelling mud		
	0.30 - 0.50	grey clay	0.35	no diat, abund gyp
	0.50 - 0.54	sapropel		
	0.54 - 1.64	grey green, sandy basal clay	1.35	none visible

HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
CP22	0.00 - 1.50	very light grey clay	0.50	none visible
			1.50	fans,spicules 20%
	1.50 - 1.90	light grey clay	1.90	spheres, fans 15%
	1.90 - 2.34	light grey to green clay	2.20	none visible
CP23	0.00 - 0.40	dark grey clay	0.20	spheres 25%, some gyp xals
	0.40 - 0.80	light grey sandy clay	0.60	none visible
	0.80 - 1.18	dark grey clay	1.00	bone shaped cylinders 20%
CP24	0.00 - 0.36	light grey gypsum rich clay		
	0.36 - 0.48	brown, gypsum rich clay		
	0.48 - 2.27	grey to dark grey clay	1.00	Broken Campylodiscus complete Hyalodiscus and sponge spicules 10 - 15%
			2.00	Broken Campylodiscus complete Hyalodiscus and sponge spicules 15-20%
	2.27 - 2.47	brown to dark grey gritty basal clay		
CP25	0.00 - 0.40	light to dark grey and brown sandy clay		
	0.40 -1.65	grey to dark grey clay mottled in parts	0.50	sponge spicules only 10%
			1.50	none visible
	1.65 - 1.91	greenish, sandy basal clay		
CP26	0.00 - 0.38	yellow, gypsum rich sandy clay		
	0.38 - 0.64	green, gypsum rich clay		
	0.64 - 0.76	brown sandy clay		
	0.76 - 1.01	light grey, slightly sandy clay	0.90	none visible
	1.01 - 1.02	calcrete		

HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
CP27	0.00 - 0.08	black, strong smelling mud		
	0.08 - 0.30	gypsiferous, sandy yellow clay		
	0.30 - 0.60	greenish grey, gypsiferous clay		
	0.60 - 1.00	light grey clay	0.80	spicules, Navicula Hyalodiscus $<$ 5%
	1.00 - 1.18	dark sandy basal clay		
CP28	0.00 - 0.15	sandy grey clay		
	0.15 - 0.30	yellow and brown, gypsiferous clay		
	0.30 - 0.87	light brown to light grey clay	0.60	spicules, Hyalodiscus $<$ 5%
CP29	0.00 - 0.20	yellow clay		
	0.20 - 0.60	lt grey sandy clay with gyp. & tree roots		
	0.60 - 0.90	light grey clay	0.80	spicules, Campylodiscus complete & fragmented Hyalodiscus 10%
CP30	0.00 - 0.02	algal mat with sand		
	0.02 - 0.10	black, strong smelling mud		
	0.10 - 0.40	brown, yellow and grey gypsiferous clay		
	0.40 - 1.07	light grey clay	0.50	spicules $<$ 5%
			1.00	none visible
	1.07 - 1.17	sapropel		
	1.17 - 1.22	basal grey sandy clay		
CP31	0.00 - 0.05	algal mat with sand		
	0.05 - 0.30	light brown clay		
	0.30 - 0.72	brown to grey clay, sandier at depth		
	0.72 - 0.74	calcrete		

HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
CP32	0.00 - 0.04	algal mat with sand		
	0.04 - 0.50	green clay with gypsum		
	0.50 - 1.50	dark grey clay	1.00	spicules, Campylodiscus fragments 10%
	1.50 - 1.80	sapropel		
	1.80 - 1.92	dark grey sandy basal clay		
CP33	0.00 - 0.06	algal mat		
	0.06 - 0.40	black, strong smelling mud		
	0.40 - 0.55	green sandy clay	0.5[illegible]	none visible
	0.55 - 1.54	grey clay	1.00	spicules $<$ 5%
	1.54 - 1.69	sapropel		
	1.69 - 1.88	dark grey, clayey sand		
CP34	0.00 - 0.05	algal mat		
	0.05 - 0.28	dark grey, slightly sandy clay		
	0.28 - 0.44	black, strong smelling mud		
	0.44 - 0.65	light grey clay	0.50	none visible
	0.65 - 0.97	grey sand		
CP35	0.00 - 0.35	light grey clay	0.30	none visible
	0.35 - 0.60	brown to yellow clay	0.55	none visible
	0.60 - 0.85	grey sand		
	0.85 - 0.87	calcrete		
CP36	0.00 - 0.20	dark brown clay		
	0.20 - 0.40	light brown clay	0.30	none visible
	0.40 - 1.00	green to light grey clay	0.90	Rare complete Hyalodiscus
	1.00 - 1.31	sapropel		
	1.31 - 2.18	grey sand with decreasing clay proportion		
CP37	0.00 - 0.10	grey clay		
	0.10 - 0.35	yellow sandy clay		
	0.35 - 0.65	grey to yellow gypsiferous clay	0.50	spicules $<$ 5%
	0.65 - 0.74	weathered calcrete		

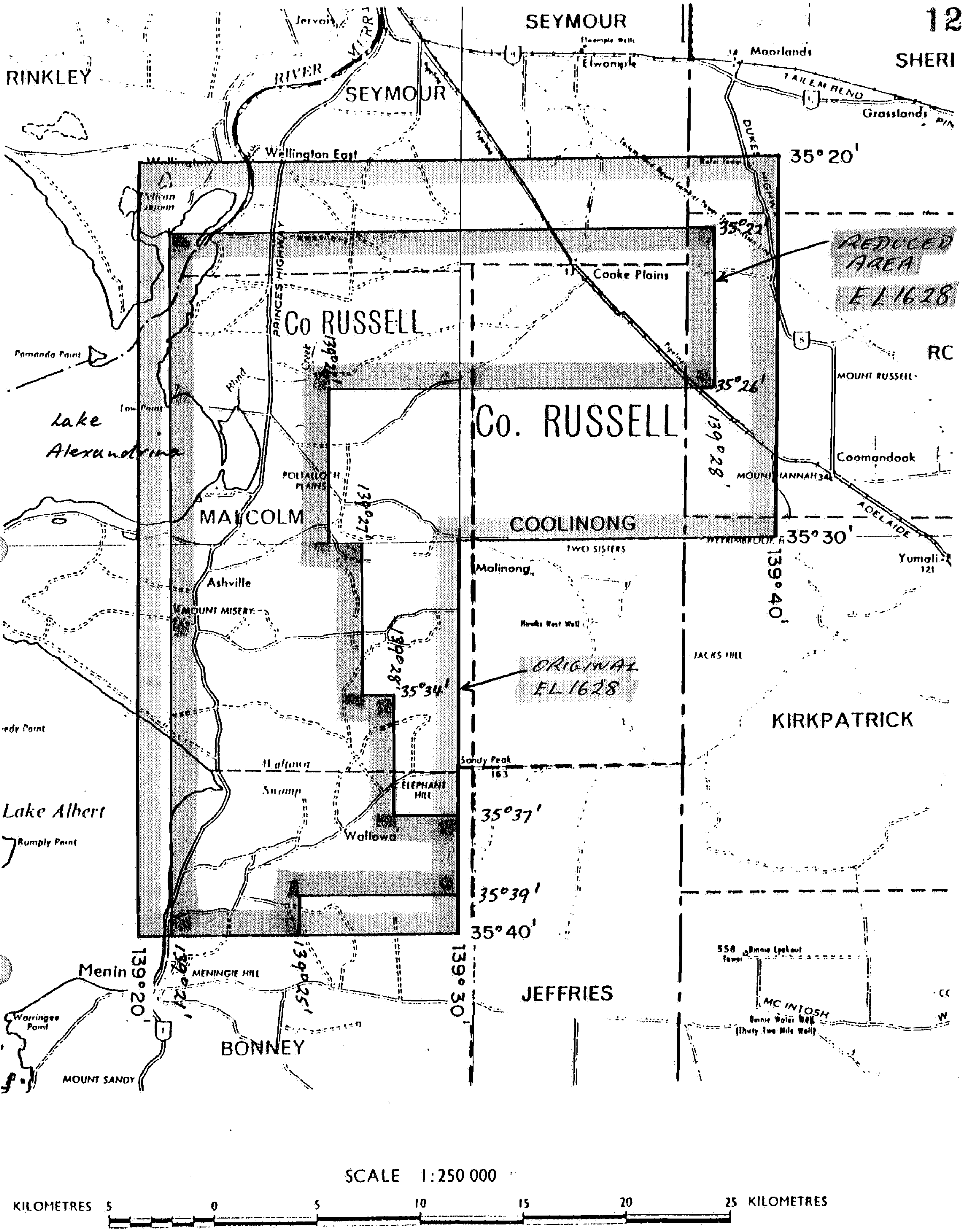
HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
CP38	0.00 - 0.08	black, strong smelling mud		
	0.08 - 0.60	yellow clay	0.20	none visible
	0.60 - 1.07	grey to green clay	0.80	spicules < 5%
	1.07 - 1.30	sapropel		
CP 39	0.00 - 0.35	black, strong smelling mud		
	0.35 - 0.42	light grey, slightly sandy clay		
	0.42 - 0.46	black, strong smelling mud		
	0.46 - 1.30	light grey to dark grey clay	0.90	spicules, Campylodiscus fragments, 6 chambered diatom. 10%
	1.30 - 1.65	alternating sapropel and dark grey clay		
	1.65 - 1.69	gritty basal clay		
CP40	0.00 - 0.12	light grey clay		
	0.12 - 0.31	black, strong smelling mud		
	0.31 - 0.56	green, slightly sandy clay	0.50	spicules < 5%
	0.56 - 1.55	dark grey clay	0.90	spicules, broken and complete Campylodiscus < 5%
CP41	0.00 - 0.23	brown to grey clay		
	0.23 - 0.71	yellow, gypsiferous clay		
	0.71 - 1.30	light grey clay	1.00	spicules <5%
	1.30 - 1.46	sapropel		
	1.46 - 2.19	grey, medium grained sand		
CP42	0.00 - 0.05	black, stron smelling mud		
	0.05 - 0.60	yellow sandy clay	0.20	none visible
	0.60 - 0.81	light grey clay	0.70	spicules, complete Hyalodiscus 10%
	0.81 - 0.91	black clay		
	0.91 - 0.92	calcrete		

HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
CP43	0.00 - 0.30	dark grey clay, sandier with depth		
	0.30 - 0.52	yellow, gypsiferous, sandy clay		
	0.52 - 1.01	light grey clay, sandy at top	0.80	spicules, broken broken Campylodiscus <5%
	1.01 - 1.09	black clay		
	1.09 - 1.30	green sandy clay with wood fragments		
	1.30 - 1.35	light grey, sandy clay		
CP44	0.00 - 0.30	grey sandy clay, less sand at depth		
	0.30 - 0.46	dark brown clay		
	0.46 - 0.60	grey, sandy clay		
	0.60 - 0.76	grey and yellow gyps-iferous clay		
	0.76 - 0.92	grey clay	0.80	spicules, complete and broken Campylodiscus 15%
	0.92 - 0.97	sapropel		
	0.97 - 1.09	dark grey sandy clay		
	1.09 - 1.10	calcrete		
CP45	0.00 - 0.05	dark grey clay		
	0.05 - 0.22	yellow clay	0.15	none visible
	0.22 - 0.45	sandy light grey clay		
	0.45 - 0.57	yellow gypsiferous clay		
	0.57 - 0.85	light grey clay	0.70	Navicula, complete and broken Campylodiscus, Hyalodiscus, spicules 30%
	0.85 - 1.02	sapropel		
	1.02 - 1.17	unable to recover sample but hit calcrete		
CP46	0.00 - 0.23	dark grey clay		
	0.23 - 0.38	light grey clay		
	0.38 - 0.83	yellow and light grey clay	0.60	spicules <5%
	0.83 - 1.32	light grey clay	1.00	spicules and Hyalodiscus <5%
	1.32 - 1.55	sapropel		
	1.55 - 1.57	grey, medium grained sand		

HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
CP47	0.00 - 0.33	dark grey clay		
	0.33 - 0.71	yellow and light grey		
	0.71 - 1.04	light grey clay	0.90	spicules and complete Campylodiscus <5%
	1.04 - 1.21	sapropel		
	1.21 - 1.25	grey, medium grained sand		
CP48	0.00 - 0.05	black, strong smelling mud		
	0.05 - 0.44	black clay	0.30	none visible
	0.44 - 0.68	light grey clay	0.50	spicules <5%
	0.68 - 1.00	green/grey clay with gypsum & sand layers	0.80	spicules with Hyalodiscus, broken Campylodiscus and other unidentified genera 15%
	1.00 - 1.45	dark grey clay		
	1.45 - 1.91	sapropel		
	1.91 - 1.95	dark grey, medium grained sand		
CP49	0.00 - 0.04	black, strong smelling mud		
	0.04 - 0.11	black clay		
	0.11 - 0.30	grey, slightly sandy clay		
	0.30 - 0.41	yellow to grey gyps-iferous clay		
	0.41 - 0.44	dark grey, medium grained sand		
CP50	0.00 - 0.06	black, strong smelling mud		
	0.06 - 0.40	black clay		
	0.40 - 0.70	yellow clay		
	0.70 - 0.95	dark grey clay	0.80	broken Campylodiscus 5-10%
	0.95 - 1.31	sapropel		
	1.31 - 1.62	unable to recover sample but hit basement		

HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
CP51	0.00 - 0.12	yellowish grey clay	0.10	none visible
	0.12 - 0.18	creamy clay	0.15	none visible
	0.18 - 0.31	brown and yellow weathered calcrete		
CP52	0.00 - 0.07	brown clay		
	0.07 - 0.42	grey sand		
CP53	0.00 - 0.07	brown sandy clay		
	0.07 - 0.51	grey clayey sand		
CP54	0.00 - 0.35	creamy sandy clay	0.20	none visible
	0.35 - 0.59	light grey clay	0.40	broken campylodiscus, Hyalodiscus, spicules 10%
	0.59 - 1.09	light brown clay	0.80	spicules 10%
	1.09 - 1.54	light to dark grey clay	1.30	Campylodiscus, spicules 10%
	1.54 - 1.74	sapropel	1.70	none visible
	1.74 - 1.87	dark grey clay	1.80	none visible
CP55	0.00 - 0.25	black, strong smelling mud		
	0.25 - 1.44	lt brown to grey clay thin sandy layers	0.40 1.00	none visible spicules <5%
	1.44 - 1.90	dark to light grey medium grained sand		
	1.90 - 2.05	green clayey sand		
CP56	0.00 - 0.05	algal mat		
	0.05 - 0.24	black, strong smelling mud		
	0.24 - 1.43	lt brown to grey clay, thin sandy layers	1.00	spicules, Campylodiscus 5%
	1.43 - 1.60	green basal clay		
	1.60 - 1.63	weathered calcrete		

HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
CP57	0.00 - 0.55	light brown clay	0.30	spicules < 5%
	0.55 - 1.20	grey clay	0.80	spicules, Hyalodiscus Campylodiscus and other unidentified genera. 25%
	1.20 - 1.46	black, clayey sand, becoming cleaner and coarser at depth		
CP58	0.00 - 0.24	dark brown clay		
	0.24 - 0.61	brown to green basal clay	0.30	none visible
CP59	0.00 - 0.22	black and brown clay with wood fibres and gypsum crystals		
	0.22 - 1.20	dark brown to grey clay	0.30	broken Campylodiscus, Hyalodiscus, spicules 15%
			0.80	broken Campylodiscus, Hyalodiscus, spicules 10%
	1.20 - 2.03	sapropel		
	2.03 - 2.11	black, medium grained sand		
	2.11 - 2.26	dark green basal clay		
CP60	0.00 - 0.25	brown soil		
	0.25 - 0.45	light brown gypsiferous clay		
	0.45 - 0.60	grey gypsum		
	0.60 - 0.72	weathered calc clay with gypsum		
	0.72 - 0.80	calcareous nod. with clay matrix.		



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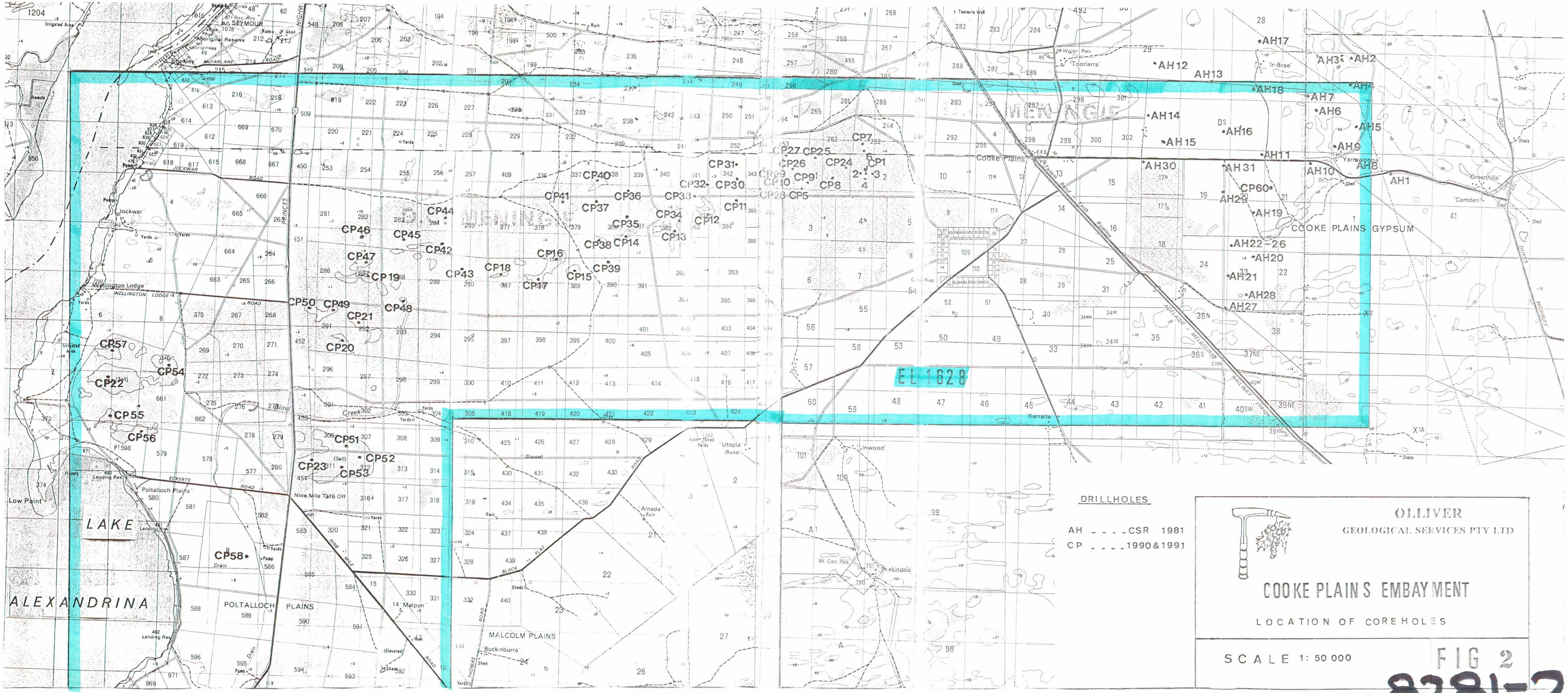
LOCALITY PLAN

SCALE	FIG 1



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COOKE PLAINS EMBAYMENT

LOCATION OF COREHOLES

SCALE 1: 50 000

FIG 2

8281-2

121

REPORT 62091

IDENTIFICATION OF DIATOM GENERA OR SPECIES, AND DIATOM ABUNDANCE ESTIMATES FOR WALTOWA SWAMP SAMPLES

Report by Elizabeth Barnett

EXECUTIVE SUMMARY

Sediments from nine Waltowa Swamp samples have been analysed for diatom abundance, and diatom genera or species identification. All the samples except WS10 contain greater than 20% diatoms. The greatest abundance of diatoms occurs in WS14 and WS20, with diatoms comprising between 40 to 50% of the sediments.

The diatom assemblage in each sample is varied. However, the largest and most common diatom in the Waltowa Swamp samples is *Campylodiscus echineis* (Ehr.). This diatom occurs mostly as whole frustules, although fragments are often present. Also common to the Waltowa Swamp samples is *Cocconeis placentula* (Ehr.), a substantially smaller diatom. Both of these occur in bloom proportions in WS14, WS20 and WS30 (1.4m).

Diatom genus and abundance are important in assessing Waltowa Swamp diatomite. Furthermore, sediment type directly affects optimal diatom extraction. Sediments with low clay content would be most suitable for diatomite recovery. Samples representative of low clay content and high diatom abundance include WS18, WS14, WS30 (1.4m), WS20, WS11 (2.0m) and WS12.

INTRODUCTION

This report is the follow up study to report 111090 on the identification and abundance of diatoms within Cooke Plains and Waltowa Swamp. In that report it was concluded that Waltowa Swamp was the more suitable area for diatomite recovery. Therefore, nine additional samples have been cored in Waltowa Swamp and analysed here to further identify genera or species of diatoms, as well as to estimate the abundance of these diatoms in relation to total sediment. The premise for this study is that if a particular species of diatom is observed in significant abundance, Waltowa Swamp may prove to be a potential site for diatomite recovery.

The sediments underlying Waltowa swamp represent a previous embayment of Lake Albert, most probably formed during Holocene sea-level high and an increased pluvial period between 5,000 and 8,000 years B.P. (refer to von der Borch and Altmann, 1979). At that time, lake waters transgressed into the area enabling the deposition of a diatomaceous unit between at least 0.6 and 2.0m. Subsequent sea-level lowering and less humid conditions have restricted deposition of lake sediments in the area although possible swamp sedimentation may still be in progress.

METHODS

Smear slides were prepared by spreading up to 2mm of wet sediment collected on a spatula over a cleaned glass slide, and mixing it with distiled water. The sediment was then evaporated to dryness, and covered with Eukitt resin and a glass coverslip. No pretreatment of the sediment was carried out, so that an estimate of diatom abundance in relation to total sediment could be obtained.

The smear slides were examined using a zeiss optical microscope at magnifications X31.25, X125 and X500 (i.e., zeiss kpl-w eyepiece at X12.5 and zeiss lenses X2.5, X10 and X40). A millimetre unit scale was incorporated in the kpl-w eyepiece for size estimates. A graduated stage was used to enable continuous traverses of the slide.

Total sediment estimates were completed at X31.25 and X125, and included using cross polarisers for quartz abundance. Clay abundances were difficult to observe and often depended on the thickness of the initial smear. Thus, an over- or underestimate of the clay could offset the percentage abundance of the remaining sediment constituents. Also, diatom abundances included an estimate of observed biovolume, i.e., the pore space within the opaline silica frustule, which varies markedly in diatom species. This may also have influenced adversely the overall percentage estimates in the sediments.

Diatom identification was carried out mostly at X500 magnification. This allowed identification to genus only; correct species identification further requires SEM techniques. However, species estimates have been included in the report if some detail of the diatom frustule could be observed using the optical microscope. Also, a species example may be listed to assist in identification if the exact species is unknown.

Determination of diatom relative abundance for each smear slide was carried out by either first completing a central and then edge traverse, or by obtaining a count in excess of 300 frustules before the traverses were completed. Although in each smear slide over 300 frustules were counted, no statistical analysis can be carried out due to variations in the thickness of sediment between slides and the settling differences within slides. Diatom relative abundance cannot be compared between smear slides. The counts per slide can only give an estimate of the diatom numbers within a particular sediment sample. Therefore, diatom estimates have been categorised semiquantitatively into dominant, very common, common, minor and rare.

DESCRIPTION OF WALTOWA SWAMP SAMPLES

Nine samples from Waltowa Swamp have been analysed for sediment composition, and diatom identification and abundance. These samples are:

WS10: 1.65m	WS11: 1.0m	WS11: 2.0m
WS12: 0.7m	WS14: 1.0m	WS18: 1.0m
WS20: 0.6m	WS30: 1.4m	WS30: 2.0m

The diatoms were identified to genus, and if possible, species using Foged (1978) and John (1983) The classification system first forwarded by Hendey (1964) for ordering of diatom genera (e.g., Table 1) has also been used. For more accurate species identification, SEM micrographs taken of diatoms in Lake Alexandrina (species identification by Gell; pers. comm.) were compared to diatoms occurring in Waltowa Swamp.

Plates 1 and 2 have been included to illustrate some of the more commonly occurring diatoms in the Waltowa Swamp assemblages. Plate 1 consists of six micrographs taken with an optical microscope; the diatoms include *Campylodiscus clypeus, Nitzschia compressa, Thalassiosira weissflogii, Melosira granulata, Nitzschia,* e.g., *acuminata, Surirella,* e.g., *fluviicygnorum, Navicula yarrensis* and *Rhopalodia gibberula*. Grains of quartz, minute isotropic fragments and framboidal pyrite are also apparent in the micrographs. Plate 2 consists of six SEM micrographs illustrating the detail within each diatom frustule; the diatoms include *Campylodiscus echineis, Hyalodiscus lentiginosus Surirella,* e.g., *ovalis* or *fluviicygnorum, Epithemia adnata* var. *minor, Cocconeis placentula* and *Synedra ulna*. A correction is necessary to Plate 2e. and f. such that the plate captions should be reversed.

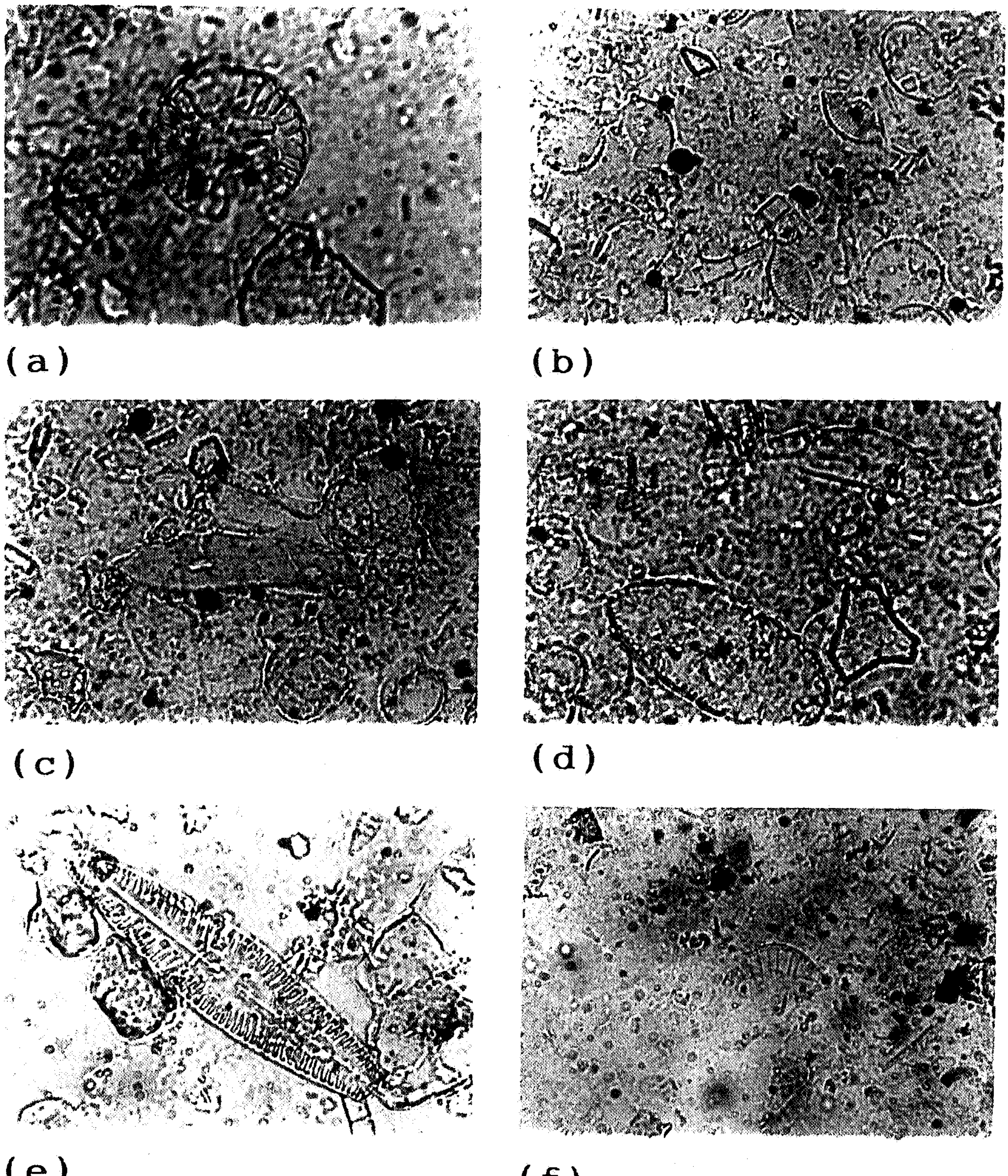

Plate 1. Micrographs of diatoms (x40): a. *Campylodiscus clypeus* Ehr. var. *biocostata* (W. Smith) Hust., b. *Nitzschia puntata* (W. Smith) Grun., *Thalassiosira weissflogii* (Grun.) and *Melosira granulata* (Ehr.) Ralfs., c. *Nitzschia* sp. e.g., *acuminata* (W. Smith) Grun. and *Thalassiosira weissflogii* (Grun.), d. *Surirella* sp. e.g., *fluviicygnorum* n., e. *Navicula yarrensis* Grun., f. *Rhopolodia* sp. e.g., *gibberula* (Ehr.) O. Mull.

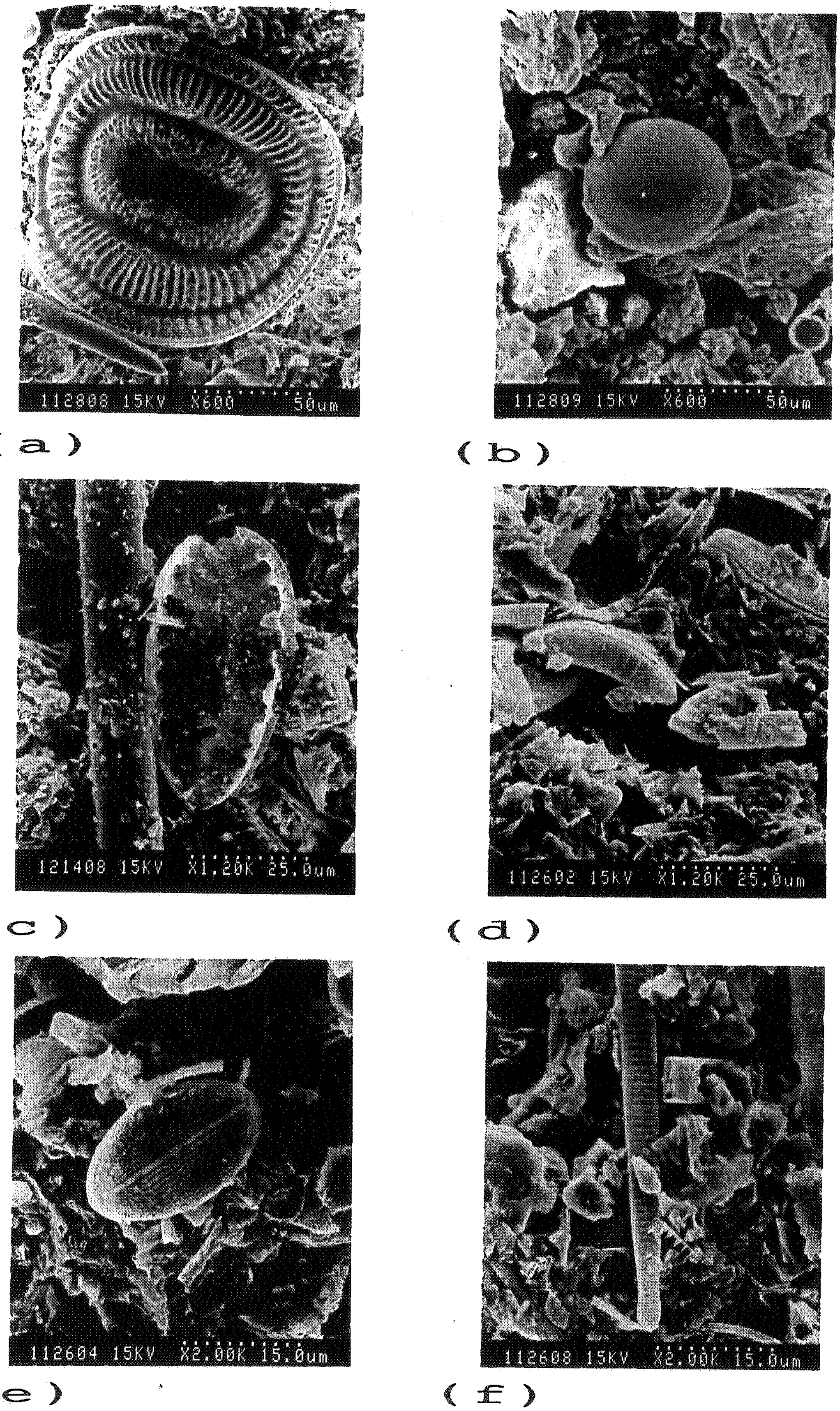

Plate 2. SEM micrographs (scale as indicated): a. *Campylodiscus daemelianus* Grun., b. *Hyalodiscus lentiginosus* John, c. *Surirella* sp. e.g., *fluviicygnorum* n. and sponge spicule, d. *Epithemia* sp. e.g., *adnata* (Kutz.) Breb. var. *minor* (Perag & Hereb.) Patr., e. *Synedra ulna* (Nitz.) Ehr., f. *Cocconeis placentula* Ehr. var. *euglypta* (Ehr.) Cl.

Furthermore, after SEM identification a number of corrections should be made in regard to species names. The most pressing correction is *Campylodiscus daemelianus* Grun. referred to in the first report and in the plate 2a. caption. It is corrected to *Campylodiscus echineis* (Ehr.) throughout this report. Also *Nitzschia punctata* (W. Smith) referred to in the first report and in the plate 1b. is now named *Nitzschia compressa* (Bailey) Boyer. In addition, some *Hyalodiscus* and small centrales may be *Podosira* sp., and some *Amphora* sp. may, in fact, be *Rhopalodia* sp..

Table 1, included at the end of this section, provides a summary of the diatom genera and semiquantitative abundance estimates occurring in each of the samples described below.

WS10: 1.65m

Smear slide description:

Over 70 % of the sediment consists of clay and organic compounds. Framboidal pyrite within the clay smear accounts for less than 5%. Fine to medium-grained quartz, and minor mica or feldspar make up 5 to 10% of the sediment. Plant matter such as cellulose fragments or pods is uncommon. sponge spicules are of minor abundance amounting to less than 2%. Diatoms account for less than 20% of the total sediment.

DIATOMS

Two transects were completed to obtain a count of over 300 frustules. The diatom fraction of the sediment consists predominantly of many fragments of *Campylodiscus echineis* (Ehr.). Whole valves of *C. echineis* (Ehr.), *C. clypeus* (Ehr.) var. *bicostata* (W. Smith) Hust. and possibly *C. samonensis* Grun. are relatively common. These range in size from 40*u* up to 200*u* with *C. echineis* having the largest valves. Abundant *Cocconeis*, e.g., *placentula* (Ehr.) frustules are present. However, *Cocconeis* sp. is a small diatom usually less than 25*u*. *Nitzschia compressa* (Bailey) Boyer, another small diatom usually less than 25*u* is common. Less common are *Amphora* sp. (possibly *Rhopalodia* sp.), *Rhopalodia gibberula* (Ehr.) O. Mull., *Epithemia adnata* (Kutz) Breb. var. *minor* and *Thalassiosira weissflogii* (Grun.). These diatoms are less than 30*u* excepting *E. adnata* (Kutz) Breb. var. *minor* which may range up to 50*u* in size. Of minor occurrence are *Mastogloia*, e.g., *pseudoexigua* Cholnoky up to 75*u*, *Amphora*, e.g., *ventricosa* (Greg.) up to 50*u*, and fragments of *Navicula yarrensis* Grun. up to 100*u*. Of lesser abundance are a number of *Nitzschia* sp., e.g., *N. apiculata* (less than 30*u*), *N. tryblionella* var. *victoriae* Grun. (approximately 60*u*) and *N. lorenziana* Grun. var.
subtilia (up to 100*u*). *Hyalodiscus lentiginosus* John up to 120*u*, and the smaller *H. scoticus* (Kutz) Grun. up to 60*u* are minor to rare. *Surirella*, e.g., *ovalis* Breb. or *fluviicygnorum* John ranging from 50 to 100*u* are also minor to rare. Of rare occurrence are *Melosira* sp. (less than 10*u*), *Cyclotella*, e.g., *meneghiniana* Kutz (up to 25*u*), *Opephora martyi* Heribaud (approximately 25*u*), *Synedra* sp. (less than 15*u*), *Diploneis*

subovalis Cl. (approximately 45*u*), and *Cymbella* sp. up to 75*u*. Cysts between 50 and 75*u* (or possible fragmented *H. lentiginosus* John) are minor to rare. A number of diatoms less than 10*u* are further present which would require SEM identification.

Diatom Relative Abundance (counts per slide)
1. *Cocconeis placentula* (87)
2. *Nitzschia compressa* (57)
3. *Campylodiscus echineis* (42), *C. clypeus* (12) and *C. samonensis* (3) (including numerous fragments of *C. echineis*) [subtotal 57]
4. *Amphora* sp. (17) and *A. ventricosa* (8) (*Amphora* is possibly *Rhopalodia* sp.) [subtotal 25]
5. *Rhopalodia gibberula* (17)
6. *Nitzschia* sp. (6), *N. apiculata* (4), *N. tryblionella* var. *victoriae* (3) and *N. lorenziana* var. *subtilia* (1) [subtotal 14]
7. *Epithemia adnata* (13)
8. *Thalassiosira weissflogii* (12)
9. *Mastogloia pseudoexigua* (9)
10. *Navicula yarrensis* fragments (8)
11. *Hyalodiscus Scoticus* (3) and *H. lentiginosus* (3) [subtotal 6]
12. *Melosira* (4) and *Surirella*, e.g., *ovalis* or *fluviicygnorum* (4)
13. *Cyclotella meneghiniana* (2) and *Synedra* sp. (2)
14. *Opephora martyi* (1), *Diploneis subovalis* (1) and *Cymbella* sp. (1).

Total counts 320

WS11: 1.0m

Smear slide description:

Clays and organic compounds constitute 50 to 60% of the sediment. Approximately 5% is framboidal pyrite or opaque fragments. Less than 3% cellulose plant matter including brown fibres and pods is apparent. Some black plant remains are associated with the pyrite. Fine to medium-grained subrounded quartz and subangular mica make up less than 5% of the sediment. Sponge spicules are minor. Diatoms account for between 30 and 35% of the total sediment.

DIATOMS

Only one transect was required to obtain a count of over 300 frustules. Whole valves of *Campylodiscus echineis* (Ehr.), *C. clypeus* (Ehr.) var. *bicostata* (W. Smith) Hust. and *Surirella*, e.g., *ovalis* Breb. or *fluviicygnorum* John predominate the assemblage. *C. echineis* (Ehr.) valves are the largest, generally up to 200*u* in size. *C. clypeus* (Ehr.) var. *bicostata* (W. Smith) Hust. and *Surirella*, e.g., *ovalis* Breb. or *fluviicygnorum* John valves range between 35 and 60*u*. *Hyalodiscus lentiginosus* John and *Navicula yarrensis* Grun. are other large quite common diatoms up to 150*u* and 100*u*, respectively. Prolific in the diatom assemblage is *Cocconeis*, e.g., *placentula* (Ehr.), however, it is generally less than 20*u*. *Nitzschia*, e.g., *apiculata* (Greg.) Grun. or *acuminata* (W. Smith) Grun. and

Thalassiosira weissflogii (Grun.) are common. *Nitzschia* sp. ranges from 30 to 40*u* and *T. weissflogii* (Grun.) is approximately 20*u* in size. Also quite common are *Rhopalodia gibberula* (Ehr.) O. Mull. up to 35*u* and *Cyclotella*, e.g., *meneghiniana* Kutz or *striata* (Kutz) Grun. approximately 25*u* in size. Of lesser abundance are *Melosira*, e.g., *granulata* (Ehr.) Ralfs and possibly, *Achnanthes*, e.g., *hungarica* (Grun.) Grun. Both of these diatoms are less than 15*u*. *Melosira striata* (Kutz) Grun. is present although rare. *Navicula elegans* W. Smith is minor. *Mastogloia*, e.g., *elliptica* var. *dansei*, a relatively large diatom up to 100*u* and *Mastogloia*, e.g., *erythraea* Lewis less than 50*u* are also minor. Minor to rare is *Amphora*, e.g., *holsatica* Hust. of up to 15*u*. *Opephora martyi* Heribaud less than 15*u*, a fragment of *Synedra ulna* (Nitz.) Ehr. and *Gyrosigma spencerii* (W. Smith) Cl., a large diatom approximately 135*u*, are all rare. A number of diatoms less than 10*u* are also present which require SEM identification.

Diatom Relative Abundance (counts per slide)
1. *Campylodiscus clypeus* var. *bicostata* (40), *C. echineis* (36) and numerous fragments [subtotal 76]
2. *Cocconeis placentula* (60)
3. *Surirella*, e.g., *ovalis* or *fluviicygnorum* (39)
4. *Nitzschia apiculata* or *N. acuminata* (32)
5. *Thalassiosira weissflogii* (29)
6. *Navicula yarrensis* (19) and *N. elegans* (4)
7. *Hyalodiscus lentiginosus* (17)
8. *Rhopalodia gibberula* (14)
9. *Melosira granulata* (10) and *M. striata* (2) [subtotal 12]
10. *Mastogloia elliptica* var. *dansei* (5), *M. erythraea* (4) and *Mastogloia* sp. (3) [subtotal 12]
11. *Cyclotella meneghiniana* or *C. striata* (11)
12. *Achnanthes hungarica* (6)
13. *Amphora holsatica* (3)
14. *Opephora martyi* (1), *Synedra ulna* (1) and *Gyrosigma spencerii* (1)

Total counts 337

WS11: 2.0m

Smear slide description:

Less than 50% of the sediment consists of clays and organic compounds. Framboidal pyrite represents less than 5%. Cellulose plant matter including semitransparent fragments, pods or pollen grains and opaque fragments represents up to 20% of the sediment. Approximately 5% is fine to medium-grained subrounded quartz. Sponge spicules are rare. Diatoms account for approximately 30 to 35% of the total sediment.

DIATOMS

Two transects were completed to obtain a count of over 300 frustules. Whole *Campylodiscus echineis* (Ehr.) up to 200*u* are dominant with fragments also numerous. *Cocconeis*, e.g., *placentula* (Ehr.) and *Nitzschia hummii* Hust. or, e.g., *vidovichii* Grun. are very common to dominant. However, *C. placentula* (Ehr.) frustules are generally less than 25*u* and *N. hummii* Hust. or, e.g., *vidovichii* Grun. is mostly fragmented and less than 125*u*. (A whole frustule of *N. hummii* Hust. or, e.g., *vidovichii* Grun. within the slide measured approximately 500*u*). A number of centrales are present although less than 15*u*, and with no characteristic features to identify genus. *Hyalodiscus lentiginosus* John and *Navicula yarrensis* Grun., relatively large diatoms up to 100*u*, are minor. Also of minor abundance are *Mastogloia*, e.g., *elliptica* (Ag.) Cl. (less than 50*u*) and *Rhopalodia gibberula* (Ehr.) O. Mull. (less than 35*u*). Of lesser abundance are *Melosira striata* (Kutz) Grun. and *Nitzschia punctata* (W. Smith) both less than 25*u*. Minor to rare is *Cocconeis pseudomarginata* Greg.. Cysts greater than 50*u* are also present. Of rare occurrence are *Grammatophora oceanica* Ehr. (approximately 60*u*), *Navicula elegans* W. Smith (also 60*u*), *Diploneis subovalis* Cl. (up to 40*u*), *Nitzschia triblionella* var. *victoriae* and *N.*, e.g., *longissima* (Breb.) Ralfs (up to 130*u* and 200*u*, respectively). *Surirella*, e.g., *ovalis* Breb. or *fluviicygnorum* John of up to 60*u* is also rare. Some small diatoms less than 10*u* are present.

Diatom Relative Abundance (counts per slide)
1. *Campylodiscus echineis* (92)
2. *Cocconeis placentula* (76) and *C. psuedomarginata* (3) [subtotal 79]
3. *Nitzschia hummii* (67), *N. punctata* (5) and *N. longissima* (2) and *N. triblionella* var. *victoriae* (1) [subtotal 75]
4. Small centrales, e.g., *Melosira* sp. (28) and *M. striata* (5) [subtotal 33]
5. *Navicula yarrensis* (12) and *N. elegans* (1) [13]
6. *Rhopalodia gibberula* (11)
7. *Hyalodiscus lentiginosus* (10)
8. *Mastogloia elliptica* (8)
9. Possible cysts (3)
10. *Grammatophora oceanica* (1), *Diploneis subovalis* (1)

Total counts 326

WS12: 0.7m

Smear slide description:

Clays, organic compounds and framboidal pyrite comprise 40 to 50% of the sediment. Cellulose plant matter including semitransparent fragments and opaques associated with framboidal pyrite is less than 2%. Up to 30% is subrounded silt to sand-sized quartz and mica. Sponge spicules are present although less than 5%. Diatoms account for between 30 and 35% of the total sediment.

DIATOMS

Two transects were completed to give an excess of 300 frustules. Whole *Campylodiscus echineis* (Ehr.) up to 200*u* as well as fragments dominate the assemblage. *C. clypeus* (Ehr.) var. *bicostata* (W. Smith) Hust. less than 50*u* is also present although in lesser abundance. Of common occurrence in the assemblage is *Hyalodiscus lentiginosus* John, up to 100*u* in diameter. Different species of *Surirella*, e.g., *ovalis* Breb., *fluviicygnorum* John or *fastuosa* (Ehr.) Kutz, ranging in size from 60 to 100*u*, are quite common. Small centrales less than 20*u* are common. These could possibly be *Thalassiosira* sp. or *Melosira* sp.. *Thalassiosira weissflogii* (Grun.) of approximately 20*u* is common throughout the slide. Also common is *Cocconeis*, e.g., *placentula* (Ehr.), usually less than 25*u*. Particular to this assemblage and common throughout is a diatom up to 50*u* in length resembling *Fragilaria hyalina* (Kutz) Grun., *Synedra* sp. or *Nitzschia* sp.. *Melosira sulcata* (Ehr.) Kutz and *M. granulata* (Ehr.) Ralfs are minor to common and are generally less than 15*u*. *Nitzschia compressa* (Bailey) Boyer up to 25*u* is minor. Also minor are *Epithemia adnata* (Kutz) Breb. var. *minor* (up to 50*u*), *Amphora*, e.g., *holsatica* Hust. (less than 25*u*), *Nitzschia*, e.g., *obtusa* W. Smith var. *scalpellifornus* Grun. (less than 75*u*) and possible cysts up to 50*u*. Minor to rare are *Amphora*, e.g., *ventricosa* Greg., *Nitzschia hummii* Hust., *Navicula yarrensis* Grun. and *Navicula* sp.. Numerous small diatoms less than 10*u* and fragments occur throughout the slide. SEM identification would be required for these.

Diatom Relative Abundance (counts per slide)

1. *Campylodiscus echineis* (117) and *C. clypeus* (Ehr.) var. *bicostata* (27) [subtotal 144]
2. Small centrales, e.g., *Melosira* sp., (46), *M. sulcata* (12) and *M. granulata* (8) [subtotal 66]
3. *Hyalodiscus lentiginosus* (38)
4. *Thalassiosira weissflogii* (34)
5. *Surirella*, e.g., *ovalis*, *fluviicygnorum* or *fastuosa* (31)
6. *Cocconeis placentula* (25)
7. *Fragilaria hyalina* (*Synedra* sp. or *Nitzschia* sp.) (17)
8. *Nitzschia compressa* (8), *N. obtusa* var. *scalpellifornus* (4) and *N. hummii* (2) [subtotal 14]
9. *Amphora holsatica* (5) and *A.*, e.g., *ventricosa* (2) (possible *Rhopalodia* sp.) [subtotal 7]
10. *Epithemia adnata* var. *minor* (6) and cysts (6)
11. *Navicula yarrensis* (1) and *Navicula* sp. (1) [subtotal 2]

Total counts 382

WS14: 1.0m

Smear slide description:
Clays, organic compounds and framboidal pyrite comprise between 30 and 40% of the sediment. Plant matter including opaques associated with framboidal pyrite and fibrous fragments is less than 10%. Between 10 and 15% is fine-grained quartz and minor mica grains. Sponge spicules comprise less than 5%. Diatoms account for between 40 and 50% of the total sediment.

DIATOMS

Only one transect was required to obtain over 300 frustules. *Campylodiscus echineis* (Ehr.) generally less than 200*u* dominates the assemblage together with the smaller *Cocconeis*, e.g., *placentula* (Ehr.) (less than 25*u*). Of much lesser abundance are small centrales, possibly including *Podosira* sp.. *Hyalodiscus lentiginosus* John up to 150*u* is minor. Also of minor abundance are *Amphora*, e.g., *holsatica* Hust., *Thalassiosira weissflogii* (Grun.). *Achnanthes*, e.g., *hauckiana* Grun. var. *rostrata* Schulz, *Melosira*, e.g., *sulcata* (Ehr.) Kutz and *Rhopalodia gibberula*

(Ehr.) O. Mull. These diatoms are all around 25*u* in size. Cysts may occur in minor abundance. Of even lesser abundance are *Campylodiscus clypeus* (Ehr.) var. *bicostata* (W. Smith) Hust. (up to 50*u*), *Nitzschia compressa* (Bailey) Boyer (less than 25*u*), and *Surirella*, e.g., *ovalis* Breb. or *fluviicygnorum* John (approximately 75*u*). *Melosira*, e.g., *granulata* (Ehr.) Ralfs (less than 15*u*), *Neidium affine* (Ehr.) Pfitz. var. *amphirhynchus* (Ehr.) (up to 50*u*), and *Nitzschia hummii* Hust. and *N.*, e.g., *apiculata* (Greg.) Grun. are rare. Some smaller diatoms less than 10*u* are present.

Diatom Relative Abundance (counts per slide)
1. *Cocconeis placentula* (142)
2. *Campylodiscus echineis* (125) and *C. clypeus* var. *bicostata* (4) [subtotal 129]
3. Small centrales, e.g., *Podosira* (30)
4. *Hyalodiscus lentiginosus* (11)
5. *Amphora holsatica* (8)
6. *Achnanthes hauckiana* var. *rostrata* (7) and *Thalassiosira weissflogii* (7)
7. *Melosira sulcata* (6) and *M. granulata* (1) [subtotal 7]
8. *Rhopalodia gibberula* (6), and possible cysts (6)
9. *Nitzschia compressa* (4), *N. hummii* (2) and *N. apiculata* (1) [subtotal 7]
10. *Surirella*, e.g., *ovalis* or *fluviicygnorum* (4)
11. *Neidium affine* var. *amphirhynchus* (1)

Total count 365

WS18: 1.0m

smear slide description:
Approximately 30% of the sediment is clay, organic compounds and framboidal pyrite. Plant matter including opaques associated with framboidal pyrite, pods and semitransparent brown fragments comprises less than 10%. Between 30 and 40% of the sediment consists of poorly sorted, subrounded silt to sand-sized quartz with some mica grains. Sponge spicules although present are uncommon. Diatoms account for 30 to 35% of the total sediment.

DIATOMS

Two transects were completed to give a count of 300 frustules. The assemblage is dominated by small centrales less than 15*u*. These possibly include *Melosira*, e.g., *sulcata* (Ehr.) Kutz, *M. sulcata* form *radiata* Grun. and *Podosira* sp. although SEM identification is necessary. *Campylodiscus echineis* (Ehr.) up to 150*u* is very common. *Cocconeis*, e.g., *placentula* (Ehr.), generally less than 25*u* is common. Of lesser abundance are *Thalassiosira weissflogii* (Grun.), *Rhopalodia gibberula* (Ehr.) O. Mull. (both approximately 30*u*), and possible cysts between 50 and 75*u*. *Hyalodiscus lentiginosus* John up to 120*u* is minor. Also of minor occurrence are *Nitzschia apiculata* (Greg.) Grun. (less than 35*u*) and *N. compressa* (Bailey) Boyer (up to 15*u*). *Opephora martyi* Heribaud up to 15*u* and *Mastogloia*, e.g., *pumila* (Grun.) Cl. approximately 35 to 50*u* are minor to rare. Of rare occurrence are *Fragilaria*, e.g., *hyalina* (Kutz) Grun., *F.*, e.g., *vaucheriae* (Kutz) Peters, *Achnanthes*, e.g., *delicatula* (Kutz)

Grun. (all less than 25*u*), *Navicula yarrensis* Grun. fragments, *Navicula* sp. (50u), *Gyrosigma* or *Pleurosigma* sp. (up to 250*u*) and *Surirella*, e.g., *ovalis* Breb. or *fluviicygnorum* John (between 60 and 75*u*).

Diatom Relative Abundance (counts per slide)
1. Small centrales, e.g., *Melosira* sp. or *Podosira* sp. (146)
2. *Campylodiscus echineis* (51)
3. *Cocconeis placentula* (36)
4. *Rhopalodia gibberula* (13)
5. *Thalassiosira weissflogii* (11)
6. Possible cysts (10)
7. *Nitzschia apiculata* (5) and *N. compressa* (5) [subtotal 10]
8. *Hyalodiscus lentiginosus* (8)
9. *Opephora martyi* (3) and *Mastogloia pumila* (3)
10. *Fragilaria hyalina* (2) and *F. vaucheriae* (1) [subtotal 3]
11. *Gyrosigma* sp. (2), *Surirella*, e.g., *ovalis* or *fluviicygnorum* (2), *Achnanthes delicatula* (1), *Navicula yarrensis* fragments and *Navicula* sp. (1)

Total count 300

WS20: 0.6m
Smear slide description
Clays, organic compounds and framboidal pyrite amount to between 40 and 45% of the sediment. Included in this percentage estimate is a precipitate, possibly a mineral salt; X-ray diffraction would be useful in this sample to identify the mineralogy. Cellulose plant matter comprises less than 2% of the sediment. Approximately 10 to 15% is subangular to subrounded, silt to sand-sized quartz. Sponge spicules make up less than 2%. Diatoms account for between 40 and 45% of the total sediment.

DIATOMS
Two transects were completed to obtain an excess of 300 frustules. Whole *Campylodiscus echineis* (Ehr.) up to 150*u* and fragments dominate the assemblage. *Cocconeis*, e.g., *placentula* (Ehr.) less than 25*u* is very common. A number of small centrales less than 15*u* are present. These could possibly be *Melosira*, e.g., *sulcata* (Ehr.) Kutz and *M. sulcata* form *radiata* Grun.. Of lesser abundance but still common are *Rhopalodia gibberula* (Ehr.) O. Mull. up to 40*u*, and possible cysts greater than 50*u*. Whole *Hyalodiscus lentiginosus* John approximately 60*u* as well as fragments are quite common. Of minor occurrence are *Thalassiosira weissflogii* (Grun.) less than 30*u* and *Campylodiscus clypeus* (Ehr.) var. *bicostata* (W. Smith) Hust up to 50*u*. Also minor are *Amphora*, e.g., *holsatica* Hust. less than 25*u*, *Nitzschia triblionella* var. *victoriae* Grun. up to 100*u*, *Navicula yarrensis* Grun. and *Surirella*, e.g., *ovalis* Breb. or *fluviicygnorum* John, each up to 75*u*, and fragments of *Navicula* sp.. Minor to rare are *Gyrosigma*, e.g., *balticum* (Ehr.) Rabd. fragments (around 125*u*) and *Nitzschia compressa* (Bailey) Boyer up to 30*u*. *Achnanthes*, e.g., *hauckiana* Grun. var. *rostrata* Schulz (up to 50*u*), *Mastogloia*, e.g., *elliptica* var. *dansei* (up to 100*u*), *Navicula*, e.g., *elegans* W. Smith (less than 100*u*) and *N.* e.g., *hamulifera* Grun. are all rare. Numerous opaline silica fragments occur thoughout the slide.

Diatom Relative Abundance (counts per slide)
1. *Campylodiscus echineis* (149) including fragments and *C. clypeus* var. *bicostata* (8) [subtotal 157]
2. *Cocconeis placentula* (69)
3. Small centrales, e.g., *Melosira* sp. (47)
4. *Rhopalodia gibberula* (26)
5. Possible cysts (17)
6. *Hyalodiscus lentiginosus* including fragments (15)
7. *Thalassiosira weissflogii* (10)
8. *Navicula yarrensis* (4), *Navicula* sp. (4), *N. elegans* (1) and *N. hamulifera* (1) [subtotal 10]
9. *Amphora holsatica* (8)
10. *Nitzschia triblionella* var. *victoriae* (5) and *N. compressa* (3) [subtotal 8]
11. *Surirella, e.g., ovalis* or *fluviicygnorum* (4)
12. *Gyrosigma balticum* (3)
13. *Achnanthes hauckiana* var. *rostrata* (2)
14. *Mastogloia elliptica* var *dansei* (1)

Total count 377

WS30: 1.4m

Smear slide description

Between 30 and 40% of the sediment is clay, organic compounds and framboidal pryrite. Minor alteration or precipitation may be present. Cellulose plant material including opaques associated with framboidal pyrite and fibrous matter is less than 10%. Silt and minor sand-sized quartz comprises 10 to 15% of the sediment. Sponge spicules are present although less than 5%. Diatoms account for between 35 and 40% of the total sediment.

DIATOMS

Onlyone transect was required to give an excess of 300 frustules. *Cocconeis*, e.g., *placentula* (Ehr.) less than 30*u*, and whole and fragmented *Campylodiscus echineis* (Ehr.) up to 200*u* dominate the assemblage. Whole and fragmented *Hyalodiscus lentiginosus* John up to 125*u* are common. Of lesser abundance although common are small centrales, e.g., *Melosira* sp. less than 15*u*, possible cysts between 50 and 100*u* and *Rhopalodia gibberula* (Ehr.) O. Mull. up to 30*u*. Minor to common are *Surirella*, e.g., *ovalis* Breb. or *fluviicygnorum* John greater than 100*u* and *Cyclotella*, e.g., *striata* (Kutz) Grun. up to 25*u*. *Campylodiscus clypeus* (Ehr.) var. *bicostata* (W. Smith) Hust. approximately 50*u* and *Nitzschia* e.g., *hungarica* Grun. less than 50*u* are minor. Also minor is *Thalassiosira weissflogii* (Grun.) up to 35*u*. Minor to rare are *Navicula*, e.g., *hamulifera* Grun. greater than 50*u* and *Nitzschia compressa* (Bailey) Boyer of approximately 30*u*. *Achnanthes*, e.g., *delicatula* (Kutz) Grun. less than 15*u* and *Navicula*, e.g., *gastrum* (Ehr.) var. *bicostata* (W. Smith) less than 50*u* are rare. A number of diatoms less than 15*u* are present as also numerous fragments of *Campylodiscus* sp. and *Hyalodiscus* sp..

Diatom Relative Abundance (counts per slide)

1. *Cocconeis placentula* (137)
2. *Campylodiscus echineis* (118) with numerous fragments, *C. clypeus* var. *bicostata* (9) [subtotal 127]
3. *Hyalodiscus lentiginosus* (39) with numerous fragments
4. Possible cysts (18)
5. Small centrales, e.g., *Melosira* sp. (17)
6. *Rhopalodia gibberula* (16)
7. *Surirella*, e.g., *ovalis* or *fluviicygnorum* (13)
8. *Cyclotella striata* (11)
9. *Nitzschia hungarica* (8) and *N. compressa* (3) [subtotal 11]
10. *Thalassiosira weissflogii* (5)
11. *Navicula hamulifera* (3) and *N. gastrum* var. *bicostata* (1) [subtotal 4]
12. *Achnanthes delicatula* (1)

Total count 399

WS30: 2.0m

Smear slide description:

As much as 60% of the sediment consists of clay, organic compounds and framboidal pyrite with possible alteration or precipitates. Plant matter including opaques associated with framboidal pyrite, cellular fragments, fibres and fibrous fragments comprises approximately 15%. Silt to mostly sand-sized quartz comprises less than 5%. Sponge spicules are present although uncommon. Diatoms, some of which appear to have undergone alteration, account for between 20 and 25% of the total sediment.

DIATOMS

Two transects were completed to obtain over 300 frustules. Whole *Campylodiscus echineis* (Ehr.) up to 150*u* and fragments are very common. *Cocconeis*, e.g., *placentula* (Ehr.) of approximately 25*u* is common. Small centrales, e.g., *Melosira sulcata* (Ehr.) Kutz and *M. granulata* (Ehr.) Ralfs less than 15*u* are also common. Of lesser abundance although still common are *Nitzschia compressa* (Bailey) Boyer and *Rhopalodia gibberula* (Ehr.) O. Mull.. Both of these diatoms are less than 25*u*. Quite common are fragmented *Navicula yarrensis* Grun. up to 75*u*, *Nitzschia*, e.g., *hungarica* Grun. less than 50*u* and *Thalassiosira weissflogii* (Grun.) less than 25*u*. Of minor occurrence are *Camplyodiscus clypeus* (Ehr.) var. *bicostata* (W. Smith) Hust. greater than 50*u*, possible cysts of approximately 50*u*, whole and fragmented *Hyalodiscus lentiginosus* John up to 125*u*, *Opephora martyi* Heribaud less than 15*u*, *Mastogloia*, e.g., *pumila* (Grun.) and *Surirella*, e.g., *ovalis* Breb. or *fluviicygnorum* John up to 50*u*. Minor to rare are *Amphora*, e.g., *holsatica* Hust. (less than 25*u*), *A.*, e.g., *ventricosa* Greg. (approximately 75*u*) (these could possibly be *Rhopalodia* sp.), *Nitzschia*, e.g., *sigma* (Kutz) W. Smith (greater than 60*u*) and *N. triblionella* var. *victoriae* Grun. (less than 150*u*). *Cyclotella*, e.g., *meneghiniana* Kutz or *striata* (Kutz) Grun., *Synedra ulna* (Nitz.) Ehr. fragments, *Synedra* sp. and *Achnanthes*, e.g., *hauckiana* Grun. var. *rostrata* Schulz, all less than 25*u*, are rare. Numerous diatom fragments and small diatoms less than 10*u* which require SEM identification are also present.

Diatom relative abundance (counts per slide)

1. *Campylodiscus echineis* (68) and *C. clypeus* (9) [subtotal77]
2. *Cocconeis placentula* (63)
3. *Nitzschia compressa* (27), *N. hungarica* (12), *N. sigma* (3) and *N. triblionella* var. *victoriae* (3) [subtotal 45]
4. Small centrales, e.g., *Melosira* sp. (39)
5. *Rhopalodia gibberula* (20)
6. *Navicula yarrensis* (15)
7. *Thalassiosira weissflogii* (10)
8. Possible cysts (7)
9. *Amphora holsatica* (4) and *A. ventricosa* (3) [subtotal 7]
10. *Hyalodiscus lentiginosus* (6), *Opephora martyi* (6), *Mastogloia pumila* (6) and *Surirella*, e.g., *ovalis* or *fluviicygnorum* (6)
11. *Synedra ulna* (1) and *Synedra* sp. (1) [subtotal 2]
12. *Cyclotella striata* (1) and *Achnanthes hauckiana* var. *rostrata* (1)

Total count 311

TABLE 1

DIATOM RELATIVE ABUNDANCE IN WALTOWA SWAMP SAMPLES

GENUS	WS10	WS11/1	WS11/2	WS12	WS14	WS18	WS20	WS30/1	WS30/2
Melosira	M	M-C	M	C	C	VC	C	M	M-C
Hyalodiscus	M	C	M-C	C	M-C	M	C	C	M
Thalassiosira	M-C	C		C	M	M-C	M-C	M	M-C
Cyclotella	R	M-C						M-C	R
Centrals	M	M-C	C	C	C	VC	C	M-C	C
Cysts	M	R-M	M	M	M	M-C	C	C	M
Fragilaria				M-C		R-M			
Grammatophora			R						
Opephora	R	R				R-M			M
Synedra	R	R							R
Achnanthes					M	R	R		R
Cocconeis	VC	VC	VC-D	C	VC-D	C	VC	VC-D	VC
Navicula	M	C	C	R	M	R	M	M	C
Diploneis	R		R						
Gyrosigma		R				R	R		
Mastoglaia	M	M-C	M			R-M	R		M
Neidium					R				
Cymbella	R								
Amphora	C	R-M		M	M		M		M
Epithemia	M-C			M					
Rhopaladia	M-C	M-C	C		M	M-C	C	C	C
Nitzschia	VC	C	VC-D	M-C	M	M-C	M	M-C	C
Camphylodiscus	C	VC	D	D	D	C-VC	D	D	VC
Surirella	M	C	R	C	M	R	M	M-C	M

Key: R = 1 or 2, M = <10, C = 10 to 50, VC = >50 and D = dominant genus

DISCUSSION

Diatom abundance in the nine Waltowa Swamp samples ranged from less than 20% to up to 50% of the total sediment. WS14 contained the highest percentage of diatoms, between 40 and 50% followed by WS20 with 40 to 45% and WS30 (1.4m) with 35 to 40%. Four of the samples: WS11 (1.0m), WS11 (2.0m), WS12 and WS18, all contained between 30 and 35% diatoms. WS30 (2.0m) and WS10 had the least number of diatoms with between 20 and 25% and less than 20%. respectively.

In all the samples, the diatom assemblage included *Melosira, Hyalodiscus,* small centrales, cysts, *Cocconeis, Navicula, Nitzschia, Campylodiscus* and *Surirella*. *Rhopalodia* occurred in every sample except WS12. One of the most common of these diatoms and the largest in the assemblage is *Campylodiscus echineis* (Ehr.). It ranges from fragmented pieces to frustules greater than 200*u*. Also common throughout is *Cocconeis,* e.g., *placentula* (Ehr.), however, this particular diatom is generally smaller than 30*u*. Both *Campylodiscus echineis* (Ehr.) and *Cocconeis,* e.g., *placentula* (Ehr.) occur in bloom proportions in WS14, WS20 and WS30 (1.4m), thus dominating the assemblages and accounting for the increase in diatom abundance in these samples. *Melosira* sp. is another small diatom generally less than 15*u* that can occur in bloom proportions. It most probably dominates the assemblage in WS18, however, due to its size does not contribute significantly to total abundance. *Hyalodiscus lentiginosus* John and *Surirella,* e.g., *ovalis* Breb. or *fluviicygnorum* John are two of the larger diatoms up to 120*u*. Both of these although minor in some samples, add significantly to diatom abundance where they occur in greater numbers, e.g., WS11 (1.0m), WS12 and WS30 (1.0m).

Each sample consisted of a different assemblage. WS10 contained the most varied assemblage although many genera or species were minor to rare. Of note in this assemblage are *Nitzschia compressa* (Bailey) Boyer, and *Amphora* sp. (possibly *Rhopalodia* sp.), occurring in greater numbers than elsewhere in Waltowa Swamp. In WS11 (1.0m), another varied assemblage, numerous *Campylodiscus clypeus* (Ehr.) var. *bicostata* (W. Smith) Hust. and *Surirella,* e.g., *ovalis* Breb. or *fluviicygnorum* John actually outnumber *C. echineis* (Ehr.). However, both of these are smaller than *C. echineis* (Ehr.), thus contributing less to total abundance. WS11 (2.0m) represents a markedly different diatom assemblage compared to the other samples. Very common in this assemblage is mostly fragmented *Nitzschia hummii* Hust. or, e.g., *vidovichii* Grun., a littoral benthic diatom species. *Grammatophora oceanica* Ehr., a brackish to marine water species is also present although rare. The diatom assemblage in WS12 also contrasts other samples. A number of diatoms up to 50*u* in length, possibly *Fragilaria,* are present in this assemblage alone. WS18 contained a greater number of small centrales than in any other assemblage. However, identification of these requires SEM. In the remaining samples, WS14, WS20, WS30 (1.0m) and WS30 (2.0m), the diatom assemblage appeared to be less varied mostly as a result of *Campylodiscus echineis* (Ehr.) and *Cocconeis, e.g., placentula* (Ehr.) blooms.

For diatom extraction in the Waltowa Swamp samples, diatom abundance and assemblages should be considered in regard to the remaining sedimentary components. For example, WS14, WS20 and WS30 (1.4m) all have greater than 35% diatoms, however, the amount of quartz, clay, organic compounds and plant matter in each may affect their actual recovery. Diatoms could be separated from sand-sized quartz by repeated seiving, and organic matter could be easily removed from the samples using 30% H_2O_2. However, the removal of clays is a more difficult process, possibly requiring heavy liquids separation. Therefore, samples with a high percentage of diatoms but low in clays would have a greater economic potential. These include WS18, WS14, WS30 (1.4m), WS20, WS11 (2.0m) and WS12.

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EL 1628 MALCOLM PLAINS

QUARTERLY REPORT No. 8 TO 21 DECEMBER 1991

TENURE

EL 1628 of 839 sq km granted to Olliver Geological Services Pty Ltd on 22 December 1989 for six months was renewed for six months to 21 December 1990 and was renewed over a reduced area of 433 sq km for a further twelve months to 21 December 1991. Renewal for another term was not sought. Four Mineral Claims were registered on 20 December 1991 over Ashville Gypsum Deposits.

FIELD INVESTIGATIONS

NINTH FIELD TRIP - undertaken by Sean Kennedy and Peter Hornsby from 25 to 27 November 1991 to peg Mineral Claims.

WALTOWA SWAMP

A geological report on the results of 49 push tube holes is nearing completion.

EXPENDITURE

Item	21 Months to 21.09.91	3 Months to 21.12.91	Total for 2 years
Tenement Fees	3 251.75	nil	3 251.75
Geological Services	42 977.50	2 105.00	45 082.50
Administration	22 750.00	1 500.00	24 250.00
Office Costs	4 345.38	213.45	4 558.84
Data Acquisition	350.35	nil	350.35
Field Operations	7 402.72	797.25	8 199.97
Laboratory Testing	6 386.65	nil	6 386.65
Aboriginal Liaison	200.00	-	200.00
TOTAL	87 664.35	4 615.70	92 280.06

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Exploration Consultant

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EL 1628 MALCOLM PLAINS

SUMMARY REPORT - EXPLORATION FOR DIATOMITE IN WALTOWA SWAMP

by

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January 1992

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INTRODUCTION

EL 1628 of 839 sq km was granted to Olliver Geological Services Pty Ltd on 22 December 1989 for six months and was renewed for six months to 22 December 1990. A further renewal was granted over a reduced area of 433 sq km (Figure 1) for twelve months to 21 December 1991.

Waltowa Swamp about 110 km southeast of Adelaide and 10 km north of Meningie is a swampy depression extending 8 km eastwards from Lake Albert (Figure 2).

Target is filter-grade diatomite in Holocene sediments deposited during the last marine transgression which peaked about 6 000 years ago.

Investigations for diatomite in Cooke Plains Embayment also in EL 1628 and 20 km north of Waltowa Swamp are summarised by Olliver and Kennedy (1991).

Postgraduate research by Altmann (1976) and Von der Borch and Altmann (1979) had reported a diatomite unit in Cooke Plains Embayment with a maximum thickness of 2.1m and diatom content of up to 70%. A similar study of Waltowa Swamp was not completed. However, Prof. Chris Von der Borch (School of Earth Sciences, Flinders University) advised that diatomite-rich material had also been intersected here.

Location, access, physiography, geological setting, drilling methods and results of the first nine holes are decribed in Quarterly Report no. 2 to 21 June 1990 (Olliver and Kennedy, 1990).

DRILLING PROGRAM

A total of 48 holes were drilled using push tube coring methods with minor hand augering during the following field trips. Hole locations are shown on Figure 2.

Date	No of Holes	Designation
24-28 April 1990	9	WS 1-9
13-15 February 1991	15	WS 10-24
5-7 March 1991	4	WS 30-33
18-22 September 1991	20	WS 38-57

Depth varied from 0.76 in WS9 to 2.71 m in WS40.

RESULTS OF DRILLING

The following Holocene sedimentary sequence as summarised in Table 1 from detailed logs in the Appendix from oldest to youngest rests on calcrete basement.

1. Basal clay - grey to green sandy in parts and generally calcareous at base.

2. Sand - white, grey to dark grey occasionally yellow or green medium to coarse grained well sorted. Clayey in parts.

3. Sapropel - black organic-rich clay with occasional thin sandy layers.

4. Diatomite -

5. Clay usually gypsiferous - light grey to yellow, brown and green clay with minor sandy layers.

6. Black mud.

7. Sand - dark brown to grey, medium to coarse grained.

8. Soil.

9. Salt.

TABLE 1

DRILLHOLE INTERSECTIONS - WALTOWA SWAMP

Hole WS	Salt	Soil	Sand	Black Mud	Gyp Clay	Diatomite From	Diatomite To	Diatomite Thickness	Diatomite Est%	Sapropel	Sand	Clay	Calcrete
1	-	0-.28	-	-	-	.28	.71	.43	Trace	-	.71-2.28	2.28-2.57	-
2	0-.05	-	-	.05-.40	-	.40	1.50	1.10	20-30	1.50-1.70	-	1.70-2.06	-
3	0-.05	-	.05-.35	-	-	-	-	-	-	-	-	-	-
	.35-.40	-	.40-.50	-	-	.50	1.42	.92	10	1.42-2.20	2.20-2.26	-	-
4	-	-	0-20	.20-.40	-	.40	1.28	.88	30-40	1.28-1.70	1.70-1.95	-	-
5	-	-	-	-	-	0	1.40	1.40	20-25	1.40-1.60	1.60-2.09	-	-
6	0-.05	-	-	.05-.25	-	.25	.60	.35	20	.60-1.35	1.35-1.65	1.65-2.15	-
7	-	0-.34	-	-	-	.34	1.20	.86	10-15	1.20-1.50	1.50-2.62	-	-
8	-	-	-	-	-	0	1.85	1.85	15-30	-	1.85-2.00	-	-
9	0-.05	-	-	.05-.10	-	.10	.30	.20	15	.30-.55	.55-.76	-	-
10	-	0-.20	-	-	.20-.90	.90	1.80	.90	10-25	-	1.80-2.27	-	-
11	-	0-.30	-	-	.30-.80	.80	2.10	1.30	30-35	-	2.10-2.67	2.67-2.68	-
12	-	0-.17	-	-	.17-.52	.52	1.35	.83	10-35	-	1.35-2.00	2.00-2.21	-
13	-	-	-	-	0-.30	.30	.64	.34	10	-	-	.64-.78	-
14	-	-	-	-	-	0	2.07	2.07	15-50	-	2.07-2.41	-	-
15	-	0-.35	-	-	-	.35	.70	.35	10	-	.70-.80	-	-
16	-	-	-	-	0-.66	.66	.70	.34	20	.70-.99	.99-2.31	-	-
17	-	0-.20	-	-	-	.20	.66	.46	10	-	.66-1.76	-	-
18	-	0-.40	-	-	-	.40	1.35	.95	30-35	-	1.35-1.76	1.76-2.03	-
19	-	0-.35	-	-	.35-.70	.70	1.55	.85	15	-	1.55-1.70	1.70-1.98	1.98-2.03
20	-	-	-	0-.10	-	.10	.45	.35	-	.45-.50	-	-	-
	-	-	-	-	-	.50	1.55	1.05	15-45	1.55-1.80	1.80-2.15	-	-
21	-	-	-	-	-	0	.30	.30	-	-	.30-1.09	1.09-1.14	-

TABLE 1

DRILLHOLE INTERSECTIONS - WALTOWA SWAMP

Hole WS	Salt	Soil	Sand	Black Mud	Gyp Clay	Diatomite From	To	Thickness	Est%	Sapropel	Sand	Clay	Calcrete
22	-	-	0-.25	-	.25-.80	.80	1.05	.25	Tr	1.05-1.15	1.15-2.39	-	-
23	0-.08	-	-	.08-.63	-	.63	1.25	.62	15	1.25-1.53	1.53-1.98	1.98-2.11	-
24	0-.08	-	-	.08-.35	-	.35	1.20	.85	5-15	1.20-2.13	2.13-2.23	-	-
30	-	0-.20	-	-	.20-.70	.70	2.10	1.40	20-40	-	2.10-2.22	-	-
31	-	0-.12	-	-	.12-.48	.48	1.24	.76	30	-	1.24-1.72	1.72-1.84	1.84-1.92
32	-	0-.30	-	-	.30-.57	.57	.75	.18	20	-	.75-2.60	-	-
33	-	-	-	-	0-.40	.40	1.20	.80	15	-	1.20-2.38	-	-
38	-	-	-	-	0-1.10	1.10	1.30	.20	10	- 1.35-1.40	1.30-1.35 1.40-1.63	 -	 -
39	-	0-.20	-	-	.20-.43	.43	1.00	.57	30	-	1.00-1.67	-	-
40	-	0-.25	-	-	.25-.55	.55	1.90	1.35	15-35	- 1.95-2.00	1.90-1.95 2.00-2.50	- 2.50-2.71	- -
41	-	-	-	-	0-.70	.70	.90	.20	15	-	.90-1.56	-	-
42	-	0-.08	-	-	.08-1.00	1.00	1.50	.50	40	-	1.50-1.71	-	-
43	-	0-.15	-	-	.15-.50	.50	1.50	1.00	20-30	1.50-1.70	1.70-1.72	-	-
44	-	0-.20	-	-	.20-1.13	1.13	1.20	.07	-	-	1.20-1.48	-	-
46	-	0-.10	-	-	.10-.27	.27	1.78	1.51	5-10	-	1.78-1.95	-	-
47	-	0-.15	-	-	.15-.95	.95	1.55	.60	25	-	1.55-1.93	-	-
48	-	0-.34?	-	-	.34-.95	.95	1.95	1.00	20	1.95-2.06	2.06-2.08	-	-
49	-	0-.10	-	-	.10-.70	.70	1.50	.80	10	-	1.50-2.00	-	-
50	-	0-.10	-	-	-	.10	.55	.45	15	-	.55-1.18	1.18-1.47	-
51	-	0-.15	-	-	.15-.28	.28	.48	.20	-	-	.48-1.13	1.13-1.82	-
52	-	-	1-.10	-	.10-.70	.70	1.25	.55	Trace	1.25-1.75	1.75-1.95	1.95-2.19	-

TABLE 1

DRILLHOLE INTERSECTIONS - WALTOWA SWAMP

Hole WS	Salt	Soil	Sand	Black Mud	Gyp Clay	Diatomite From	To	Thickness	Est%	Sapropel	Sand	Clay	Calcrete
53	-	-	0-.20	-	.20-.60	.60	1.50	.90	10	1.50-2.12	2.12-2.32	-	-
54	-	0-.20	-	-	.20-.50	.50	.95	.45	25	-	.95-1.37	1.37-1.62	-
55	-	0-.48	-	-	.48-.70	.70	1.15	.45	40	1.15-2.13	-	-	-
56	-	-	0-.34	-	.34-.50	.50	1.40	.90	30	-	1.40-1.65	1.65-1.79	-
57	-	-	0-.15	-	.15-.39	.39	1.00	.61	10	1.00-1.10	1.10-2.32	-	-

SAMPLE TESTING

Drillcore was logged geologically by Sean Kennedy and diatom content was estimated under the microscope (Appendix A). For holes WS10-24 and 30-33, thin section slides prepared by Barnett (1990) for her palaeontological study were used as standards. Contents for holes WS1-9 reported herein have been adjusted from those appended to Quarterly Report no. 2 (Olliver and Kennedy, 1990) to incorporate later information.

The following laboratory investigations have been completed.

. Barnett (1990) - diatom genera or species were identified and abundance of diatoms was estimated by grain count for the following two samples in Quarterly Report no. 4

WS	depth(m)
2	1.30
8	1.30

. Amdel Ltd - mineral composition was determined from optical microscopy, x-ray diffraction and chemical analyses of the following samples in Quarterly Report no. 3

WS	Intersection (m)
2	0.40-1.50
4	0.20-1.28
8	0.00-1.70

. John Keeling (SADME) - determined clay mineralogy of two samples of sapropel

WS	Intersection (m)
3	1.42-2.20
6	0.60-1.35

. Barnett (1991) - diatom genera or species were identified and abundance of diatoms was estimated by grain count for the following nine samples in Quarterly Report no.7

WS	Depth(m)
10	1.65
11	1.00
	2.00
12	0.70
14	1.00
18	1.00
20	0.60
30	1.40
	2.00

DIATOMITE EVALUATION

The diatomite unit is soft clay, pale to dark grey grading to yellow, brown and rarely green with thin sandy layers and patches and occasional aggregates of gypsum crystals.

Diatomite is at the surface in WS5, 8, 14, 21 and 1.00 to 1.13m below younger sediment in WS 42, 38 and 44.

Thickness ranges from only 0.07m in WS44 to 2.07m in WS14 similar to the maximum of 1.9m in CP22 in Cooke Plains Embayment (Olliver & Kennedy, 1991).

The extent of the diatomite unit is best outlined by the 0.5m thickness isopach (Figure 2). The main zone is about 6km long centred on WS8 and 14 with 15-30% diatom content over 1.85m thickness and 15-20% over 2.07m respectively and extends north northwest through WS20 with 15-45% over 1.05m to WS2 with 20-30% over 1.10m and southeast to WS43, 48 and 46 with 1.00m, 1.00m and 1.51m but only 5-30%.

Another zone about 1.5 km diameter is centred on WS4 and 5 with 30-40% over 0.88m and 20-25% over 1.4m.

Relative abundance of diatoms and other constituents is summarised in Table 2 from Barnett (1990) and (1991).

For the nine selected samples, diatom content ranged from 20% to almost 50% of total sediments with maximum recorded in WS14 at 1.00m. Clay, organic matter and framboidal pyrite generally total 30-50% with 60% in WS30 at 2.0m and 70% in WS10 at 0.70m.

Detrital quartz and minor mica and feldspar combined total 5-15% with a high of 30-40% in WS12 and 18.

Sponge spicules are usually trace and nowhere exceeds 5%.

The dominant diatom and the largest is Campylodiscus echineis (Ehr.) as fragmented pieces and complete frustules to 200 microns. Cocconeis placentula is common throughout but less than 30 microns and often less than 20 microns.

The two diatoms occur in bloom proportions in WS14, 20 and 30.

Melosira sp generally less than 15 microns also occurs in bloom proportions and dominate in WS18 but because size is small, contribution to overall diatom abundance is not significant.

Two other large diatoms Hyalodiscus and Surirella up to 120 microns are significant on WS11, 12 and 30.

TABLE 2

MINERAL CONTENT (%) - WALTOWA SWAMP

SAMPLE WS	m	DIATOMS	SPONGE SPICULES	CLAY (+ORG + PY)	QUARTZ (+MICA + FELD)
2	1.30	20-25	Tr	60-70	<10
8	1.30	20-25	-	60-70	10
10	1.65	20	< 2	70	5-10
11	1.00	30-35	Tr	50-60	< 5
	2.00	30-35	Tr	50	5
12	0.70	30-35	< 5	40-50	30
14	1.00	40-50	< 5	30-40	10-15
18	1.00	30-35	Tr	30	30-40
20	0.60	40-45	< 2	40-45	10-15
30	1.40	35-40	< 5	30-40	10-15
	2.00	20-25	Tr	60	5

CONCLUSIONS

Waltowa Swamp contains soft grey diatomite-bearing clay underlain by medium to coarse-grained sand and basal grey to green clay deposited in the Holocene during the periods of high rainfall and marine transgression which peaked 6 000 years ago.

The diatomite ranges from 0.07 to 2.07m thick in 48 core holes and is restricted to the deeper parts of Waltowa Swamp.

Diatomite assemblage is dominated by the large (up to 200 microns) Campylodiscus echineis (Ehr.) and the smaller (less than 30 microns) Cocconeis placentula. Diatom abundance does not exceed 50% in any hole and the balance is clay, organic matter, framoidal pyrite and lesser detrital quartz.

The diatomite is too low grade and too restricted in extent to warrant further investigations. Accordingly, EL 1628 was allowed to expire on 21 December 1991 after two years of tenure.

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APPENDIX

GEOLOGICAL LOGS OF CORE HOLES

AND ESTIMATES OF DIATOM CONTENT

WALTOWA SWAMP WS1-24, 30-33, 38-57

HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
WS1	0.00 - 0.28	black soil		
	0.28 - 0.71	light grey clay	0.60	spicules $<$5%
	0.71 - 2.28	grey to yellow c. gr. sand, wellsorted, subrounded to rounded	1.20	none visible
		with dark specks	1.88	none visible
	2.28 - 2.57	greenish grey m.gr. sand grading to green clay	2.40	none visible
WS2	0.00 - 0.05	salt		
	0.05 - 0.40	black, strong smelling mud		
	0.40 - 1.50	grey clay	0.60	spheres 30%
			1.30	spheres, spines fans 20-25%
	1.50 - 1.70	sapropel		
	1.70 - 2.06	greenish grey sandy clay	1.90	none visible
WS3	0.00 - 0.05	salt		
	0.05 - 0.35	dark sand		
	0.35 - 0.40	salt		
	0.40 - 0.50	dark, coarse sand		
	0.50 - 1.42	dark grey to brown clay	0.70	"footballs" etc 10%
	1.42 - 2.20	sapropel		
	2.20 - 2.26	dark coarse sand		
WS4	0.00 - 0.20	sand		
	0.20 - 0.40	black, strong smelling mud		
	0.40 - 1.28	grey clay	1.10	diverse fauna 30-40%
	1.28 - 1.70	sapropel		
	1.70 - 1.95	coarse grained sand		
WS5	0.00 - 1.20	grey clay	0.60	none
	1.20 - 1.40	light grey clay	1.30	diverse fauna 20-25%
	1.40 - 1.60	sapropel		
	1.60 - 2.09	coarse, white sand		

HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
WS6	0.00 - 0.05	salt		
	0.05 - 0.25	black, strong smelling mud		
	0.25 - 0.60	green to grey clay	0.40	"footballs", fans spheres etc 20%
	0.60 - 1.35	sapropel		
	1.35 - 1.65	dark grey coarse sand		
	1.65 - 2.15	grey to green clayey sand		
WS7	0.00 - 0.34	black to brown soil		
	0.34 - 1.20	yellow to grey clay	0.45	spheres 10-15%
			1.10	fans 10-15%
	1.20 - 1.50	sapropel		
	1.50 - 2.62	grey sand	2.00	none visible
WS8	0.00 - 1.15	light brown to grey clay	1.00	spines 30%
	1.15 - 1.85	grey clay	1.30	diverse fauna 20-25%
			1.70	spheres etc 15-20%
	1.85 - 2.00	coarse grained white sand		
WS9	0.00 - 0.10	salt and black mud		
	0.10 - 0.30	sandy grey clay	0.20	spheres 15% gypsum xals
	0.30 - 0.55	sapropel		
	0.55 - 0.76	coarse grained grey sand		
WS10	0.00 - 0.20	brown soil		
	0.20 - 0.90	light grey and yellow clay	0.50	sponge spicules $<$ 5%
	0.90 - 1.15	light grey clay	1.00	sponge spicules, Hyalodiscus, broken Campylodiscus 10%
	1.15 - 1.80	grey clay	1.65	broken Campylodiscus, spicules, Hyalodiscus Navicula and other unidentified forms 25% (Barnett - 15-20%)
	1.80 - 2.00	grey sand with organic matter at top		
	2.00 - 2.27	light grey, clay rich sand		

HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
WS11	0.00 - 0.30	brown soil		
	0.30 - 0.80	yellow, gypsiferous clay		
	0.80 - 2.10	grey clay with yellow near top	1.00	sponge spicules, Campylodiscus, Hyalodiscus - broken and complete 25% (Barnett - 30-35%)
			2.00	Hyalodiscus, broken and complete Campylodiscus 30% with wood fibres (Barnett - 30-35%)
	2.10 - 2.67	grey sand		
	2.67 - 2.68	grey clay	2.68	sponge spicules, Hyalodiscus, Navicula 10%
WS12	0.00 - 0.17	brown soil		
	0.17 - 0.52	yellow clay		
	0.52 - 0.85	light grey sandy clay	0.70	sponge spicules, Hyalodiscus, broken Campylodiscus 20% with organic matter (Barnett - 30-35%)
	0.85 - 1.35	grey clay	1.20	sponge spicules, Campylodiscus, broken and complete Hyalodiscus 10%
	1.35 - 2.00	medium grained grey sand		
	2.00 - 2.21	green sandy basal clay	2.10	Organic matter and rounded and fractured quartz grains
WS13	0.00 - 0.30	brown and yellow clay		
	0.30 - 0.64	grey clay	0.55	sponge spicules, Campylodiscus 10% with rounded quartz grains
	0.64 - 0.78	green sandy basal clay		

HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
WS14	0.00 - 0.18	grey clay		
	0.18 - 0.76	lt grey clay with brown patches	0.30	spicules, broken Campylodiscus etc 15% with organic matter and very fine grains
	0.76 - 1.15	grey clay	1.00	complete Campylodiscus, Hyalodiscus, sponge spicules and other unidentified genera $>$50%? (Barnett - 40-50%)
	1.15 - 2.07	grey clay, sandier at depth		
	2.07 - 2.41	medium grained light grey sand		
WS15	0.00 - 0.35	dark brown soil		
	0.35 - 0.70	light brown to grey clay	0.50	Spicules, broken Campylodiscus etc 10%
	0.70 - 0.80	medium grained grey sand		
WS16	0.00 - 0.66	yellow to lt grey gyps. clay	0.60	broken and complete Campylodiscus, Hyalodiscus, Navicula, spicules etc 20%
	0.66 - 0.70	grey clay		
	0.70 - 0.99	sapropel		
	0.99 - 2.31	medium grained grey sand		
WS17	0.00 - 0.20	dark brown soil		
	0.20 - 0.50	yellow to light grey clay	0.30	broken Campylodiscus and unidentified spherical diatoms about 25μ in diameter 10%
	0.50 - 0.53	black clay		
	0.53 - 0.66	light grey sandy clay		
	0.66 - 1.76	medium grained grey sand		

HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
WS18	0.00 - 0.40	dark brown soil		
	0.40 - 0.55	dark grey clay		
	0.55 - 1.35	grey clay	1.00	Complete and broken Campylodiscus 20%, with plant fibres, other organic matter and quartz grains (Barnett - 30-35%)
	1.35 - 1.76	grey sand		
	1.76 - 2.03	green basal clay		
WS19	0.00 - 0.35	dark brown soil		
	0.35 - 0.70?	br and yellow sandy gypsif clay		
	?0.70 - 1.55	grey clay. (most of sample lost)	1.55	sponge spicules, broken and complete Campylodiscus, Hyalodiscus and other unidentified genera 15%
	1.55 - 1.70	grey, clay-rich sand		
	1.70 - 1.98	grey sandy clay	1.85	none visible
	1.98 - 2.03	weathered calcrete		
WS20	0.00 - 0.10	black, strong smelling mud		
	0.10 - 0.45	dark grey clay		
	0.45 - 0.50	sapropel		
	0.50 - 0.90	lt grey clay, br and sandy patches	0.60	sponge spicules, broken and complete Campylodiscus, Hyalodiscus and other unidentified genera 25% (Barnett 40-45%)
	0.90 - 1.55	grey clay	1.30	sponge spicules, broken Campylodiscus and unidentified oval genus 30μ x 20μ 15%
	1.55 - 1.80	sapropel with thin layers white sand		
	1.80 - 2.15	medium grained, dark grey sand		

HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
WS21	0.00 - 0.15	dark grey clay		No material investigated
	0.15 - 0.30	grey clay		
	0.30 - 1.09	grey, clay-rich sand		
	1.09 - 1.14	grey basal clay		
WS22	0.00 - 0.25	coarse grained, brown sand		
	0.25 - 0.80	yellow and green gypsiferous clay	0.70	sponge spicules, broken and complete Campylodiscus, Hyalodiscus and unidentified barrel shaped genus 25%
	0.80 - 1.05	grey clay	1.00	sponge spicules, broken Campylodiscus $<$ 5%
	1.05 - 1.15	sapropel with sandy layers		
	1.15 - 2.39	m.g. grey sand, finer at depth		
WS23	0.00 - 0.08	salt		
	0.08 - 0.63	black, strong smelling mud		
	0.63 - 0.70	light grey clay		
	0.70 - 1.25	dark grey clay	0.85	sponge spicules, broken Campylodiscus, Navicula and ?Nitzschia 15%
	1.25 - 1.53	sapropel		
	1.53 - 1.98	medium grained, grey sand		
	1.98 - 2.11	green basal clay		
WS24	0.00 - 0.08	salt		
	0.08 - 0.35	black, strong smelling mud		
	0.35 - 0.57	dark grey clay		
	0.57 - 0.72	green clay	0.65	Campylodiscus fragments and sponge spicules 5%
	0.72 - 1.20	dark grey clay	1.00	sponge spicules, broken Campylodiscus, Navicula and ?Nitzschia 15%

HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
WS24 (cont)	1.20 - 2.13	sapropel		
	2.13 - 2.23	dark grey, clay-rich sand		
WS30	0.00 - 0.20	brown soil and clay		
	0.20 - 0.70	yellow and brown gypsif. clay		
	0.70 - 2.10	grey clay, darker with depth	0.80	sponge spicules $<5\%$
			1.40	broken and complete Hyalodiscus and Campylodiscus with sponge spicules $<5\%$ (Barnett - 35-40%)
			2.00	broken and complete Campylodiscus with sponge spicules 10% (Barnett - 20-25%)
	2.10 - 2.22	grey, medium grained sand		
WS31	0.00 - 0.12	black soil		
	0.12 - 0.48	brown and yellow clay		
	0.48 - 0.63	light brown to grey clay		
	0.63 - 0.77	light grey sandy clay		
	0.77 - 1.24	grey clay with sandy patches	1.00	broken and complete Hyalodiscus and Campylodiscus 30%
	1.24 - 1.72	grey m.g. sand with organic matter		
	1.72 - 1.84	green basal clay		
	1.84 - 1.92	weathered calcrete		
WS32	0.00 - 0.30	black soil		
	0.30 - 0.57	brown and yellow clay		
	0.57 - 0.75	light grey clay	0.70	broken Campylodiscus complete Navicula, Hyalodiscus and sponge spicules 20%
	0.75 - 0.90	greenish, clay rich sand		
	0.90 - 2.60	grey, medium grained		

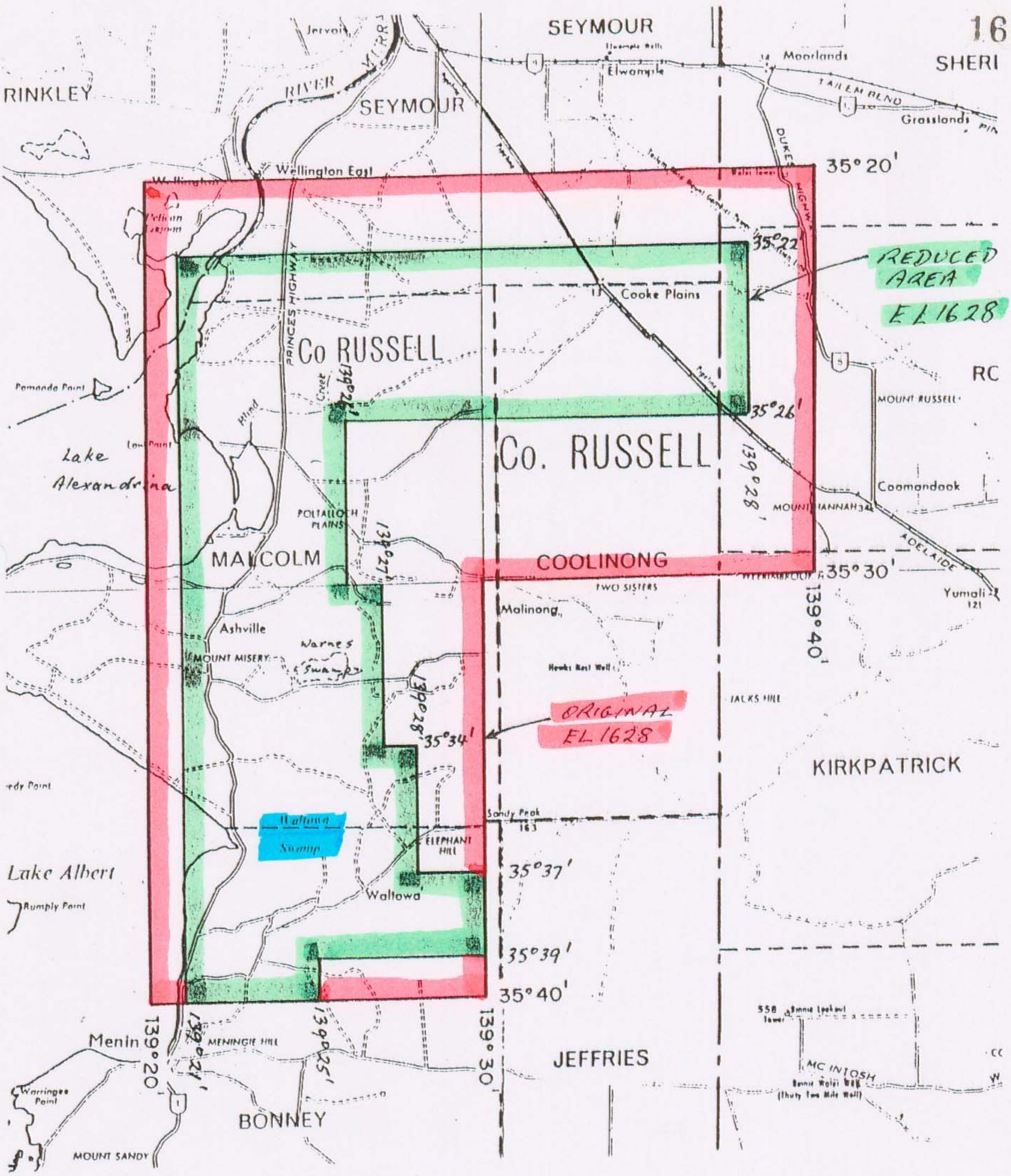
HOLE NO.	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
WS33	0.00 - 0.40	dark brown clay		
	0.40 - 1.20	grey clay, greenish near top	0.80	broken and complete Campylodiscus, Hyalodiscus and sponge spicules etc 15%
	1.20 - 1.60	grey, clayey sand		
	1.60 - 2.30	light grey, medium grained sand		
	2.30 - 2.38	greenish clayey sand		
WS38	0.00-0.35	grey clay	0.2	none visible
	0.35-0.60	brown and yellow clay		
	0.60-1.10	light grey, slightly gypsiferous clay	0.9	spicules 10%
	1.10-1.30	grey clay	1.2	complete Hyalodiscus, broken Campylodiscus 10%
	1.30-1.35	grey clayey sand		
	1.35-1.40	sapropel		
	1.40-1.63	grey sand, clay at base		
WS39	0.00-0.20	brown soil		
	0.20-0.43	grey and yellow clay		
	0.43-1.00	light grey to yellow clay gypsiferous	0.6	broken and complete Campylodiscus, Navicula, Hyalodiscus, and spicules 30%
	1.00-1.67	grey sand		
WS40	0.00-0.25	brown soil		
	0.25-0.55	brown and yellow clay		
	0.55-1.00	light brown clay	0.7	Navicula, spicules, broken Campylodiscus 15%
	1.00-1.90	grey clay	1.2	broken and complete Campylodiscus, spicules 20%
			1.8	broken and complete Campylodiscus, Navicula, Hyalodiscus, spicules 35%
	1.90-1.95	grey sand		
	1.95-2.00	sapropel		
	2.00-2.50	medium grained dark grey to grey sand		
	2.50-2.71	green, sandy basal clay		
WS41	0.00-0.10	grey clay		
	0.10-0.70	light yellow-grey clay	0.6	spicules <5%
	0.70-0.90	grey clay	0.8	broken Campylodiscus, Hyalodiscus, spicules 15%
	0.90-1.56	medium grained grey sand		

HOLE NO	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE
WS42	0.00-0.08	soil		
	0.08-0.45	dark grey clay		
	0.45-1.00	light grey-yellow clay	0.6	broken Campylodiscus, spicules <5%
	1.00-1.50	light grey clay with thin sandy patches	1.4	broken and complete Campylodiscus, Navicula, Hyalodiscus, spicules 40%
	1.50-1.71	dark grey, clayey sand		
WS43	0.00-0.15	soil and vegetation		
	0.15-0.50	brown and yellow clay		
	0.50-1.20	light brown clay	1.0	broken and complete Campylodiscus, spicules, Navicula 20%
	1.20-1.50	light grey clay	1.4	broken and complete Campylodiscus, spicules, Hyalodiscus 30%
	1.50-1.70	sandy sapropel		
	1.70-1.72	medium grained grey sand		
WS44	0.00-0.20	brown soil		
	0.20-0.48	dark brown clay		
	0.48-1.13	light brown-yellow clay	0.9	spicules 10%
	1.13-1.20	light grey clay		
	1.20-1.48	medium grained grey sand		
WS45	0.00-0.16	brown soil		
	0.16-0.85	brown and yellow gypsiferous clay	0.7	spicules 5%
	0.85-1.15	light brown clay	1.0	spicules, broken Campylodiscus 10%
	1.15-1.70	light grey clay, darker at depth	1.5	broken and complete Campylodiscus, Navicula, Hyalodiscus, spicules 35%
WS46	0.00-0.10	brown soil		
	0.10-0.27	dark brown and yellow clay		
	0.27-1.10	yellow clay	1.0	broken Campylodiscus, spicules 5%
	1.10-1.78	light grey clay, sandier at depth	1.6	broken and complete Campylodiscus, spicules 10%
	1.78-1.95	fine to medium grained grey sand		

HOLE NO	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE	
WS47	0.00-0.15	brown soil			
	0.15-0.95	yellow clay	0.6	spicules	10%
	0.95-1.55	light grey clay	1.2	broken Campylodiscus, Hyalodiscus, spicules	25%
	1.55-1.93	medium grained grey sand			
WS48	0.00-0.34	SAMPLE LOST			
	0.34-0.95	brown clay			
	0.95-1.55	light grey clay with plant matter	1.2	spicules, Hyalodiscus, Campylodiscus	20%
	1.55-1.85	light grey clay	1.7	spicules, Hyalodiscus, Campylodiscus	20%
	1.85-1.95	grey sandy clay			
	1.95-2.06	sapropel			
	2.06-2.08	medium grained grey sand			
WS49	0.00-0.10	brown soil			
	0.10-0.70	brown clay			
	0.70-1.50	light yellow to grey, sandy clay	1.3	Campylodiscus, spicules	10%
	1.50-2.00	medium grained grey sand			
WS50	0.00-0.10	brown soil			
	0.10-0.55	grey clay	0.3	broken Campylodiscus, spicules	15%
	0.55-1.00	medium grained white sand			
	1.00-1.18	medium grained grey sand			
	1.18-1.47	sandy green basal clay	1.3	none visible	
WS51	0.00-0.15	brown soil			
	0.15-0.28	brown clay			
	0.28-0.48	light grey sandy clay			
	0.48-0.80	fine grained clayey sand			
	0.80-1.13	grey to brown, calcareous clayey sand			
	1.13-1.33	green, calcareous, sandy clay			
	1.33-1.82	sample lost into hole, but believed to be sand			

HOLE NO	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE	
WS52	0.00-0.10	medium grained grey sand			
	0.10-0.70	dark brown clay			
	0.70-1.25	light grey-green, sandy clay	1.0	Campylodiscus, spicules	<5%
	1.25-1.75	sapropel			
	1.75-1.95	medium grained, dark grey sand			
	1.95-2.19	calcareous green basal clay			
WS53	0.00-0.20	medium grained brown sand			
	0.20-0.41	dark brown clay			
	0.41-0.60	mottled dark grey clay			
	0.60-1.00	light grey clay	0.8	broken Campylodiscus, spicules, Navicula	10%
	1.00-1.50	dark grey clay			
	1.50-2.12	sapropel			
	2.12-2.32	medium grained dark grey sand			
WS54	0.00-0.20	dark brown soil and clay			
	0.20-0.50	grey to yellow gypsiferous clay			
	0.50-0.95	light grey clay	0.7	Hyalodiscus, spicules, Campylodiscus	25%
	0.95-1.37	medium grained grey sand			
	1.37-1.62	green clay, calcareous at base			
WS55	0.00-0.48	dark brown soil and clay			
	0.48-0.70	light grey, gypsiferous clay	0.65	spicules, Hyalodiscus Campylodiscus	10%
	0.70-0.85	green clay			
	0.85-1.15	light grey clay	1.0	complete Campylodiscus Hyalodiscus	40%
	1.15-2.13	sapropel			

HOLE NO	INTERVAL (m)	DESCRIPTION	SAMPLE (m)	DIATOM TYPE AND ESTIMATED ABUNDANCE	
WS56	0.00-0.10	dark grey clayey sand			
	0.10-0.34	medium grained brown sand			
	0.34-0.50	dark brown clay			
	0.50-0.98	light grey gypsiferous clay	0.7	Campylodiscus, spicules	30%
	0.98-1.40	light grey clay, darker at depth	1.2	broken Campylodiscus Navicula, spicules	30%
	1.40-1.65	grey medium grained sand			
	1.65-1.79	grey-green sandy, basal clay			
WS57	0.00-0.15	coarse grained brown sand			
	0.15-0.39	dark brown clay			
	0.39-1.00	light grey gypsiferous clay	0.7	Campylodiscus, spicules	10%
	1.00-1.10	sapropel			
	1.10-2.32	grey medium grained sand			



SCALE 1:250 000

KILOMETRES 5 0 5 10 15 20 25 KILOMETRES

OLLIVER GEOLOGICAL SERVICES PTY LTD

EL1628

LOCALITY PLAN

SCALE 1:250 000

FIG 1

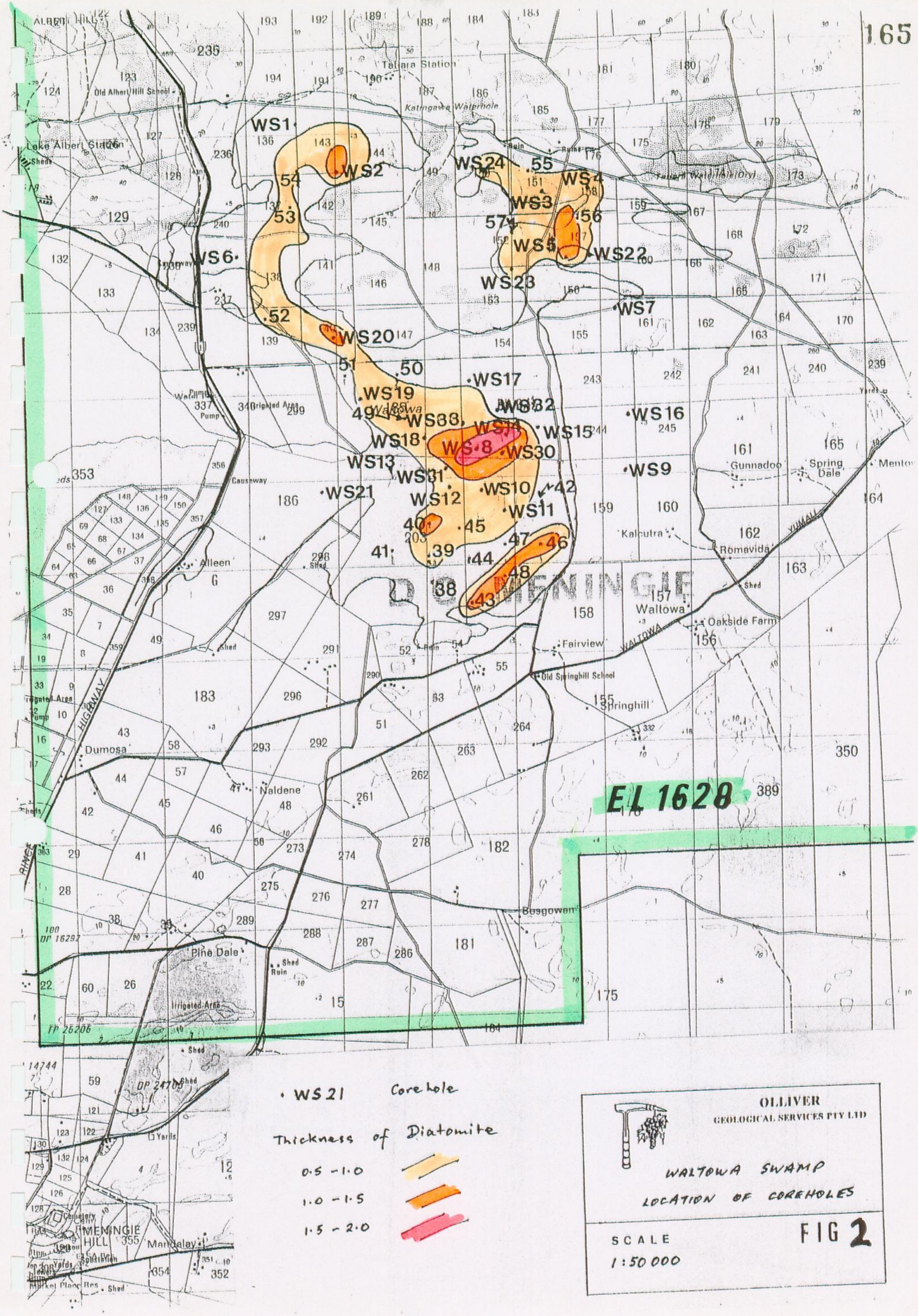

WS1
WS2
WS3
WS4
WS5
WS6
WS7
WS8
WS9
WS10
WS11
WS12
WS13
WS14
WS15
WS16
WS17
WS18
WS19
WS20
WS21
WS22
WS23
WS24
WS30
WS31
WS32
WS33
DOMENINGIE
EL 1628
• WS21 Core hole
Thickness of Diatomite
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
OLLIVER
GEOLOGICAL SERVICES PTY LTD
WALTOWA SWAMP
LOCATION OF COREHOLES
SCALE
1:50 000

FIG 2

ASHVILLE GYPSUM DEPOSITS

DISCOVERY, GEOLOGY AND RESERVES - GEOLOGICAL INVESTIGATIONS DURING 1991 AND 1992

BY

JEFFREY G OLLIVER
OLLIVER GEOLOGICAL SERVICES PTY LTD

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This report was released to open file on 5/12/95 via EL1628 and envelope 8281 (M1980)

Received 1/9/92.

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SUMMARY

Gypsum in economic quantities and grades has been discovered in two swamps close to the Princes Highway, about 135 km southeast by road from Adelaide.

The two deposits, Warnes and Lihou were discovered in 1991 by Olliver Geological Services Pty Ltd during investigations on Exploration License 1628. Current mineral tenure is Mineral Claims 2664, 2665 and 2666 over Warnes due to expire in March 1993 and Mineral Claim 2687 over Lihou due to expire in April 1993.

Push tube and hand auger drilling has outlined reserves of 4.4 million tonnes at Warnes and 1.7 million tonnes at Lihou, with average grades of raw gypsum of 82.4% and 67.4% respectively. The main contaminants are calcium/magnesium carbonate and salt.

The gypsum extends virtually from the lake surface, being overlain in places by an algal mat only a few centimetres thick. As the gypsum is unconsolidated, the deposits would be suitable either for seasonal open-cut mining or a year round dredging operation.

The high grade centre of Warnes is expected to produce washed salt-free material with 92% gypsum suitable for plaster manufacture.

The deposits are considered to be economic for the following reasons:

(a) Suitable tonnages and grades.
(b) Ease of mining.
(c) Proximity to Adelaide and ports with road and rail links to Eastern Australian population centres.
(d) Dwindling reserves at other traditional South Australian gypsum sources.

These gypsum deposits are a significant addition to the industrial mineral inventory of South Australia.

INTRODUCTION

Exploration Licence (EL) 1628 was obtained to investigate diatomite in swampy depressions marginal to Lake Alexandrina and Lake Albert between Tailem Bend and Meningie about 135 km southeast of Adelaide (Fig. 1). As Cooke Plains gypsum deposit on the eastern margin of Cooke Plains Embayment has been mined for many years, gypsum was a secondary target.

Scout drilling in Warnes Swamp and Lihou Swamp in early 1991 encountered gypsum in all 8 holes rather than the diatomite-bearing sequence in Cooke Plains Embayment and Waltowa Swamp.

These occurrences were not recorded in the extensive data file on gypsum in the South Australian Department of Mines and Energy (SADME) and more detailed investigations were justified.

GYPSUM IN AUSTRALIA

Uses

<u>Plaster</u>: (70%) - when calcined, gypsum ($CaSO_4.2H_2O$) loses 75% of the combined water to form the hemihydrate $CaSO_4.½H_2O$ - Plaster of Paris which has two main end uses:

- o plaster for walling, surgical and casting purposes,
- o plaster board - plaster between two thick sheets of paper, now used extensively for internal walling.

<u>Cement</u>: (20%) - from 2 to 10% uncalcined gypsum is added to cement clinker as a retardant.

<u>Agriculture</u>: (10%) - crushed and milled or natural fine-grained gypsum is added to soil as fertiliser and conditioner to enhance crop yields.

<u>Minor Uses</u>:
- filler in paper, paint and toothpaste,
- oil drilling mud.

Production

More than 70 countries produce the estimated world total of 70 million tonnes per year. Since 1981, Australian output has varied from 1 million to a maximum of 1.7 million tonnes in 1989. South Australia is the dominant supplier (about 90%) from the following sources:

Lake MacDonnell	-	Gypsum Resources of Australia (Boral-CSR Joint Venture) crush selenite (rock gypsum) on site and rail 70km to Port Thevenard for shipment to plaster and cement factories in Australia and overseas.
Blanchetown	-	David Linke screens consolidated gypsarenite (seed gypsum) and trucks to Angaston cement works and Adelaide plaster factories.
Southern Yorke Peninsula	-	Adelaide Brighton Cement mine at Marion Lake, Spider Lake and Lake Fowler, and truck to Klein Point for shipping to Birkenhead cement works.
Kangaroo Island	-	CSR ship crushed selenite from the stockpile remnant at Ballast Head to interstate plaster factories.
Cooke Plains	-	Patterson Bros truck unconsolidated seed gypsum to Adelaide, Melbourne and Sydney for agricultural uses eg. mushroom cultivation, commercial and private gardens.

About 20 further deposits scattered throughout South Australia supply local farming markets.

In the near future, replacements will be required for Kangaroo Island, South Yorke Peninsula, and Cooke Plains. A large proven resource has yet to be mined at Streaky Bay on Eyre Peninsula.

LOCATION AND ACCESS

Lihou Swamp is 19km north of Meningie, a small town on the sealed Princes highway on the eastern shores of Lake Albert. Warnes Swamp is 4.5km east of Lihou Swamp.

Sections	-	212, 213, 218, 223, 224, 225, 466 & 467.
Hundred	-	Malcolm
County	-	Russell
1:250,000 sheet	-	Barker 5154-13
1:50,000 sheet	-	Meningie 6726-1
District Council	-	Meningie
Planning Area	-	Murray Mallee

A full range of services is available at Meningie and Tailem Bend which are linked by the sealed princes Highway.

Lihou Swamp abuts the Highway 19km by road north of Meningie (Plate 2) and Warnes Swamp is 4.5km eastwards along the graded all-weather unsealed Crosby Road (Plate 1).

The village of Ashville with a hall and one farmhouse is 3km north of the Princes Highway - Crosby Road junction.

ENVIRONMENTAL FACTORS

Environmental Setting (from Laut et al, 1977)

Environmental Province	2	Murray Mallee
Environmental Region	2.1	Murray Lakes
Environmental Association	2.1.4	Mt Misery

Climate

Dry summer and cold wet winter with Meningie recording:

mean annual rainfall	466mm
mean annual evaporation	1700mm

Topography

An undulating higher plain rises from Lake Alexandrina and Lake Albert to more than 70m AHD near Tatiara homestead (Figure 3). Surface of Warnes and Lihou Lakes approximates 3m AHD.

Drainage

Warnes and Lihou Lakes are both separate internal drainage systems not connected to Lake Albert. There are no stream channels.

Groundwater

In summer, the water table is approximately 0.5m below the lake surface. In winter, water covers the surface to a maximum depth of 0.5m (RJ Warnes pers comm.). Springs along the western margins of both lakes keep the nearby section wet even in summer. Spring water from the southwestern corner of Lihou analysed in February 1991 recorded 9631ppm total dissolved solids.

Lake Surface and Surrounds

In summer, most of Warnes is covered with gypsum crystals with lesser areas of salt and algal mat (Plates 5-8). In contrast, Lihou has more salt and algal mat (Plates 4, 9, 10).

Samphire is abundant around the lake margins and on the low gypsum dunes, the darker patches on figures 4 and 5.

Samphire and saltbush shrublands on the margins have been degraded by grazing (Laut et al, 1977).

Much of the vegetation on higher ground has been cleared for pasture improvement (Plates 2, 3, 5).

Mallee eucalypts survive as isolated trees and small clumps with casuarina, melaleuca and leptospermum common.

Dr Peter Hornsby has completed an initial vegetation survey (Hornsby, 1992).

Sites of Scientific or Cultural Value

None known on or near Warnes and Lihou Lakes.

Representatives of Ngarrindjeri Land and Progress Association inspected the area in October 1991. There are no sites of Aboriginal significance that would be jeopardised or adversely affected by exploration or mining.

Land Use

None for the lakes. The margins are used for grazing sheep, dairy and beef cattle and cereal crops.

Calcrete is mined from a road rubble pit on the northern shore of Lihou Swamp. There are two abandoned pits in the north western and western edges of MC 2687.

Nearest Building

Kandramooka homestead and outbuildings are 1.2km east of the probable eastern limit of workings at Warnes. Similarly, The Pines homestead is 700m north and Dunmedoh Park is 500m south of Lihou.

Proposed Mining Operations

<u>Track Construction</u>

No new tracks are envisaged.

Crosby Road will probably be sealed from Princes Highway to Warnes. The public road along the western margin of Warnes will require upgrading to carry loaded semi-trailers.

Mining Methods

A small floating dredge is the preferred method to enable year-round mining with the gypsum slurry pumped to stockpiles or beneficiation plant ideally on the western margin at Warnes and one of the abandoned rubble pits at Lihou.

Stockpiles

Long windrows several metres high with flattened tops will be required to facilitate rain water leaching of salt.

On Site Buildings

All or some of the following will be required:

- mine office
- weigh bridge
- washing plant
- storage hopper
- loading facility
- vehicle/equipment service shed
- covered stockpile.

Rehabilitation

Removal of stockpiles, equipment and buildings not required at end of mining.

Mined out areas would simply be left as lakes. The margins of Lake Alexandrina and Lake Albert are of considerable importance for water birds (Laut et al, 1977). New bodies of water would contribute to the conservation of these birds.

MINERAL TENURE

EL 1628 was granted to Olliver Geological Services Pty Ltd on 22 December 1989 initially for six months, was renewed for six months and a reduced area was renewed for a further twelve months (Figure 2) and expired on 21 December 1991.

Four Mineral Claims (MC) were pegged in December 1991 as shown on Figure 3 - and registered for Olliver Geological Services Pty Ltd as follows:

- MC 2664, 2665 and 2666 over Warnes Deposit on 3 March 1992.

- MC 2687 over Lihou Deposit on 23 April 1992.

Under Section 25 of the Mining Act 1971 as amended, the claim holder has an exclusive right to prospect, explore and to apply for a mining lease within 12 months from the date of registration.

LAND OWNERSHIP

The two gypsum deposits are mainly on freehold and minor Crown land as follows:

1. Sections 212, 213, 218

   Freehold owned by Robert John and Elizabeth Anne Warnes 'The Pines' Ashville via Meningie, South Australia, 5264.

2. Section 223

   Freehold owned by Douglas Lionel and Peter Douglas Lihou of Meningie, South Australia, 5264.

   A tenant lives in 'Dunmedoh Park'.

3. Section 224

   Freehold owned by James Barry and Patricia Clare McClure, Private Bag 2, Tailem Bend, South Australia, 5260.

   They live at 'Tatiara' on section 190.

4. Sections 225 and 227

   Freehold owned by George Karl and Adrienne Wanda Plenk, PO Box 26, Meningie, South Australia, 5264, who live at 'Kandramooka'.

5. Sections 466 and 467 are Crown land under the control of the Minister of Lands administered by Department of Lands Office, Murray Bridge.

6. The road reserve between sections 212 and 213 is controlled by District Council of Meningie, South Australia, 5264.

Land ownership boundary fences are shown on Figures 4 and 5.

GEOLOGICAL SETTING

Ashville gypsum deposits are near the western margin of the Murray Basin which contains fairly shallow water Tertiary sediments on the Coastal Plain - a physiographic unit on PINNAROO 1:250,000 sheet (Rogers 1980). The Coastal Plain is essentially a relatively flat surface 10 to 30m above sea level.

During a period of high rainfall from 5,000 to 8,000 years ago and the peak of marine transgression 6,000 years ago, Lake Alexandrina and Lake Albert extended further eastwards than present. During this period, estuarine, lagoonal and lacustrine sediments were deposited on Pleistocene calcrete in Cooke Plains Embayment (von der Borch and Altmann, 1979) and Waltowa Swamp.
These Holocene sediments are equated with St Kilda Formation in St Vincent Basin (Rogers, 1980). In Cooke Plain Embayment east of the Dukes Highway, evaporitic gypsum beds of Yamba Formation were formed in saline lakes and during later aridity were blown into gypsarenite lunette dunes (King, 1951) to form the Cooke Plains gypsum deposit which has been mined for many years.

At Warnes and Lihou Swamps, saline groundwater from springs on the western margins was evaporated to form gypsum.

As both swamps were partly shielded from the prevailing west and south westerly winds, major lunette dunes were not developed on the eastern margins. Therefore, the characteristic landform for South Australian gypsum deposits was not present here and explains why these deposits were not discovered until 1991.

DRILLING PROGRAM

Field Operations

Hand drilling was undertaken on the following six field trips.

(1) 15 February 1991 — Kennedy and field assistant
- Warnes - initial 3 holes (WS27-29)
- Lihou - initial 2 holes (L1-2)

(2) 7 March 1991 — Kennedy, Olliver and two assistants - to check initial holes.
- Warnes - 3 holes (WS34-36)
- Lihou - 1 hole (L3)

Samples from these 9 holes were submitted to Classic Laboratories for chemical analyses.

No further activity was possible in 1991 as the lakes were full of water.

(3) 2-4 January 1992 — Kennedy, Olliver and six assistants pattern drilling Warnes (Plates 5-8)
- 34 holes (WS38-71) in lake and 7 (WS109-115) in dunes
- total 41 holes.

(4) 18-20 January 1992

Kennedy and two assistants pattern drilling Warnes.

- 37 holes (WS72-105) in lake and three in small lakes to north (WS106-108) and 5 (WS116-120) in dunes.
- total 42 holes.

(5) 27-29 February 1992

Kennedy and three assistants pattern drilling Lihou (Plates 9-10).

- 45 holes (L4-48) in lake.

(6) 16-18 March 1992

Kennedy and assistant infill holes in lakes.

Warnes	-	7 holes (WS121-127)
Lihou	-	15 Holes (L49-63)

Total holes drilled were:

Warnes	-	main lake	-	81	133·69
		small lakes	-	3	4·25
		dunes	-	12	11·45
		Sub-total	-	96	149·39 m
Lihou	-	lake	-	63	129·7
TOTAL				159	279·09

Drilling Methods

The most efficient technique to drill unconsolidated sediments in swamps is simply to push 32mm diameter PVC pipe by hand. A small short handled sledge hammer is used to hit an aluminium dolly which fits snugly into the top of the PVC pipe (Plate 6). The dolly should have a vertical air hole.

The pipe, usually 2m long, is hammered vertically either within several centimetres of the lake surface or until no further penetration occurs (Plate 7). The pipe is filled with water and a rubber bung is inserted in the top. Extraction is by either hand (Plate 8) or by the two-handled gripping device.

Hole number, depth and up direction are written on the pipe. Excess pipe at the top owing to compaction of sediment is cut off and both ends are taped.

Hand augering (Plates 9 & 10) was used to check when PVC pipe was still in gypsum but could penetrate no further.

Sampling

PVC pipe containing the core sample was cut by circular saw longitudinally with two diametrically opposite cuts (Plate 11) and split open by a wire device (Plate 12). The split core was logged lithologically (Plate 13), selected samples were checked under the microscope, and half core was bagged for chemical analyses. The remaining tubes of half core and bagged hand auger samples are stored at McLaren Vale.

SITE GEOLOGY

Warnes

The main lake 3.7 km long and 1.5 km wide is bordered by calcrete and to a lesser extent aeolian sand.

There is one main calcrete island 300m by 200m near the eastern margin and a smaller island near the central southern edge. Numerous narrow linear and curved aeolian gypsum dunes have formed on the surface with the main zone along the western side of the island (Figure 4). No gypsum was intersected in 19 holes (WS29, 42, 43, 51, 53, 59, 60, 61, 67, 84, 89, 92-97, 99 and 105) near the lake edge as these were sited in the marginal carbonate facies of Warren (1980).

Results of drilling are summarised in Table A from detailed logs in Appendix A. The generalised sequence of lake sediments is as follows:

<u>Algal Mat</u>:

From 0.02m to 0.10m thick in 36 holes.

<u>Gypsum</u>:

In all but 19 marginal holes and forms the lake surface in 35 holes.

Thickness ranges from 0.15m in WS53 to maximum of 3.72m in WS74.

Mainly as unconsolidated mesh of crystals from fine to coarse. Colour is generally white through light to dark grey occasionally green to yellow with rare brown staining.

Thin dark organic layers and white layers of carbonate clay/silt are common and small pinkish gastropod shells are scattered throughout. Rare quartz sand is present in places near the base.

<u>Calcareous Gypsum to Gypsiferous Calcareous Clay</u>:

Generally white to grey and gradational below the gypsum. Overall, carbonate content increases with depth.

Sand:

Mainly grey to brown, rarely green, fine grained and clayey to calcareous in places and some iron staining.

Clay:

Brown, cream, grey to green calcareous or sandy in parts to orange and iron-rich, perhaps diatomaceous in WS97 and WS100.

Calcrete:

Lake basement reached definitely in 36 holes and probably in another 9.

Warnes Dunes

Cream, light brown, brown to white fine to medium grained gypsum crystals range from 0.46m in WS116 to maximum of 1.58m in WS111 as summarised in Table B.

Eight of the 12 holes were stopped whilst still in gypsum. The underlying sediments were reached in:

- o WS114 clay at 1.50m
- o WS116 gypsiferous calcareous clay
- o WS119 calcrete basement at 0.52m.

Warnes Small Lakes

The small lakes immediately north contain gypsum with 1.40m in WS106 and 0.65m in WS107 (Table C). However, the lakes 1-2 km further north (Figure 3) only contain calcareous sediments and only the largest was tested by WS108.

Lihou Dunes

No holes were drilled as these dunes are generally less than 0.5m above lake surface.

Lihou

This almost annular lake 2 km by 1.5 km is bordered by calcrete. A peninsula composed of mallee covered calcrete extends 700 metres into the lake from the western margin.

Curved aeolian gypsum dunes have formed in the north and northeast of the lake with the main zone 400m by 200m immediately east of the peninsula (Figure 5). No gypsum was intersected in 24 holes (L 10, 31, 32, 36-38, 40-48, 50-52, 55, 56, 59, 61-63) which were in the marginal carbonate facies of Warren (1980).

Results of drilling are summarised in Table D from detailed logs in Appendix A. The generalised sequence of lake sediments is as follows:

TABLE A

DRILL HOLE SUMMARY - WARNES LAKE

Showing lithological intervals and gypsum thickness in metres

HOLE WS	Algal mat	Gypsum	Gypsum thick.	Calc.gyps/ Gyps. calc	Sand	Clay	Calcrete basement
27	0-0.10	0.10-1.40	1.40	-	-	-	?1.40
28	0-0.04	0.04-1.25	1.21	1.25-1.51	-	-	?1.51
29	-	0.00-0.35	0.35	-	-	-	0.35
34	0-0.20	0.20-2.00	1.80+	-	-	-	-
35	0-0.03	0.03-1.26	1.23	-	-	1.26-1.31	1.31
36	0-0.03	0.03-1.62	1.59	-	-	-	1.62
38	0-0.03	0.03-0.45	0.42	-	-	0.45-1.92	1.92
39	0-0.08	0.08-2.17	2.05	-	-	-	?2.17
40	0-0.08	0.08-2.08	2.00	-	-	-	?2.08
41	0-0.05	0.05-0.90	0.85	0.90-1.40	-	1.40-1.90+	2.21
42	0-0.05	-	-	0.05-0.60		0.60-0.81	0.81
43	0-0.05	-	-	0.05-0.85	-	0.85-0.91	0.91
44	0-0.05	0.05-1.00	0.95	-	-	1.00-2.50	-
45	0-0.05	1.05-1.69	1.64	-	-	-	?1.69
46	0-0.05	0.05-2.00	1.95+	-	-	-	-
47	0-0.05	0.05-1.20	1.15	-	-	1.20-1.91	1.91
48	-	0.00-0.70	0.70	-	-	0.70-1.80	1.81
49	-	0.00-0.60	0.60	-	-	0.60-1.25	1.25
50	0-0.05	0.05-0.70	0.65	-	-	0.70-1.91	-
51	-	0.00-0.12	0.12	0.12-0.60	-	0.60-1.24	?1.24
52	0-0.05	0.05-0.58	0.53	0.58-1.30	-	1.30-1.80	-
53	-	0.00-0.15	0.15	0.15-0.60	0.60-0.75	0.75-1.01	-
54	-	0.00-1.15	1.15	-	-	1.15-1.67	1.67
55	-	0.00-1.55	1.55+	-	-	-	1.80
56	0-0.02	0.02-1.38	1.36	-	-	-	-
57	-	0.00-2.20	2.20+	-	-	-	-
58	-	0.00-2.00	2.00+	-	-	-	?2.20
59	-	-	-	0.00-0.56	0.56-0.92	-	0.92
60	-	-	-	0.00-0.15	-	0.15-1.60	?1.64
61	-	0.00-0.10	0.10	-	-	0.10-1.63	-
62	-	0.00-1.35	1.35	-	-	1.35-1.69+	-
63	0-0.05	0.05-1.46	1.41+	-	-	-	1.79
64	0-0.05	0.05-2.40	2.35+	-	-	-	-
65	0-0.03	0.03-2.65	2.62+	-	-	-	-
66	-	0.00-0.75	0.75	-	-	-	0.75
67	0-0.03	-	-	-	-	0.03-1.10	1.10
68	0-0.10	0.10-1.45	1.35+	-	-	-	-
69	0-0.05	0.05-3.00	2.95+	-	-	-	-
70	-	0.00-1.64	1.64	-	1.64-2.00	2.00-2.24	-
71	-	0.00-0.62	0.62	-	-	-	0.62
72	0-0.02	0.02-1.57	1.55	-	-	-	1.57
73	-	0.00-3.40	3.40	3.40-3.71	-	-	3.71
74	-	0.00-3.72	3.72	-	-	-	?3.72

TABLE B

DRILL HOLE SUMMARY - WARNES LAKE DUNES

Showing lithological intervals and gypsum thickness in metres

HOLE WS	Algal mat	Gypsum	Gypsum thick.	Calc.gyps/ Gyps. calc	Sand	Clay	Calcrete basement
109	-	0.00-0.67	0.67+	-	-	-	-
110	-	0.00-0.50	0.50+	-	-	-	-
111	-	0.00-1.58	1.58+	-	-	-	-
112	-	0.00-0.70	0.70+	-	-	-	-
113	-	0.00-0.50	0.50+	-	-	-	-
114	-	0.00-1.50	1.50	-	-	1.50-1.60	-
115	-	0.00-0.94	0.94+	-	-	-	-
116	-	0.00-0.46	0.46	0.46-0.93	-	-	-
117	-	0.00-1.27	1.27+	-	-	-	-
118	-	0.00-1.11	1.11	-	-	-	-
119	-	0.00-0.52	0.52	-	-	-	0.52
120	-	0.00-1.13	1.13+	-	-	-	-

TABLE C

DRILL HOLE SUMMARY - WARNES SMALL LAKES

Showing lithological intervals and gypsum thickness in metres

HOLE WS	Algal mat	Gypsum	Gypsum thick.	Calc.gyps/ Gyps. calc	Sand	Clay	Calcrete basement
106	-	0.00-1.40	1.40	-	-	-	1.40
107	-	0.00-0.65	0.65	-	-	0.65-1.05	-
108	-	-	-	0.00-1.45	-	1.45-1.80	-

TABLE D

DRILL HOLE SUMMARY - LIHOU SWAMP

Showing lithological intervals and gypsum thickness in metres

HOLE L	Algal mat	Gypsum	Gypsum thick.	Calc.gyps/ Gyps. calc	Sand	Clay	Calcrete basement
1	-	0.00-0.75	0.75	0.75-2.20	-	-	2.20
2	0-0.06	0.06-1.40	1.34+	-	-	-	1.86
3	0-0.02	0.02-1.73	1.71	-	-	-	-
4	0-0.02	0.02-2.98	2.96	-	-	-	2.98
5	0-0.02	0.02-2.50	2.48	2.50-3.58	-	3.58-3.73	3.73
6	0-0.02	0.02-0.85	0.83	-	0.85-2.49	-	2.49
7	0-0.02	0.02-2.45	2.43	-	-	-	2.43
8	-	0.00-2.76	2.76+	-	-	-	-
9	0-0.02	0.02-2.42	2.42	-	-	-	-
10	0-0.02	-	-	-		0.02-3.00	
					3.00-3.25	3.25-3.45	-
11	0-0.02	0.02-2.89	2.87+	-	-	-	-
12	-	0.00-2.23	2.23+	-	-	-	-
13	0-0.02	0.02-2.71	2.69+	-	-	-	-
14	-	0.00-0.91	0.91	0.91-1.86	-	-	1.86
15	0-0.02	0.02-0.75	0.73	0.73-2.21	-	-	2.21
16	0-0.05	0.05-0.75	0.70	0.75-1.97	-	-	1.97
17	0-0.03	0.03-0.75	0.72	0.75-1.94	-	-	1.94
18	-	0.00-0.60	0.60	0.60-1.50	1.50-1.99	-	1.99
19	-	0.00-2.18	2.18	-	-	-	2.18
20	-	0.00-2.47	2.47	2.47-3.08	-	-	3.08
21	-	0.00-2.43	2.43	2.43-3.50	-	-	3.50
22	0-0.02	0.02-0.80	0.78	0.80-2.80	-	2.80-3.08	3.08
23	0-0.03	0.03-2.34	2.31	-	-	2.34-2.54	2.54
24	-	0.00-1.60	1.60	1.60-2.79	2.79-2.84	-	2.84
25	-	0.00-1.04	1.04	1.04-1.90	-	-	-
26	-	0.00-0.70	0.70	0.70-1.40	1.40-1.51	-	-
27	-	0.00-0.85	0.85	0.85-1.60	(limestone)	1.60-1.87	1.93
28	-	0.00-0.50	0.50	0.50-1.00	1.00-1.90	-	1.90
29	-	0.00-2.04	2.04	-	-	-	2.04
30	-	0.00-0.90	0.90	-	-	0.90-2.27	-
31	-	-	-	0.00-0.29	0.29-1.78	-	1.78
32	-	-	-	0.00-0.55	0.55-1.00	1.00-1.70	1.70
33	-	0.00-1.86	1.86	-	-	-	1.86
34	0-0.02	0.02-2.60	2.58	-	-	2.60-2.71	2.71
35	-	0.00-0.80	0.80	-	-	0.80-1.77	1.77
36	0-0.02	-	-	-	-	0.02-1.66	1.66
37	0-0.02	-	-	-	-	0.02-0.92	0.92
38	0-0.02	-	-	-	-	0.02-1.05	1.05
39	0-0.02	0.02-1.42	1.40	1.42-1.67	-	1.67-1.89+	2.35
40	0-0.05	-	-	0.05-0.60	-	-	0.60

TABLE D (continued)

DRILL HOLE SUMMARY – LIHOU SWAMP

Showing lithological intervals and gypsum thickness in metres

HOLE L	Algal mat	Gypsum	Gypsum thick.	Calc.gyps/ Gyps. calc	Sand	Clay	Calcrete basement
41	0-0.02	–	–	–	–	0.02-1.50	
				1.50-2.50	2.50-2.54	–	2.54
42	–	–	–	–	–	0.00-0.69	0.69
43	–	–	–	0.00-0.50	(limestone)	0.50-1.10	
	–	–	–		1.10-2.00	2.00-2.45	2.45
44	0-0.02	–	–	–	–	0.02-1.65	1.65
45	0-0.02	–	–	–	–	0.02-1.05	1.05
46	–	–	–	0.00-0.65	–	0.65-0.94	0.94
47	0-0.02	–	–	0.02-0.80	(limestone)	–	
				0.80-1.17+	–	–	1.60
48	–	–	–	–	–	0.00-1.26	1.26
49	–	0.00-1.42	1.42	1.42-2.00	–	2.00-3.00	
					3.00-3.50	–	3.50
50	–	–	–	0.00-0.60	(limestone)	0.60-1.20	
					1.20-2.72	–	2.72
51	–	–	–	–	–	0.00-3.48	–
52	0-0.04	–	–	–	–	0.04-0.67	0.67
53	0-0.03	0.03-2.72	2.69	–	–	–	–
54	0-0.05	–	–	0.05-0.64	–	0.64-1.93	
					1.93-2.65	2.65-3.15	3.15
55	–	–	–	–	–	0.00-0.28	0.28
56	0-0.05	–	–	–	–	0.05-2.00+	2.28
57	0-0.04	0.04-0.65	0.61	0.65-1.72	–	–	
		1.72-2.21	0.49	–	2.21-2.37	–	2.37
58	–	0.00-2.28	2.28	–	–	–	2.28
59	–	–	–	0.00-0.93	0.93-1.22	1.22-1.55	
					1.55-1.95	–	1.95
60	–	0.00-1.94	1.94	–	–	–	1.94
61	–	–	–	0.00-0.30	–	0.30-0.72	0.72
62	0-0.25	0.25-0.40	0.15	–	0.40-0.61	–	0.61
63	–	–	–	–	–	0.00-0.56	0.56

Algal Mat:

This varies in thickness from 0.02m to 0.20m, and is recorded in 31 holes.

Gypsum:

This unit is found in 40 of the holes, and ranges in thickness from 0.15m in L62 to 2.96m in L4. It forms the lake surface in five of the holes. The gypsum is mainly unconsolidated and varies in grain size from fine to very coarse, the grain size usually increasing with depth. In L23 and L58, unconsolidated very coarse crystals were encountered. The gypsum unit becomes more calcareous with depth. Colour is creamy to white at the surface but may range to grey at depth. White layers of carbonate clay/silt are more common than at Warnes.

Calcareous Gypsum to Gypsiferous Calcarious Clay:

Generally underlying the gypsum. Colour varies from white to grey and becomes more calcareous with depth.

Sand:

Underlies the gypsum and gypsiferous calcareous clay. Colour is most commonly grey, with black carbonaceous sand in L49. Clay content increases with depth.

Clay:

Commonly grey but may be green and more calcareous with depth and is occasionally iron stained.

Calcrete:

Calcrete basement, encountered in 51 holes is grey to yellow-grey, hard and crystalline. Depth to calcrete basement ranges from 0.56m in L63 to 3.73m in L5.

In L57 and L58, limestone separates gypsiferous layers.

QUALITY OF GYPSUM

The first 21 samples from the 8 scout holes in 1991 were analysed in Adelaide by Classic Laboratories Ltd.

The main sampling program in 1992 produced 287 samples which were analysed in Brisbane by Australian Laboratory Services Pty Ltd (ALS) using the following techniques:

- samples were dried at 45°C prior to pulverising
- analysis applies to acid-digested samples in 1 + 1 HCl
- gypsum content is calculated from S concentrations
- excess Ca is reported as $CaCO_3$
- Na and K are reported as chlorides.

The analytical results in Classic report 1AD1158 in Appendix B1 have been adjusted in Appendix B2 for calculation of average grades to conform with ALS results based on check analyses of five samples from holes WS27, WS34, WS35, L2 and L3. Appendix A contains the adjusted values.

Weighted average gypsum contents for each hole are calculated in Appendix C using Areas of Influence as shown on Figure 6 for Warnes and Figure 7 for Lihou based on a minimum gypsum thickness of 0.5m.

Overall average grade of in situ gypsum for Warnes based on 60 holes is 82.4% gypsum and 4.5% salt and for Lihou - 38 holes is 67.4% gypsum and 4.0% salt. The other main contaminant is carbonate generally as finegrained calcite ($CaCO_3$) and dolomite ($CaMgCO_3$).

For the dunes at Warnes, the weighted average was calculated for WS109 to 120.

An arithmetic average for the 12 holes was:

- raw gypsum - 88.3%
- salt - 3.07%

RESERVES

Warnes - Main Lake

Based on Figures 6 and 8 and calculations in Appendix D1, measured reserves of gypsum are summarised in Table E.

Bulk density is assumed to be 1.35 tonnes per cubic metre, as used by South Australian Department of Mines and Energy for unconsolidated gypsarenite.

TABLE E

RESERVES - WARNES MAIN LAKE

	TOTAL MORE THAN 0.5M THICK	DELETE WS52, 66, 85, 101 - 104
No. of Holes	60	53
Av. Thickness (m)	1.39	1.47
Area (ha)	214	198
Volume (mill m^3)	3.409	3.252
MILLION TONNES		
By Areas fig. 6	4.60	4.20
By Isopachs fig. 8	4.42	4.39
AVERAGE GRADE (%)		
Raw Gypsum	82.4	83.4
Salt	4.5	4.5
Expected Washed Gypsum	86.1	87.1

From Table E, the lower rounded value of 4.4 million tonnes is adopted as the total measured in situ geological reserves of raw gypsum with a thickness of 0.5m or more.

Mineable reserves will depend on mining methods and may be increased by including marginal gypsum less than 0.5m thick.

The average grade of 82.4% gypsum may be improved by deleting lower grade marginal holes such as WS52, 66, 85 and 101-104 as in column 2 of Table E.

Refined salt-free gypsum with a minimum of 87% gypsum is expected to exceed 4.0 million tonnes.

Selective mining of the central high grade zone of WS46, 56, 62-65 and 69-71 where average grades range from 85.3 to 90.2% gypsum should provide plaster grade washed product with 92% gypsum.

Warnes - Dunes

From calculations in Appendix D2 based on areas of dunes in Figure 4 and density of 1.35, indicated in situ geological reserves of raw gypsum total 90,000 tonnes.

Raw gypsum averages 88.3%. With the removal of an average salt content of 3.1%, washed product is expected to contain 91.1% gypsum.

Lihou

Based on Figures 7, 9 and 10, and calculations in Appendix D3 and D4, measured reserves of gypsum are summarised in Table F. Bulk density of 1.35 is assumed.

TABLE F

RESERVES - LIHOU

	A	B	C	D
	TOTAL MORE THAN 0.5m THICK	HIGHER GRADE MORE THAN 0.5m THICK	DELETE L5, 35, REDUCE L20, 21, 34, 57 & 58	DELETE L4, 23, 27, 28, 39, 49, 53
No. of Holes	38	36	36	28
Av. Thickness (m)	1.47	1.23	1.48	1.41
Area (ha)	87	67	67	65.4
Volume (mill m^3)	1.276	0.820	1.232	0.967
MILLION TONNES				
By Area (fig. 7)	1.97	-	1.66	1.31
By Isopach (fig. 9)	1.72	-	-	-
(fig. 10)	-	1.11	-	-
AVERAGE GRADE %				
Raw Gypsum	67.4	70.8	70.8	73.3
Salt	4.0	4.0	4.0	4.0
Expected Washed Gypsum	70.1	73.6	73.6	76.2

From Table F Column A, the lower rounded value of 1.7 million tonnes is adopted as the total measured in situ geological reserves of raw gypsum with a thickness of 0.5m or more.

Mineable reserves will depend on mining methods and may be increased slightly by including marginal gypsum less than 0.5m thick.

The overall average grade of 67.4% gypsum may be upgraded to:

- 70.8% by deleting lower grade mainly basal intervals (Column B)
- 70.8% by deleting low grade holes (Column C)
- 73.3% by deleting moderately low grade holes (Column D).

Refined salt-free gypsum with a minimum of 76% gypsum is expected to exceed 1.0 million tonnes.

Selective mining of the higher grade upper 0.60-0.75m thick south central zone of L15, 16, 17, 20, 21 and 26 where average grades range from 80.3 to 84.1% should provide limited quantities of washed product with 85% gypsum.

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APPENDIX A

LITHOLOGICAL LOGS AND GYPSUM ASSAYS

VARNES SWAMP BOREHOLES - LITHOLOGICAL LOGS AND GYPSUM ASSAYS

MAIN LAKE

HOLE NO	INTERVAL (metres)	LITHOLOGY	GYPSUM percent
WS 27	0.00-0.10	algal mat	
	0.10-1.09	white to cream, f.g. gypsum	86.9*
	1.09-1.40	light grey, m.g. gypsum	83.9*
WS 28	0.00-0.04	algal mat	
	0.04-0.20	gypsum	
	0.20-0.87	cream, f.g. gypsum	84.0*
	0.87-1.25	gritty, light grey gypsum	81.5*
	1.25-1.51	gritty grey, calcareous clay	
WS 29	0.00-0.35	creamy gypsum with dark inclusions	
WS 34	0.00-0.20	algal mat with organic matter	
	0.20-1.00	white m.g. gypsum with dark band	91.1*
	1.00-1.90	grey, c.g. gypsum, becoming calcareous	89.0*
	1.90-2.00	as above	87.0*
WS 35	0.00-0.03	gypsiferous algal mat	
	0.03-0.55	creamy gypsum	75.8*
	0.55-1.26	white c.g. gypsum	87.4*
	1.26-1.31	dark grey sandy clay with calcrete	
WS 36	0.00-0.03	algal mat	
	0.03-0.49	cream to white gypsum with minor organic matter	91.7*
	0.49-1.62	white, c.g. gypsum	89.1*

*Classic analysis corrected to ALS standard

WS 38	0.00-0.15	dark, c.g. gypsum with algal mat	
	0.15-0.45	lt grey, m.g. gypsum with thin organic layers	89.9
	0.45-1.75	lt grey, f.g. calcareous clay	4.1
	1.75-1.92	dk grey, f.g. calcareous clay with org. matter	4.5
WS 39	0.00-0.08	algal mat	
	0.08-0.75	lt grey, m.g. gypsum with thin organic layers	88.1
	0.75-0.78	dark grey, organic rich layer	
	0.78-2.17	yellow-grey, m.g. gypsum	77.0
WS 40	0.00-0.08	algal mat	
	0.08-0.80	lt grey, m.g. gypsum with thin organic layers	84.8
	0.80-2.08	lt grey to yellow, m.g. gypsum	79.6
WS 41	0.00-0.05	algal mat	
	0.05-0.90	white, m.g. gypsum, organic layers near top	82.7
	0.90-1.40	grey, slightly gypsiferous, calcareous clay	14.9
	1.40-1.90	grey, calcareous clay with m.g. quartz sand	1.3

HOLE NO	INTERVAL (metres)	LITHOLOGY	GYPSUM percent
WS 42	0.00-0.05	algal mat	
	0.05-0.60	grey, gypsiferous, calcareous clay with brown staining near base	27.1
	0.60-0.81	brown clay and calcrete	
WS 43	0.00-0.05	algal mat	
	0.05-0.35	white, calcareous clay with m.g. gypsum and gastropod shells	
	0.35-0.85	light grey, gypsiferous calcareous clay with gastropod shells	27.0
	0.85-0.91	clay and calcrete	
WS 44	0.00-0.05	algal mat	
	0.05-1.00	white to grey, m.g. gypsum	87.4
	1.00-2.20	light grey calcareous mud, slightly gypsiferous	6.1
	2.20-2.50	dark clay	
WS 45	0.00-0.05	algal mat with grey gypsum	
	0.05-1.00	white, m.g. gypsum	88.2
	1.00-1.69	grey, m.g. calcareous gypsum	71.6
WS 46	0.00-0.05	algal mat	
	0.05-0.30	light grey, m.g. gypsum with organic matter	
	0.30-1.10	white, m.g. gypsum	89.4
	1.10-2.00	grey, m.g. gypsum	87.5
WS 47	0.00-0.05	algal mat	
	0.05-0.80	white, m.g. gypsum with thin organic layers	
	0.80-1.20	yellow-grey, m.g. gypsum	86.9
	1.20-1.85	grey clay	4.8
	1.85-1.91	calcareous clay	
WS 48	0.00-0.10	grey, c.g. gypsum with algal mat	
	0.10-0.70	white, m.g. gypsum with grey organic matter and gastropod shells	85.9
	0.70-1.80	grey, calcareous clay	7.0
WS 49	0.00-0.60	light grey, m.g. gypsum	83.4
	0.60-1.25	light grey, calcareous clay	4.8
	1.25-1.32	gypsiferous calcrete	
WS 50	0.00-0.05	algal mat	
	0.05-0.60	white, m.g. gypsum	77.2
	0.60-0.70	white, calcareous clay	
	0.70-1.91	light grey to dark grey, calcareous clay	5.9
WS 51	0.00-0.12	gypsum	
	0.12-0.60	white to grey-green gypsiferous,calcareous clay	46.2
	0.60-0.62	black mud	
	0.62-1.24	dark grey to brown, calcareous clay	3.8

HOLE NO	INTERVAL (metres)	LITHOLOGY	GYPSUM percent
WS 52	0.00-0.05	algal mat	
	0.05-0.58	white gypsum	
	0.58-1.30	white to grey calcareous clay	58.3
	1.30-1.82	calcareous clay with dark organic matter	5.0
WS 53	0.00-0.15	algal mat and grey gypsum	
	0.15-0.20	limestone	
	0.20-0.60	white and grey, calcareous clay with organic matter	2.2
	0.60-0.75	grey to brown sand	
	0.75-1.01	brown clay	
WS 54	0.00-1.15	white to light grey m.g. gypsum with gastropods	84.4
	1.15-1.62	grey, calcareous clay	2.5
	1.62-1.67	brown, calcareous clay	
WS 55	0.00-1.55	white to light grey, m.g. to c.g. gypsum	82.0
WS 56	0.00-0.02	algal mat	
	0.02-0.95	white, f.g. gypsum with gastropod shells	86.1
	0.95-1.38	light grey, m.g. gypsum	87.0
WS 57	0.00-1.46	white to light grey, m.g. gypsum	82.3
	1.46-2.20	as above	83.0
WS 58	0.00-0.15	light grey, f.g. gypsum	
	0.15-0.80	white, m.g. gypsum	86.6
	0.80-2.00	grey, m.g. to c.g. gypsum	83.6
WS 59	0.00-0.56	cream, slightly gypsiferous, calcareous clay	24.2
	0.56-0.92	quartz sand, less calcareous with depth	1.9
WS 60	0.00-0.15	gypsiferous, calcareous clay	
	0.15-0.90	calcareous clay	18.4
	0.90-1.60	grey and brown calcareous clay	
WS 61	0.00-0.10	grey gypsum	
	0.10-0.55	grey calcareous clay	17.8
	0.55-1.20	iron stained calcareous clay	0.6
	1.20-1.63	highly iron stained calcareous clay	0.3
WS 62	0.00-0.12	white, f.g. gypsum with thin organic layers	
	0.12-1.35	white, m.g. gypsum with gastropods	85.3
	1.35-1.69	dark grey sandy calcareous clay	14.3
WS 63	0.00-0.05	algal mat	
	0.05-0.95	white, m.g. gypsum	87.4
	0.95-1.46	light grey, m.g. gypsum	83.2

HOLE NO	INTERVAL (metres)	LITHOLOGY	GYPSUM percent
WS 64	0.00-0.05	algal mat	
	0.05-0.90	white, m.g. gypsum	87.3
	0.90-1.73	light grey, m.g. to c.g. gypsum	86.1
	1.73-2.40	as above	88.6
WS 65	0.00-0.03	algal mat	
	0.03-0.95	white, m.g. gypsum with thin organic layers	88.5
	0.95-1.40	light grey, c.g. to m.g. gypsum	86.1
	1.40-2.65	as above	87.8
WS 66	0.00-0.75	white to grey, m.g. gypsum with calc. patches	67.5
	0.75-0.84	weathered calcrete	
WS 67	0.00-0.03	algal mat	
	0.03-0.45	light grey, c.g. calcareous clay	6.5
	0.45-1.10	brown and grey clay with calcrete at base	
WS 68	0.00-0.10	algal mat with light grey, f.g. gypsum	
	0.10-1.20	white, m.g gypsum	
	1.20-1.45	light grey, m.g. gypsum	82.6
WS 69	0.00-0.05	algal mat with light grey gypsum	
	0.05-1.05	white, m.g. gypsum	90.0
	1.05-2.34	light grey, m.g. gypsum	90.3
	2.34-3.00	light grey, c.g. gypsum	87.0
WS 70	0.00-1.25	white, f.g. gypsum	90.2
	1.25-1.64	light grey, f.g. calcareous gypsum	58.7
	1.64-2.00	grey-green, clayey sand	
	2.00-2.24	brown, sandy clay	
WS 71	0.00-0.15	creamy, f.g. gypsum	
	0.15-0.62	white, m.g. gypsum	89.0
WS 72	0.00-0.02	algal mat	
	0.02-1.57	white to grey, m.g. to c.g. gypsum	82.1
WS 73	0.00-1.00	white, m.g. to c.g. gypsum	88.1
	1.00-1.81	light grey, c.g. gypsum	83.2
	1.81-2.87	: : : :	73.8
	2.87-3.40	grey gypsum with layers of selenite to 0.5cm	71.6
	3.40-3.71	gypsiferous grey clay and calcrete	45.6
WS 74	0.00-1.25	white, c.g. gypsum	88.9
	1.25-1.86	light grey, m.g. gypsum	85.8
	1.86-3.05	: : : :	77.5
	3.05-3.72	grey, m.g. calcareous gypsum	67.1

HOLE NO	INTERVAL (metres)	LITHOLOGY	GYPSUM percent
WS 75	0.00-0.30	creamy, f.g. gypsum	
	0.30-1.10	white, m.g. gypsum	86.8
	1.10-2.10	light grey to grey, m.g. to c.g. gypsum	74.4
	2.10-2.34	: : : : : : :	85.6
WS 76	0.00-0.05	algal mat	
	0.05-1.48	white to light grey, m.g. gypsum	84.2
	1.48-2.10	grey, m.g. gypsum	71.4
	2.10-2.62	grey, c.g. sand	
	2.62-3.22	green, sandy clay	
WS 77	0.00-0.15	creamy, f.g. gypsum	
	0.15-0.90	white, m.g. gypsum	78.6
	0.90-1.56	calcareous sand	
WS 78	0.00-0.10	dark grey, f.g. gypsum	
	0.10-1.03	white, m.g. gypsum, bedrock at base	82.8
WS 79	0.00-1.53	white, m.g. gypsum, limestone at base	86.2
WS 80	0.00-1.24	white, m.g. gypsum	85.2
	1.24-1.46	creamy clay and sandy brown clay, lst at base	
WS 81	0.00-1.35	white, m.g. gypsum	84.7
	1.35-1.41	grey, calcareous gypsum	
WS 82	0.00-0.02	algal mat	
	0.02-1.00	white, f.g. to m.g. gypsum	82.2
	1.00-1.32	grey to dark grey, slightly calcareous gypsum	57.9
	1.32-1.77	greenish grey clay	
WS 83	0.00-0.10	grey, f.g. gypsum	
	0.10-0.95	white, m.g. gypsum	77.4
	0.95-1.11	grey, calcareous clay with iron staining	
WS 84	0.00-0.05	algal mat	
	0.05-0.25	gypsiferous calcareous clay	24.6
	0.25-0.38	white, weathered calcrete	
	0.38-0.49	brown clay and sand	
WS 85	0.00-0.40	grey and cream, f.g. to m.g. calcareous gypsum	61.6
	0.40-0.57	brown sand	
WS 86	0.00-0.69	white, m.g. gypsum	
	0.69-1.25	white to cream, m.g. gypsum	76.0
	1.25-1.54	grey gypsum	80.5
	1.54-1.90	grey c.g. sand	
	1.90-2.25	grey, m.g. clayey sand	
WS 87	0.00-1.05	white gypsum	82.7
	1.05-1.84	creamy to grey, clayey sand	

HOLE NO	INTERVAL (metres)	LITHOLOGY	GYPSUM percent
WS 88	0.00-0.41	creamy, f.g. gypsum	75.7
	0.41-0.45	brown clay	
WS 89	0.00-0.85	creamy, f.g. gypsiferous clay	41.9
	0.85-0.91	iron rich clay	
WS 90	0.00-0.15	white gypsum	
	0.15-0.50	gypsiferous calcareous clay	50.5
	0.50-0.95	brown, iron rich clay	
WS 91	0.00-0.05	algal mat	
	0.05-0.80	white, m.g. gypsum	86.7
	0.80-1.81	grey, calcareous clay	14.2
WS 92	0.00-0.05	algal mat	
	0.05-0.80	calcareous clay and limestone	6.3
	0.80-1.18	grey clay with black mud	
WS 93	0.00-0.02	algal mat	
	0.02-0.50	grey to white, calcareous clay	11.8
	0.50-0.87	calcareous clay	
WS 94	0.00-0.28	brown clay	
WS 95	0.00-0.02	algal mat	
	0.02-0.45	white, m.g. gypsum	
	0.45-1.81	white to grey calcareous clay	36.4
	1.81-2.18	dark mud	
WS 96	0.00-0.45	creamy, calcareous clay with gastropods	12.6
	0.45-0.95	grey, iron stained sand	
	0.95-1.39	dark grey sandy clay	
WS 97	0.00-0.05	algal mat	
	0.05-1.10	creamy, gypsiferous, calcareous clay	42.5
	1.10-1.30	grey ?diatomite	15.3
	1.30-2.14	grey and grey-green sandy clay	
WS 98	0.00-0.35	white, m.g. gypsum	
	0.35-0.75	white, gypsiferous calcareous clay	61.8
	0.75-0.99	iron stained grey sand	
WS 99	0.00-1.00	white, calcareous clay, gypsiferous at top	29.1
	1.00-1.45	white to brown sand	
	1.45-2.35	greenish, clayey sand with gypsum layers	
WS 100	0.00-0.20	grey, f.g. gypsum	
	0.20-1.40	white to light grey, m.g. gypsum	82.7
	1.40-1.60	light grey sand	
	1.60-1.90	grey ?diatomite clay	
	1.90-2.07	brown clay	

HOLE NO	INTERVAL (metres)	LITHOLOGY	GYPSUM percent
WS 101	0.00-0.30	creamy gypsum	
	0.30-0.40	white, m.g. slightly calcareous gypsum	69.5
	0.40-1.10	grey, sandy calcareous clay with green patches	5.4
	1.10-1.90	grey, m.g. sand	
	1.90-2.12	green sandy clay	
WS 102	0.00-0.52	calcareous gypsum	
	0.52-0.93	calcareous, gypsiferous clay	58.2
	0.93-1.46	iron stained green and grey calcareous sand	4.7
	1.46-1.75	grey, m.g. sand	
	1.75-1.85	green, sandy clay	
WS 103	0.00-0.02	algal mat	
	0.02-0.95	white, calcareous, gypsiferous mud	42.9
	0.95-1.84	grey sand with clay at base	
WS 104	0.00-1.00	cream to light grey, m.g. to c.g. gypsum	71.5
	1.00-1.10	grey sand	
	1.10-1.53	orange sandy clay	
WS 105	0.00-0.20	white to grey gypsum	
	0.20-0.80	grey, gypsiferous, calcareous clay	43.4
	0.80-0.92	quartz sand	
	0.92-0.95	white, calcareous mud	
	0.95-1.35	creamy, grey green, gypsiferous, calc. clay	41.8
	1.35-1.72	green clay	
WS 121	0.00-0.88	cream, f.g. to m.g. gypsum limestone at base	77.4
WS 122	0.00-0.32	cream to white, f.g. gypsum	85.8
	0.32-1.05	white m.g. gypsum with ?quartz sand	69.9
	1.05-1.15	white, iron stained gypsum	
	1.15-1.27	greenish, grey clay	
WS 123	0.00-0.50	cream gypsum	82.6
	0.50-0.84	orange, sandy clay	
WS 124	0.00-0.99	white, m.g. gypsum with ?quartz sand	66.7
	0.99-2.76	white to grey, m.g. to c.g. gypsum	81.2
	2.76-2.91	unable to recover sample, very hard at base	
WS 125	0.00-0.04	algal mat	
	0.04-0.95	white f.g. gypsum	85.4
	0.95-1.67	light grey gypsum	81.5
	1.67-1.89	sample not recovered, very hard at base	

HOLE NO	INTERVAL (metres)	LITHOLOGY	GYPSUM percent
WS 126	0.00-0.05	algal mat	
	0.05-0.84	white to cream, m.g. gypsum	85.6
	0.84-1.13	f.g. dark calcareous and organic layer	63.1
	1.13-1.60	yellow to grey m.g. to f.g. calcareous gypsum	64.7
	1.60-2.33	calcareous sand, grading to grey clay	
WS 127	0.00-0.40	cream, f.g. gypsum	74.5
	0.40-1.78	white to orange sand grading to orange clay	

VARNES SWAMP BOREHOLES - LITHOLOGICAL LOGS AND GYPSUM ASSAYS

DUNES

HOLE NO	INTERVAL (metres)	LITHOLOGY	GYPSUM percent
WS 109	0.00-0.67	creamy, f.g. gypsum	85.5
WS 110	0.00-0.50	light brown to creamy, f.g. gypsum	88.9
WS 111	0.00-0.50	light brown to creamy, f.g. gypsum	
	0.50-1.00	light brown to creamy, m.g. gypsum	89.4
	1.00-1.58	white, m.g. gypsum	84.5
WS 112	0.00-0.70	creamy, f.g. gypsum	84.4
WS 113	0.00-0.50	creamy, f.g. gypsum	86.0
WS 114	0.00-0.27	light brown, f.g. gypsum	88.4
	0.27-1.50	creamy to white gypsum	90.9
	1.50-1.60	brown basal clay	
WS 115	0.00-0.94	creamy, f.g. gypsum	91.3
WS 116	0.00-0.46	creamy, f.g. gypsum	
	0.46-0.93	gypsiferous, calcareous clay with sand layers	51.4
WS 117	0.00-0.55	creamy to light brown, f.g. gypsum	85.5
	0.55-1.27	white, m.g. gypsum	87.0
WS 118	0.00-1.11	brown to cream, m.g. gypsum	93.1
WS 119	0.00-0.52	cream to brown, m.g. gypsum	89.2
WS 120	0.00-0.45	cream, f.g. gypsum	89.3
	0.45-1.13	white, m.g. gypsum	95.3

VARNES SWAMP BOREHOLES - LITHOLOGICAL LOGS AND GYPSUM ASSAYS

SMALL LAKES

HOLE NO	INTERVAL (metres)	LITHOLOGY	GYPSUM percent
WS 106	0.00-0.40	cream to white f.g. gypsum	82.9
	0.40-1.40	white, f.g. gypsum, hard at base	84.3
WS 107	0.00-0.65	cream to white, f.g. gypsum	79.5
	0.65-1.05	grey, sandy clay with iron staining	
WS 108	0.00-1.45	slightly gypsiferous, cream to white clay	16.9
	1.45-1.80	black, gritty mud	

LIHOU SWAMP BOREHOLES - LITHOLOGICAL LOGS AND GYPSUM ASSAYS

HOLE NO	INTERVAL (metres)	LITHOLOGY	GYPSUM percent
L 1	0.00-0.08	algal mat with small gastropods	
	0.08-0.21	light grey, fine grained gypsum	74.1*
	0.21-0.40	white, slightly coarser gypsum	
	0.40-0.75	cream, m.g. gypsum	79.2*
	0.75-1.79	green gypsiferous calcareous clay with calcrete	42.8
	1.79-2.10	green gypsiferous calcareous clay with calcrete	51.6
	2.10-2.20	green gypsiferous calcareous clay with calcrete	
L 2	0.00-0.06	algal mat with small gastropods	
	0.06-0.33	light grey f.g. gypsum	75.9*
	0.33-1.18	white to light grey f.g. gypsum	71.0*
	1.18-1.40	calcareous light grey gypsum	56.9*
	1.40-1.86	sample not recovered, but very hard at base	
L 3	0.00-0.02	brown algal mat	
	0.02-0.20	light grey coarse grained gypsum	
	0.20-0.82	creamy to white, f.g. to c.g. gypsum	76.4*
	0.82-1.12	white, c.g. calcareous gypsum	59.6*
	1.12-1.73	grey, c.g. calcareous gypsum	53.0*

*Classic analysis corrected to ALS standard

HOLE NO	INTERVAL (metres)	LITHOLOGY	GYPSUM percent
L 4	0.00-0.02	algal mat	
	0.02-0.45	grey to white, f.g. calcareous gypsum	58.1
	0.45-1.79	light grey to white, m.g. calcareous gypsum	
	1.79-2.89	light grey, m.g. calcareous gypsum	
	2.89-2.98	white, f.g. calcareous gypsum with hard basement	61.8
L 5	0.00-0.02	algal mat	
	0.02-0.85	light grey, gypsiferous calcareous clay	46.6
	0.85-2.50	white, f.g. to m.g. calcareous gypsum	50.6
	2.50-2.88	sandy, gypsiferous calcareous clay	
	2.88-3.58	sandy, calcareous gypsiferous clay with minor black mud	28.3
	3.58-3.73	black mud, hard at base	
L 6	0.00-0.02	algal mat	
	0.02-0.85	white, m.g. gypsum	70.4
	0.85-2.49	grey, calcareous sand, very hard at base	17.1
L 7	0.00-0.02	algal mat	
	0.02-0.20	creamy, f.g. gypsum	
	0.20-0.98	white, m.g. gypsum	75.0
	0.98-2.45	grey to light grey, c.g. calcareous gypsum	63.0

HOLE NO	INTERVAL (metres)	LITHOLOGY	GYPSUM percent
L 8	0.00-0.14	cream, f.g. gypsum	
	0.14-0.80	white, m.g. gypsum	73.0
	0.80-1.62	light grey, m.g. gypsum	78.0
	1.62-2.76	: : : :	69.5
L 9	0.00-0.02	algal mat	
	0.02-0.94	creamy to white, f.g. to m.g. gypsum	75.4
	0.94-1.52	light grey, m.g. gypsum	72.4
	1.52-2.15	: : : :	68.5
	2.15-2.42	: : : :	74.8
L 10	0.00-0.02	algal mat	
	0.02-0.20	creamy calcareous clay	
	0.20-1.05	white, calcareous clay	3.4
	1.05-2.82	grey, calcareous clay	3.1
	2.82-3.00	grey calcareous clay	
	3.00-3.25	grey sand	
	3.25-3.45	brown clay	
L 11	0.00-0.02	algal mat	
	0.02-0.65	white, m.g. gypsum	79.8
	0.65-1.54	grey, m.g. gypsum	75.9
	1.54-2.00	: : :	68.2
	2.00-2.89	grey, m.g. to c.g. gypsum, selenite at base	71.8
L 12	0.00-0.30	white, f.g. gypsum	
	0.30-1.65	banded grey, m.g. gypsum	69.9
	1.65-2.23	grey, c.g. crystalline gypsum	72.5
L 13	0.00-0.02	algal mat	
	0.02-1.15	white, m.g. gypsum	76.8
	1.15-1.78	grey, c.g. gypsum	63.9
	1.78-2.31	: : :	64.8
	2.31-2.71	: : :	64.0
L 14	0.00-0.91	creamy to white, f.g. gypsum slightly calc.	62.4
	0.91-1.60	grey, gypsiferous, calcareous clay	35.2
	1.60-1.86	grey, gypsiferous calcareous clay, hard at base	46.9
L 15	0.00-0.02	algal mat	
	0.02-0.75	white, m.g. gypsum	80.3
	0.75-2.21	grey, c.g. gypsiferous limestone, hard at base	36.6
L 16	0.00-0.05	algal mat	
	0.05-0.75	creamy to white, f.g. to c.g. gypsum	82.7
	0.75-1.39	gypsiferous limestone	24.1
	1.39-1.97	grey m.g. gypsum and dark clay	46.4
L 17	0.00-0.03	algal mat	
	0.03-0.75	creamy to white, f.g. to c.g. gypsum	84.1
	0.75-1.94	white to grey, gypsiferous limestone	32.1

HOLE NO	INTERVAL (metres)	LITHOLOGY	GYPSUM percent
L 18	0.00-0.60	creamy to white, f.g. to m.g. gypsum	79.9
	0.60-1.50	grey, gypsiferous limestone	21.3
	1.50-1.99	light to dark grey, clayey sand	3.4
L 19	0.00-0.90	creamy to white, m.g. gypsum	79.8
	0.90-1.60	grey, c.g. gypsum	67.3
	1.60-2.18	: : :	80.2
L 20	0.00-0.15	browm, m.g. gypsum with algal mat	
	0.15-0.60	white, m.g. gypsum	81.2
	0.60-1.95	grey, m.g. to c.g. calcareous gypsum	50.8
	1.95-2.47	grey, c.g. calcareous gypsum	58.6
	2.47-3.08	grey, gypsiferous, calcareous clay	31.5
L 21	0.00-0.15	algal mat and creamy, f.g. gypsum	
	0.15-0.65	white, m.g. gypsum	84.0
	0.65-1.55	light grey, m.g. calcareous gypsum	52.0
	1.55-2.43	grey, calcareous gypsum	53.1
	2.43-3.50	grey, gypsiferous clay	35.7
L 22	0.00-0.02	algal mat	
	0.02-0.80	creamy to white, f.g. to m.g. gypsum (old land surface at 0.65m)	79.1
	0.80-1.19	yellow limestone	4.7
	1.19-2.80	grey, c.g. calcareous gypsum	52.3
	2.80-3.08	black, sandy mud	
L 23	0.00-0.03	algal mat	
	0.03-0.81	creamy to white, f.g. gypsum	64.8
	0.81-1.25	coarse to very coarse loose crystals of clean gypsum in calcareous matrix	53.1
	1.25-2.34	grey, c.g. calcareous gypsum	59.9
	2.34-2.54	grey sandy mud	
L 24	0.00-0.85	creamy to white, f.g. to m.g. gypsum	68.4
	0.85-1.60	white, m.g. gypsum	68.2
	1.60-2.79	grey, c.g. calcareous gypsum	47.6
	2.79-2.84	grey, clayey sand	
L 25	0.00-1.04	creamy to white, f.g. to c.g. gypsum	73.7
	1.04-1.90	creamy to grey, limestone with coarse gypsum crystals at base	22.1
L 26	0.00-0.70	creamy to white, m.g. gypsum	82.6
	0.70-1.40	creamy, calcareous clay with c.g. ?gypsum	20.4
	1.40-1.51	grey, clayey sand	
L 27	0.00-0.85	creamy to white, f.g. to c.g. gypsum	63.9
	0.85-1.60	grey limestone	4.6
	1.65-1.87	grey ?diatomite	
	1.87-1.93	sample not recovered, but hard basement	

HOLE NO	INTERVAL (metres)	LITHOLOGY	GYPSUM percent
L 28	0.00-0.50	creamy, f.g. gypsum	60.8
	0.50-1.00	creamy to light grey, gypsiferous limestone	32.1
	1.00-1.60	light grey sandy limestone	8.0
	1.60-1.90	grey, m.g. sand	
L 29	0.00-0.75	white, f.g. gypsum	69.2
	0.75-1.45	light grey, m.g. gypsum	75.6
	1.45-2.04	: : : :	72.8
L 30	0.00-0.90	creamy to white, f.g. gypsum	68.5
	0.90-1.78	creamy to grey, calcareous clay	5.9
	1.78-2.07	grey, calcareous clay	6.1
	2.07-2.27	clay with black wood and leaves	
L 31	0.00-0.22	creamy to white, calcareous clay	5.1
	0.22-0.29	calcrete	
	0.29-0.80	yellow-brown sand	
	0.80-1.78	grey, gypsiferous sandy clay, coarser at depth	
L 32	0.00-0.55	creamy to white, calcareous clay	2.5
	0.55-1.00	calcareous sand	
	1.00-1.70	brown clay	
L 33	0.00-0.90	white, f.g. gypsum	67.7
	0.90-1.86	grey, m.g. gypsum, hard at base with limestone	69.3
L 34	0.00-0.02	algal mat	
	0.02-0.88	white, f.g. gypsum	72.7
	0.88-1.76	grey, c.g. calcareous gypsum	51.8
	1.76-2.60	grey, c.g. calcareous gypsum with thin fine carbonate layers	51.2
	2.60-2.71	dark grey clay	
L 35	0.00-0.80	white, f.g. to m.g. calcareous gypsum	50.8
	0.80-1.77	sandy ?diatomaceous mud with calcrete at base	
L 36	0.00-0.02	algal mat	
	0.02-0.83	creamy to white, calcareous clay	8.9
	0.83-1.66	dark grey to brown clay	
L 37	0.00-0.02	algal mat	
	0.02-0.35	white, gypsiferous, calcareous clay	24.9
	0.35-0.92	calcareous clay	
L 38	0.00-0.02	algal mat	
	0.02-0.65	cream to white calcareous clay with organic staining	6.4
	0.65-1.05	white, calcareous, gypsiferous clay	

HOLE NO	INTERVAL (metres)	LITHOLOGY	GYPSUM percent
L 39	0.00-0.02	algal mat	
	0.02-0.60	white, f.g. gypsum	73.4
	0.60-1.42	grey, m.g. calcareous gypsum	56.2
	1.42-1.67	grey clay, slightly gypsiferous	12.7
	1.67-1.89	grey clay	
	1.89-2.35	sample not recovered	
L 40	0.00-0.05	algal mat	
	0.05-0.60	coarsely crystalline gypsum in white, calcareous clay	42.7
	0.60-0.70	calcrete	
L 41	0.00-0.02	algal mat	
	0.02-1.50	creamy to white, calcareous clay	4.3
	1.50-2.50	grey, limestone	3.8
	2.50-2.54	grey sand	
L 42	0.00-0.69	grey to white, calcareous clay	3.1
	0.69-0.70	calcrete	
L 43	0.00-0.50	grey limestone	3.7
	0.50-1.10	brown stained, calcareous gritty clay	3.3
	1.10-2.00	gritty, fossiliferous, m.g. sand	
	2.00-2.45	?diatomite	
L 44	0.00-0.02	algal mat	
	0.02-0.85	white, calcareous clay	3.8
	0.85-1.10	calcareous, iron rich clay	
	1.10-1.65	grey, sandy ?diatomite clay	
L 45	0.00-0.02	algal mat	
	0.02-0.35	creamy to white, calcareous clay	4.9
	0.35-1.05	calcareous, white to brown, gypsiferous clay, sandy at base	
L 46	0.00-0.65	white, f.g. gypsiferous, calcareous clay with iron staining	41.8
	0.65-0.94	iron stained, calcareous clay	
L 47	0.00-0.02	algal mat	
	0.02-0.80	cream to white, limestone	3.8
	0.80-1.17	calcareous gypsum	
	1.17-1.60	sample not recovered, limestone at base	
L 48	0.00-0.84	yellow to light grey, calcareous clay	2.6
	0.84-1.26	dark grey, sandy clay	

HOLE NO	INTERVAL (metres)	LITHOLOGY	GYPSUM percent
L 49	0.00-0.99	cream to white, f.g. calcareous gypsum	59.2
	0.99-1.42	white, f.g. calcareous gypsum	62.3
	1.42-2.00	cream to grey, f.g. to m.g. gypsif. limestone	41.4
	2.00-3.00	dark grey gypsum with black clay at base	7.5
	3.00-3.50	black, clayey, m.g. sand	
L 50	0.00-0.60	cream limestone	3.3
	0.60-1.20	white calcareous clay	3.4
	1.20-2.25	white, calcareous m.g. sand	
	2.25-2.72	grey, c.g. sand	
L 51	0.00-0.60	cream, calcareous clay	4.1
	0.60-1.00	white, calcareous clay	3.6
	1.00-2.20	white, calcareous clay	3.9
	2.20-3.48	calcareous clay, becoming darker with depth	4.4
L 52	0.00-0.04	algal mat	
	0.04-0.15	light brown to cream, calcareous clay	
	0.15-0.67	white calcareous clay to limestone with thin organic layer	2.6
	0.67-0.74	weathered grey calcrete	
L 53	0.00-0.03	algal mat	
	0.03-0.97	cream to white, f.g. calcareous gypsum	57.7
	0.97-1.80	cream to white, f.g. gypsum	70.7
	1.80-2.72	grey, m.g. to c.g. gypsum with abundant hard calcareous layers	53.2
L 54	0.00-0.05	algal mat	
	0.05-0.64	cream slightly gypsiferous, calcareous clay with common gastropods	18.8
	0.64-1.93	white, f.g. calcareous clay	4.5
	1.93-2.65	grey, c.g. ?calcareous sand	3.1
	2.65-3.15	grey clay with calcareous lumps calcrete at base	4.2
L 55	0.00-0.20	brown mud	
	0.20-0.28	gypsum	
	0.28-0.32	weathered calcrete	
L 56	0.00-0.05	algal mat	
	0.05-0.22	cream, calcareous clay	
	0.22-1.00	white, calcareous clay	5.5
	1.00-1.36	light grey, calcareous clay	3.7
	1.36-2.00	grey calcareous clay	4.0

HOLE NO	INTERVAL (metres)	LITHOLOGY	GYPSUM percent
L 57	0.00-0.04	algal mat	
	0.04-0.65	cream to white, f.g. gypsum	80.1
	0.65-1.20	cream gypsiferous calcareous clay	28.8
	1.20-1.72	crystalline, gypsiferous limestone	46.1
	1.72-2.21	grey, calcareous gypsum	66.8
	2.21-2.37	grey, clayey sand	
L 58	0.00-1.17	cream to white, f.g. gypsum	82.2
	1.17-1.47	calcareous horizon underlain by coarse gypsum crystals	55.9
	1.47-2.28	grey, c.g. calcareous gypsum	52.3
L 59	0.00-0.93	cream to white, calcareous clay	10.5
	0.93-1.22	white sand	3.6
	1.22-1.55	calcareous gypsiferous clay	
	1.55-1.95	grey, m.g. sand	
L 60	0.00-0.40	cream, f.g. gypsum	
	0.40-0.70	white gypsum with thin organic layers	78.3
	0.70-0.80	white, f.g. gypsum	
	0.80-1.94	white to grey, m.g. gypsum, very hard at base	72.9
L 61	0.00-0.30	grey, gypsiferous calcareous clay	37.1
	0.30-0.72	calcareous, gypsiferous clay, hard at base	
L 62	0.00-0.25	algal mat and soil	
	0.25-0.40	gypsum	–
	0.40-0.61	white calcareous sand	
L 63	0.00-0.25	brown clay	
	0.25-0.56	cream calcareous clay	4.9

APPENDIX B

CHEMICAL ANALYSES

1.	Classic Laboratories Report 1AD 1158	24/05/91
2.	Adjustment of Classic Analyses to fit ALS Analyses	
3.	ALS Report ST3249-0	23/03/92
4.	ALS Report ST3285-0	24/03/92
5.	ALS Report AM3386-0	12/06/92

Note: Hole WS25 is now L1
Hole WS26 is now L2
Hole WS37 is now L3

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Analysis code ICP 5 Report 1AD1158 Page I1

NATA Certificate Results in %

Sample	CaO	Fe2O3	Na2O	Al2O3	TiO2	K2O	MnO
WS 25 0.0-0.21	29.2	0.100	4.34	0.260	0.020	0.140	<0.010
WS 25 0.21-0.77	34.4	0.040	1.61	0.060	0.020	0.050	<0.010
WS 25 0.77-1.79	38.1	0.110	3.10	0.100	0.010	0.090	0.020
WS 25 1.79-2.10	36.4	0.240	3.18	0.160	0.020	0.100	0.060
WS 26 0.0-0.33	28.4	0.090	4.42	0.190	0.030	0.120	<0.010
WS 26 0.33-1.18	32.0	0.080	3.70	0.090	0.010	0.100	0.020
WS 26 1.18-1.40	32.1	0.100	4.60	0.080	0.010	0.120	0.040
WS 27 0.10-1.09	30.4	0.040	2.92	0.080	0.030	0.090	<0.010
WS 27 1.09-1.40	30.1	0.070	2.86	0.070	0.050	0.090	0.020
WS 28 0.20-0.87	29.7	0.040	3.68	0.070	0.020	0.100	0.020
WS 28 0.87-1.25	30.2	0.060	3.58	0.070	<0.010	0.100	0.030
WS 34 0.20-1.00	31.4	0.050	1.48	0.110	0.020	0.090	0.010
WS 34 1.00-1.50	31.9	0.070	1.23	0.070	0.010	0.070	0.020
WS 34 1.50-2.00	32.8	0.070	1.06	0.080	0.010	0.060	0.010
WS 35 0.0-0.55	30.2	0.130	3.22	0.260	0.070	0.110	0.030
WS 35 0.55-1.26	30.8	0.060	2.40	0.090	0.030	0.090	0.010
WS 36 0.02-0.49	30.8	0.080	2.18	0.140	0.020	0.090	0.020
WS 36 0.49-1.62	31.6	0.050	2.22	0.090	0.010	0.060	0.010
WS 37 0.20-0.82	32.2	0.060	2.58	0.100	0.050	0.090	0.010
WS 37 0.82-1.12	35.7	0.100	2.26	0.080	0.010	0.060	0.020
WS 37 1.12-1.73	36.5	0.120	2.80	0.100	0.010	0.080	0.040
Detn limit	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)

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Report 1AD1158

Excess Ca CaO %	H2O @ 44C GRAV 8 %	H2O @ 220C GRAV 8 %
< .05	26.4	16.5
<0.05	16.3	16.8
0.30	23.7	8.95
< .05	24.3	10.8
.25	24.7	18.3
< .05	22.9	14.8
<0.05	27.2	14.1
<0.05	16.0	18.7
<0.05	16.2	18.1
<0.05	19.5	17.3
.25	19.0	17.9
<0.05	4.55	16.9
< .05	4.94	18.8
<0.05	2.08	18.4
<0.05	23.8	17.2
<0.05	20.1	17.0
<0.05	19.5	17.1
0.85	19.2	17.2
0.35	23.5	16.0
.35	19.1	13.9
.40	21.6	12.2

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Results in %

Fe2O3	Na2O	Al2O3	TiO2	K2O	MnO
0.100	4.34	0.260	0.020	0.140	<0.010
0.040	1.61	0.060	0.020	0.050	<0.010
0.110	3.10	0.100	0.010	0.090	0.020
0.240	3.18	0.160	0.020	0.100	0.060
0.090	4.42	0.190	0.030	0.120	<0.010
0.080	3.70	0.090	0.010	0.100	0.020
0.100	4.60	0.080	0.010	0.120	0.040
0.040	2.92	0.080	0.030	0.090	<0.010
0.070	2.86	0.070	0.050	0.090	0.020
0.040	3.68	0.070	0.020	0.100	0.020
0.060	3.58	0.070	<0.010	0.100	0.030
0.050	1.48	0.110	0.020	0.090	0.010
0.070	1.23	0.070	0.010	0.070	0.020
0.070	1.06	0.080	0.010	0.060	0.010
0.130	3.22	0.260	0.070	0.110	0.030
0.060	2.40	0.090	0.030	0.090	0.010
0.080	2.18	0.140	0.020	0.090	0.020
0.050	2.22	0.090	0.010	0.060	0.010
0.060	2.58	0.100	0.050	0.090	0.010
0.100	2.26	0.080	0.010	0.060	0.020
0.120	2.80	0.100	0.010	0.080	0.040
(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)

CLASSIC LABORATORIES LTD
Incorporated in WA; a wholly owned subsidiary of Amdel Ltd
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Mr Sean Kennedy
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LOWER MITCHAM
SA 5062

F I N A L A N A L Y S I S R E P O R T

Your Order No: LET 22.4.91 Our Job Number : 1AD1158

Samples received : 22-APR-1991 Results reported : 24-MAY-1991
No. of samples : 21
Report comprises a cover sheet and pages G1, I1 to I2, W1

This report relates specifically to the samples tested in so far as that the samples as supplied are truly representative of the sample source.

Note:
If you have any enquiries please contact Miss Anne Reed quoting the above job number.

Approved Signatory:

John Waters
Technical Manager - Adelaide

CC Mr J G Olliver SA

Report Codes:
N.A. - Not Analysed.
L.N.R. - Listed But Not Received.
I.S. - Insuffcent Sample.

Distribution Codes:
CC - Carbon Copy
EM - Electronic Media
MM - Magnetic Media

"RELIABLE ANALYSES AT COMPETITIVE COST"

CLASSIC LABORATORIES LTD

Analysis code ICP 5 Report 1AD1158

NATA Certificate Results in %

Sample	P2O5	MgO	SiO2	LOI
WS 25 0.0-0.21	0.030	1.55	2.50	32.9
WS 25 0.21-0.77	0.030	0.820	1.24	27.9
WS 25 0.77-1.79	0.030	2.58	4.54	38.3
WS 25 1.79-2.10	0.030	2.36	3.14	36.8
WS 26 0.0-0.33	0.030	1.38	1.67	32.8
WS 26 0.33-1.18	0.030	1.68	2.18	32.0
WS 26 1.18-1.40	0.030	1.78	3.32	36.9
WS 27 0.10-1.09	0.020	0.990	1.00	28.8
WS 27 1.09-1.40	0.030	1.30	1.06	28.5
WS 28 0.20-0.87	0.030	1.30	1.11	31.1
WS 28 0.87-1.25	0.030	1.38	1.15	30.3
WS 34 0.20-1.00	0.020	0.870	1.16	25.1
WS 34 1.00-1.50	0.030	0.910	1.06	24.8
WS 34 1.50-2.00	0.040	0.750	1.13	25.2
WS 35 0.0-0.55	0.040	2.18	3.48	31.0
WS 35 0.55-1.26	0.030	1.03	1.72	26.7
WS 36 0.02-0.49	0.030	0.780	1.17	27.1
WS 36 0.49-1.62	0.020	0.800	0.980	26.3
WS 37 0.20-0.82	0.030	1.56	2.64	29.1
WS 37 0.82-1.12	0.040	1.86	3.06	30.9
WS 37 1.12-1.73	0.020	2.02	3.18	33.9
Detn limit	(0.010)	(0.010)	(0.010)	(0.010)

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Client #

Report 1AD1158

Sample ID	SO3 as CaSO4	CO2 as CaCO3	Excess Ca as CaO	H2O @ 44C	H2O @ 220C
Code	GRAV 2	GRAV 4		GRAV 8	GRAV 8
Results in	%	%	%	%	%
WS 25					
0.00-0.21	58.6	10.6	<0.05	26.4	16.5
0.21-0.77	62.6	15.5	<0.05	16.3	16.8
0.77-1.79	27.2	46.6	0.30	23.7	8.95
1.79-2.10	38.0	37.6	<0.05	24.3	10.8
WS 26					
0.00-0.33	64.6	3.56	0.25	24.7	18.3
0.33-1.18	56.1	16.7	<0.05	22.9	14.8
1.18-1.40	45.0	25.3	<0.05	27.2	14.1
WS 27					
0.10-1.09	69.1	4.25	<0.05	16.0	18.7
1.09-1.40	66.3	6.71	<0.05	16.2	18.1
WS 28					
0.20-0.87	66.4	5.15	<0.05	19.5	17.3
0.87-1.25	64.4	6.67	0.25	19.0	17.9
WS 34					
0.20-1.00	72.0	5.79	<0.05	4.55	16.9
1.00-1.50	70.2	6.15	<0.05	4.94	18.8
1.50-2.00	68.8	8.03	<0.05	2.08	18.4
WS 35					
0.00-0.55	59.9	10.4	<0.05	23.8	17.2
0.55-1.26	68.1	6.35	<0.05	20.1	17.0
WS 36					
0.02-0.49	72.5	3.55	<0.05	19.5	17.1
0.49-1.62	70.4	5.00	0.85	19.2	17.2
WS 37					
0.20-0.82	60.4	13.0	0.35	23.5	16.0
0.82-1.12	48.6	27.6	0.35	19.1	13.9
1.12-1.73	41.9	32.3	1.40	21.6	12.2

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Results in %.

SAMPLE ID	WATER SOLUBLE CHLORIDE AS NaCl
WS 25	
0-0.21	10.07
0.21-0.75	3.76
0.77-1.79	6.26
1.79-2.10	7.03
WS 26	
0-0.33	10.42
0.33-1.18	8.20
1.18-1.40	10.67
WS 27	
0.1-1.09	7.06
1.09-1.40	7.06
WS 28	
0.20-0.87	8.75
0.87-1.25	8.24
WS 34	
0.20-1.0	3.66
1.0-1.50	2.92
1.50-2.0	2.42
WS 35	
0-0.55	7.24
0.55-1.26	5.55
WS 36	
0.02-0.49	5.22
0.49-1.62	5.14
WS 37	
0.20-0.82	5.80
0.82-1.12	4.66
1.12-1.73	5.68
METHOD:	WAT 2B

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LABORATORY: STAFFORD
BATCH NUMBER: ST3249-0

No. of SAMPLES: 136
DATE RECEIVED: 04/03/92
DATE COMPLETED: 23/03/92

ORDER No: LETTER SAMPLE TYPE: GYPSUM PROJECT No:

SAMPLE NUMBER	ELEMENT UNIT METHOD	CaSO4.2H2O % M277A	CaCO3 % M277A	MgCO3 % M277A	Fe2O3 % M277A	Al2O3 % M277A
WS 38 0.00-0.45		89.9	<0.01	1.61	0.05	0.04
WS 38 0.45-1.75		4.11	56.4	8.19	0.26	0.18
WS 38 1.75-1.92		4.49	39.6	6.00	0.79	0.25
WS 39 0.00-0.78		88.1	<0.01	2.40	0.05	0.03
WS 39 0.78-2.17		77.0	7.09	3.41	0.08	0.03
WS 40 0.08-0.80		84.8	2.21	2.80	0.06	0.03
WS 40 0.80-2.08		79.6	7.75	3.09	0.11	0.05
WS 41 0.05-0.90		82.7	3.30	3.28	0.08	0.06
WS 41 0.90-1.40		14.9	47.1	6.42	0.20	0.16
WS 41 1.40-1.80		1.34	12.8	1.76	0.15	0.15
WS 42 0.05-0.60		27.1	44.4	5.62	0.66	0.13
WS 43 0.05-0.85		27.0	43.0	6.23	1.17	0.13
WS 44 0.05-1.00		87.4	0.57	1.92	0.08	0.04
WS 44 1.00-2.50		6.13	48.7	6.42	0.34	0.22
WS 45 0.05-1.00		88.2	2.75	2.40	0.06	0.04
WS 45 1.00-1.69		71.6	14.5	2.65	0.11	0.08
WS 46 0.05-1.10		89.4	<0.01	2.13	0.04	0.03
WS 46 1.10-2.00		87.5	1.77	2.59	0.06	0.03
WS 47 0.05-1.20		86.9	1.57	2.45	0.04	0.03
WS 47 1.20-1.85		4.84	59.6	7.88	0.21	0.15
WS 48 0.00-0.70		85.9	1.14	2.65	0.05	0.04
WS 48 0.70-1.80		6.97	49.3	12.0	0.20	0.16
WS 49 0.00-1.32		N.R.	N.R.	N.R.	N.R.	N.R.
WS 50 0.05-0.70		77.2	6.21	4.43	0.08	0.05
WS 50 0.70-1.91		5.90	55.5	7.11	0.21	0.12
WS 51 0.00-0.60		46.2	32.5	5.56	0.28	0.08
WS 51 0.60-1.24		3.78	54.6	8.86	0.32	0.10
WS 52 0.05-1.30		58.3	25.3	4.01	0.08	0.06
WS 52 1.30-1.82		5.04	46.9	8.86	0.21	0.10
WS 53 0.20-0.60		2.15	58.9	17.0	1.15	0.34
DETECTION LIMIT:		0.01	0.01	0.01	0.01	0.01

COMMENTS:
a) Samples dried at 45'C prior to the pulverising.
b) Analysis applies to acid digested samples. (1+1HCl).
c) CaSO4 2H2O calculated from S concentration.
d) Excess Ca reported as CaCO3.
e) Na & K reported as chlorides.

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... aboratory
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Southern Cross Laboratory
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All pages of this report have been checked and approved for release.

G. Le...

Signed

AUSTRALIAN LABORATORY SERVICES P/L
A.C.N. 009 936 029

ANALYTICAL REPORT

Brisbane Head Office and Laboratory
32 Shand Street, Stafford, Q. 4053
P.O. Box 66, Everton Park, Q. 4053
Telephone: (07) 352 5577
Facsimile: (07) 352 5109

CLIENT: OLLIVER GEOLOGICAL SERVICES
ADDRESS: P O BOX 24
MCLAREN VALE
SA 5171

CONTACT: MR J OLLIVER

LABORATORY: STAFFORD
BATCH NUMBER: ST3249-0

No. of SAMPLES: 136
DATE RECEIVED: 04/03/92
DATE COMPLETED: 23/03/92

DER No: LETTER
SAMPLE TYPE: GYPSUM
PROJECT No:

SAMPLE NUMBER	ELEMENT UNIT METHOD	CaSO4.2H2O % M277A	CaCO3 % M277A	MgCO3 % M277A	Fe2O3 % M277A	Al2O3 % M277A
WS 54 0.00-1.15		84.4	2.92	3.07	0.07	0.04
WS 54 1.15-1.62		2.49	33.2	2.80	1.04	1.91
WS 55 0.00-1.55		82.0	53.4	2.55	0.06	0.03
WS 56 0.02-0.95		86.1	1.52	2.32	0.06	0.04
WS 56 0.95-1.38		87.0	1.36	2.61	0.05	0.07
WS 57 0.00-1.46		82.3	4.43	2.57	0.05	0.04
WS 57 1.46-2.20		83.0	6.09	2.26	0.08	0.03
WS 58 0.00-0.80		86.6	1.57	2.15	0.06	0.04
WS 58 0.80-2.00		83.6	4.62	2.21	0.07	0.03
WS 59 0.00-0.56		24.2	44.4	9.24	0.62	0.31
WS 59 0.56-0.92		1.86	12.5	2.49	1.03	1.24
WS 60 0.00-0.90		18.4	50.2	6.98	0.62	0.34
WS 61 0.00-0.55		17.8	14.0	4.18	0.59	0.75
WS 61 0.55-1.20		0.56	10.0	1.55	1.19	1.65
WS 61 1.20-1.63		0.32	7.43	1.48	1.52	2.02
WS 62 0.00-1.35		85.3	2.80	2.05	0.07	0.04
WS 62 1.35-1.69		14.3	6.50	2.05	0.95	1.76
WS 63 0.05-0.95		87.4	1.71	2.05	0.08	0.04
WS 63 0.95-1.46		83.2	5.00	2.65	0.11	0.05
WS 64 0.05-0.90		87.3	0.82	2.09	0.05	0.03
WS 64 0.90-1.73		86.1	2.00	2.32	0.06	0.03
WS 64 1.73-2.40		88.6	1.37	2.24	0.08	0.06
WS 65 0.03-0.95		88.5	0.46	2.24	0.06	0.03
WS 65 0.95-1.40		86.1	2.39	2.57	0.05	0.02
WS 65 1.40-2.65		87.8	2.87	1.71	0.08	0.04
WS 66 0.00-0.75		67.5	15.2	4.95	0.14	0.08
WS 67 0.03-0.45		6.46	60.7	10.5	0.53	0.14
WS 68 0.10-1.45		82.6	3.12	2.26	0.06	0.03
WS 69 0.05-1.05		90.0	<0.01	1.84	0.05	0.03
WS 69 1.05-2.34		90.3	0.32	2.30	0.06	0.03
TE TION LIMIT:		0.01	0.01	0.01	0.01	0.01

MMENTS:

AUSTRALIAN
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A.C.N. 009 936 029

ANALYTICAL REPORT

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SA 5171

CONTACT: MR J OLLIVER

LABORATORY: STAFFORD
BATCH NUMBER: ST3249-0

No. of SAMPLES: 136
DATE RECEIVED: 04/03/92
DATE COMPLETED: 23/03/92

ER No: LETTER   SAMPLE TYPE: GYPSUM   PROJECT No:

SAMPLE NUMBER	ELEMENT UNIT METHOD	CaSO4.2H2O % M277A	CaCO3 % M277A	MgCO3 % M277A	Fe2O3 % M277A	Al2O3 % M277A
WS 69 2.34-3.00		87.0	3.25	1.90	0.09	0.04
WS 70 0.00-1.25		90.2	0.96	2.01	0.05	0.03
WS 70 1.25-1.64		58.7	7.51	3.14	0.27	0.22
WS 71 0.00-0.62		89.0	1.36	1.44	0.05	0.04
WS 72 0.00-1.57		82.1	2.10	2.63	0.05	0.02
WS 73 0.00-1.00		88.1	0.57	2.03	0.05	0.03
WS 73 1.00-1.81		83.2	3.64	2.63	0.06	0.02
WS 73 1.81-2.87		73.8	11.2	3.05	0.21	0.10
WS 73 2.87-3.40		71.6	13.5	3.57	0.24	0.14
WS 73 3.40-3.71		45.6	25.2	3.30	0.53	0.58
WS 74 0.00-1.25		88.9	1.12	1.92	0.05	0.03
WS 74 1.25-1.86		85.8	3.39	2.13	0.06	0.03
WS 74 1.86-3.05		77.5	9.21	2.80	0.14	0.11
WS 74 3.05-3.72		67.1	15.5	4.03	0.34	0.26
WS 75 0.00-1.10		86.8	1.50	2.03	0.05	0.03
WS 75 1.10-2.10		74.4	7.64	2.80	0.12	0.10
WS 75 2.10-2.34		85.6	1.82	2.19	0.10	0.07
WS 07 6.05-1.48		84.2	1.55	2.07	0.06	0.04
WS 76 1.48-2.10		71.4	9.37	2.42	0.13	0.09
WS 77 0.00-0.90		78.6	10.0	3.11	0.09	0.06
WS 78 0.00-1.03		82.8	3.80	2.32	0.07	0.04
WS 79 0.00-1.53		86.2	1.30	1.84	0.05	0.02
WS 80 0.00-1.24		85.2	3.05	2.32	0.06	0.03
WS 81 0.00-1.35		84.7	3.93	2.34	0.06	0.02
WS 82 0.02-1.00		82.2	4.87	3.34	0.05	0.02
WS 82 1.00-1.32		57.9	18.7	3.62	0.18	0.07
WS 83 0.00-0.95		77.4	7.59	4.10	0.07	0.05
WS 84 0.05-0.25		24.6	42.5	12.9	0.25	0.17
WS 85 0.00-0.40		61.6	11.6	7.25	0.20	0.12
WS 86 0.00-1.25		76.0	3.48	3.93	0.17	0.09
DETECTION LIMIT:		0.01	0.01	0.01	0.01	0.01

IMENTS:

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ANALYTICAL REPORT

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SAMPLE NUMBER	ELEMENT UNIT METHOD	CaSO4.2H2O % M277A	CaCO3 % M277A	MgCO3 % M277A	Fe2O3 % M277A	Al2O3 % M277A
WS 86 1.25-1.54		80.5	6.51	2.38	0.13	0.04
WS 87 0.00-1.05		82.7	2.57	3.01	0.10	0.07
WS 88 0.00-0.41		75.7	5.77	4.97	0.16	0.12
WS 89 0.00-0.85		41.9	17.7	10.8	0.29	0.28
WS 90 0.00-0.50		50.5	7.28	9.36	0.25	0.22
WS 91 0.05-0.80		86.7	2.21	2.38	0.07	0.03
WS 91 0.80-1.81		14.2	54.3	8.07	0.13	0.12
WS 92 0.05-0.80		6.33	67.1	9.43	0.18	0.06
WS 93 0.02-0.50		11.8	58.7	9.45	0.36	0.20
WS 95 0.02-1.81		36.4	34.1	4.05	0.20	0.12
WS 96 0.00-0.45		12.6	51.1	8.44	1.10	0.20
WS 97 0.05-1.10		42.5	26.8	6.96	0.26	0.14
WS 97 1.10-1.30		15.3	50.7	5.89	0.53	0.24
WS 98 0.00-0.75		61.8	8.37	2.57	0.10	0.13
WS 99 0.00-1.00		29.1	35.7	8.67	0.93	0.27
WS 100 0.00-1.40		82.7	5.02	2.47	0.13	0.07
WS 101 0.00-0.40		69.5	10.0	4.12	0.21	0.18
WS 101 0.40-1.10		5.44	29.3	3.32	0.94	0.33
WS 101 0.00-0.93		58.2	18.2	6.79	0.24	0.14
WS 102 0.93-1.46		4.72	42.1	5.79	2.89	0.32
WS 103 0.02-0.95		42.9	33.9	6.69	0.28	0.10
WS 104 0.00-1.00		71.5	11.5	2.59	0.28	0.11
WS 105 0.04-0.95		43.4	16.8	7.19	0.40	0.44
WS 105 0.95-1.35		41.8	36.8	4.39	1.12	0.28
WS 106 0.00-0.40		82.9	3.69	3.14	0.11	0.08
WS 106 0.40-1.40		84.3	7.02	1.36	0.06	0.03
WS 107 0.00-0.65		79.5	7.71	2.55	0.12	0.10
WS 108 0.00-1.45		16.9	57.8	9.30	0.43	0.23
WS 109A 0.00-0.67		85.5	1.64	2.28	0.05	0.04
WS 110B 0.00-0.50		88.9	1.00	1.65	0.03	0.02
TI TION LIMIT:		0.01	0.01	0.01	0.01	0.01

MMENTS:

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LABORATORY: STAFFORD
BATCH NUMBER: ST3249-0

No. of SAMPLES: 136
DATE RECEIVED: 04/03/92
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DER No: LETTER
SAMPLE TYPE: GYPSUM
PROJECT No:

SAMPLE NUMBER	ELEMENT UNIT METHOD	CaSO4.2H2O % M277A	CaCO3 % M277A	MgCO3 % M277A	Fe2O3 % M277A	Al2O3 % M277A
WS 111C	0.00-1.00	89.4	2.64	1.30	0.04	0.03
WS 111C	1.00-1.58	84.5	7.57	1.80	0.03	0.02
WS 112D	0.00-0.70	84.4	1.32	2.13	0.04	0.03
WS 113E	0.00-0.50	86.0	0.62	1.65	0.03	0.02
WS 114F	0.00-0.27	88.4	<0.01	1.53	0.04	0.04
WS 114F	0.27-1.50	90.9	0.50	1.00	0.04	0.03
WS 115G	0.00-0.94	91.3	1.70	1.09	0.03	0.02
WS 116H	0.00-0.93	51.4	7.43	3.93	0.39	0.38
WS 117I	0.00-0.55	85.5	1.86	2.47	0.09	0.08
WS 117I	0.55-1.27	87.0	1.89	1.65	0.09	0.05
WS 118J	0.00-1.11	93.1	0.68	0.79	0.03	0.02
WS 119K	0.00-0.52	89.2	0.75	1.65	0.08	0.07
WS 120L	0.00-0.45	89.3	1.14	1.71	0.06	0.04
WS 120L	0.45-1.13	95.3	<0.01	0.77	0.02	0.01
WS 49	0.00-0.60	83.4	2.61	2.03	0.05	0.04
WS 49	0.60-1.25	4.77	54.3	7.54	0.25	0.14
TE TION LIMIT:		0.01	0.01	0.01	0.01	0.01

MMENTS:

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DATE RECEIVED: 04/03/92
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DER No: LETTER SAMPLE TYPE: GYPSUM PROJECT No:

SAMPLE NUMBER	ELEMENT UNIT METHOD	Na as NaCl % M277A	K as KCl % M277A			
WS 38 0.00-0.45		4.72	0.06			
WS 38 0.45-1.75		13.8	0.15			
WS 38 1.75-1.92		12.6	0.16			
WS 39 0.00-0.78		5.49	<0.01			
WS 39 0.78-2.17		5.76	0.20			
WS 40 0.08-0.80		5.18	0.07			
WS 40 0.80-2.08		5.14	0.03			
WS 41 0.05-0.90		5.66	<0.01			
WS 41 0.90-1.40		8.88	0.06			
WS 41 1.40-1.80		3.48	<0.01			
WS 42 0.05-0.60		5.74	0.13			
WS 43 0.05-0.85		6.52	0.49			
WS 44 0.05-1.00		4.90	0.17			
WS 44 1.00-2.50		9.71	0.18			
WS 45 0.05-1.00		3.61	<0.01			
WS 45 1.00-1.69		4.72	0.02			
WS 46 0.05-1.10		4.89	<0.01			
WS 46 1.10-2.00		4.64	<0.01			
WS 47 0.05-1.20		5.68	<0.01			
WS 47 1.20-1.85		12.2	0.14			
WS 48 0.00-0.70		5.89	0.09			
WS 48 0.70-1.80		13.3	0.19			
WS 49 0.00-1.32		N.R.	N.R.			
WS 50 0.05-0.70		5.95	0.04			
WS 50 0.70-1.91		10.8	0.11			
WS 51 0.00-0.60		6.62	0.29			
WS 51 0.60-1.24		15.2	0.32			
WS 52 0.05-1.30		5.46	0.01			
WS 52 1.30-1.82		18.5	0.33			
WS 53 0.20-0.60		7.77	0.42			
DETECTION LIMIT:		0.01	0.01			

COMMENTS:

sv Laboratory
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ge Laboratory
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ANALYTICAL REPORT

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CONTACT: MR J OLLIVER

LABORATORY: STAFFORD
BATCH NUMBER: ST3249-0

No. of SAMPLES: 136
DATE RECEIVED: 04/03/92
DATE COMPLETED: 23/03/92

ER No: LETTER SAMPLE TYPE: GYPSUM PROJECT No:

SAMPLE NUMBER	ELEMENT UNIT METHOD	Na as NaCl % M277A	K as KCl % M277A			
WS 54 0.00-1.15		5.15	<0.01			
WS 54 1.15-1.62		4.07	0.63			
WS 55 0.00-1.55		4.55	0.20			
WS 56 0.02-0.95		4.74	0.12			
WS 56 0.95-1.38		4.75	<0.01			
WS 57 0.00-1.46		4.67	0.21			
WS 57 1.46-2.20		3.91	0.13			
WS 58 0.00-0.80		4.49	0.01			
WS 58 0.80-2.00		3.88	<0.01			
WS 59 0.00-0.56		7.93	0.30			
WS 59 0.56-0.92		3.76	0.30			
WS 60 0.00-0.90		6.37	0.26			
WS 61 0.00-0.55		4.37	0.58			
WS 61 0.55-1.20		2.59	0.54			
WS 61 1.20-1.63		2.24	0.40			
WS 62 0.00-1.35		4.16	0.12			
WS 62 1.35-1.69		3.12	0.83			
WS 63 0.05-0.95		3.97	0.09			
WS 63 0.95-1.46		3.97	0.02			
WS 64 0.05-0.90		5.02	0.06			
WS 64 0.90-1.73		4.38	0.15			
WS 64 1.73-2.40		3.96	0.04			
WS 65 0.03-0.95		4.68	0.03			
WS 65 0.95-1.40		4.76	0.22			
WS 65 1.40-2.65		3.33	0.27			
WS 66 0.00-0.75		4.89	0.02			
WS 67 0.03-0.45		6.39	0.24			
WS 68 0.10-1.45		3.31	0.30			
WS 69 0.05-1.05		3.78	0.07			
WS 69 1.05-2.34		3.76	0.02			
DETECTION LIMIT:		0.01	0.01			

MMENTS:

vi Laboratory
: ( ) 79 9155 Fax: (077) 79 9729
rs Towers Laboratory
: (077) 87 4155 Fax: (077) 87 4220
e Laboratory
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go boratory
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Southern Cross Laboratory
Phone: (090) 49 1292 Fax: (090) 49 1374

AUSTRALIAN LABORATORY SERVICES P/L

A.C.N. 009 936 029

Brisbane Head Office and Laboratory
32 Shand Street, Stafford, Q. 4053
P.O. Box 66, Everton Park, Q. 4053
Telephone: (07) 352 5577
Facsimile: (07) 352 5109

ANALYTICAL REPORT

CLIENT: OLLIVER GEOLOGICAL SERVICES
ADDRESS: P O BOX 24
MCLAREN VALE
SA 5171

CONTACT: MR J OLLIVER

LABORATORY: STAFFORD
BATCH NUMBER: ST3249-0

No. of SAMPLES: 136
DATE RECEIVED: 04/03/92
DATE COMPLETED: 23/03/92

ɾDER No: LETTER   SAMPLE TYPE: GYPSUM   PROJECT No:

SAMPLE NUMBER	ELEMENT UNIT METHOD	Na as NaCl % M277A	K as KCl % M277A			
WS 69 2.34-3.00		3.62	0.12			
WS 70 0.00-1.25		3.30	0.02			
WS 70 1.25-1.64		4.29	0.29			
WS 71 0.00-0.62		2.97	0.38			
WS 72 0.00-1.57		5.58	0.16			
WS 73 0.00-1.00		4.06	0.17			
WS 73 1.00-1.81		4.46	0.36			
WS 73 1.81-2.87		3.83	0.17			
WS 73 2.87-3.40		3.43	0.07			
WS 73 3.40-3.71		3.47	0.33			
WS 74 0.00-1.25		3.48	0.05			
WS 74 1.25-1.86		3.57	0.25			
WS 74 1.86-3.05		3.29	0.25			
WS 74 3.05-3.72		3.89	0.11			
WS 75 0.00-1.10		3.64	0.08			
WS 75 1.10-2.10		3.68	0.21			
WS 75 2.10-2.34		3.44	<0.01			
WS 07 6.05-1.48		4.07	<0.01			
WS 76 1.48-2.10		4.01	0.12			
WS 77 0.00-0.90		4.48	0.11			
WS 78 0.00-1.03		3.55	0.17			
WS 79 0.00-1.53		3.22	<0.01			
WS 80 0.00-1.24		3.40	<0.01			
WS 81 0.00-1.35		3.59	0.15			
WS 82 0.02-1.00		3.55	0.16			
WS 82 1.00-1.32		5.79	<0.01			
WS 83 0.00-0.95		4.08	0.32			
WS 84 0.05-0.25		6.86	0.46			
WS 85 0.00-0.40		5.91	0.21			
WS 86 0.00-1.25		4.78	0.17			
T TION LIMIT:		0.01	0.01			

ɔMMENTS:

AUSTRALIAN LABORATORY SERVICES P/L

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[redacted]

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ANALYTICAL REPORT

CLIENT: OLLIVER GEOLOGICAL SERVICES
ADDRESS: P O BOX 24
MCLAREN VALE
SA 5171

CONTACT: MR J OLLIVER

LABORATORY: STAFFORD
BATCH NUMBER: ST3249-0

No. of SAMPLES: 136
DATE RECEIVED: 04/03/92
DATE COMPLETED: 23/03/92

)ER No: LETTER SAMPLE TYPE: GYPSUM PROJECT No:

SAMPLE NUMBER	ELEMENT UNIT METHOD	Na as NaCl % M277A	K as KCl % M277A			
WS 86 1.25-1.54		4.11	0.40			
WS 87 0.00-1.05		3.40	0.05			
WS 88 0.00-0.41		4.12	<0.01			
WS 89 0.00-0.85		5.54	0.09			
WS 90 0.00-0.50		4.95	0.24			
WS 91 0.05-0.80		3.87	<0.01			
WS 91 0.80-1.81		6.76	0.02			
WS 92 0.05-0.80		5.80	0.18			
WS 93 0.02-0.50		7.10	0.25			
WS 95 0.02-1.81		5.68	0.03			
WS 96 0.00-0.45		6.88	0.13			
WS 97 0.05-1.10		6.97	<0.01			
WS 97 1.10-1.30		6.51	0.04			
WS 98 0.00-0.75		3.33	0.11			
WS 99 0.00-1.00		4.72	0.13			
WS 100 0.00-1.40		3.37	0.02			
WS 101 0.00-0.40		5.13	0.10			
WS 101 0.40-1.10		5.08	0.40			
WS 101 0.00-0.93		4.19	0.22			
WS 102 0.93-1.46		6.13	0.28			
WS 103 0.02-0.95		4.66	0.11			
WS 104 0.00-1.00		3.79	0.09			
WS 105 0.04-0.95		3.55	0.16			
WS 105 0.95-1.35		3.36	0.15			
WS 106 0.00-0.40		3.94	0.06			
WS 106 0.40-1.40		2.26	0.06			
WS 107 0.00-0.65		3.36	0.10			
WS 108 0.00-1.45		4.86	0.20			
WS 109A 0.00-0.67		4.28	0.09			
WS 110B 0.00-0.50		3.78	0.08			
E(ION LIMIT:		0.01	0.01			

IMENTS:

AUSTRALIAN LABORATORY SERVICES P/L
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ANALYTICAL REPORT

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ADDRESS: P O BOX 24
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CONTACT: MR J OLLIVER

LABORATORY: STAFFORD
BATCH NUMBER: ST3249-0

No. of SAMPLES: 136
DATE RECEIVED: 04/03/92
DATE COMPLETED: 23/03/92

ɌDER No: LETTER   SAMPLE TYPE: GYPSUM   PROJECT No:

SAMPLE NUMBER	ELEMENT UNIT METHOD	Na as NaCl % M277A	K as KCl % M277A			
WS 111C 0.00-1.00		2.54	0.06			
WS 111C 1.00-1.58		2.24	0.05			
WS 112D 0.00-0.70		4.00	0.09			
WS 113E 0.00-0.50		4.24	0.08			
WS 114F 0.00-0.27		2.60	0.06			
WS 114F 0.27-1.50		2.41	0.06			
WS 115G 0.00-0.94		1.80	0.03			
WS 116H 0.00-0.93		3.03	0.14			
WS 117I 0.00-0.55		2.72	0.02			
WS 117I 0.55-1.27		1.69	0.05			
WS 118J 0.00-1.11		1.26	0.04			
WS 119K 0.00-0.52		3.02	0.10			
WS 120L 0.00-0.45		2.85	0.08			
WS 120L 0.45-1.13		1.78	0.04			
WS 49 0.00-0.60		4.01	0.10			
WS 49 0.60-1.25		9.68	0.19			
ET CTION LIMIT:		0.01	0.01			

OMMENTS:

AUSTRALIAN LABORATORY SERVICES P/L

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ANALYTICAL REPORT

CLIENT: OLLIVER GEOLOGICAL SERVICES
ADDRESS: P O BOX 24
MCLAREN VALE
SA 5171

CONTACT: MR J OLLIVER

LABORATORY: STAFFORD
BATCH NUMBER: ST3285-0

No. of SAMPLES: 106
DATE RECEIVED: 10/03/92
DATE COMPLETED: 24/03/92

DER No: LETTER SAMPLE TYPE: ROCK CHIP PROJECT No:

SAMPLE NUMBER	ELEMENT UNIT METHOD	CaSO4 2H2O % M277A	CaCO3 % M277A	MgCO3 % M277A	Fe2O3 % M277A	Al2O3 % M277A
L4 0-1.79	1.79	58.1	23.7	6.37	0.10	0.06
L4 1.79-2.98	1.19	61.8	26.5	3.24	0.14	0.04
L5 0-0.84	1.84	46.6	28.7	10.7	0.17	0.18
L5 0.84-2.50	1.66	50.6	30.6	6.36	0.09	0.06
L5 2.50-3.58	1.08	28.3	53.3	3.21	0.21	0.07
L0 0.02-0.85	0.83	70.4	16.9	4.81	0.07	0.07
L0 0.85-2.49	1.64	17.1	34.5	4.23	0.25	0.35
L7 0.02-0.98	0.96	75.0	13.6	3.97	0.06	0.07
L7 0.98-2.45	1.47	63.0	26.1	2.41	0.07	0.04
L8 0-0.80	0.78	73.0	11.7	5.22	0.07	0.06
L8 0.80-1.62	0.82	78.1	11.3	2.74	0.05	0.02
L8 1.62-2.76	1.14	69.5	19.2	2.44	0.10	0.04
L9 0.02-0.94	0.92	75.4	11.7	4.17	0.06	0.03
L9 0.94-1.52	0.58	72.4	17.0	2.91	0.06	0.03
L9 1.52-2.15	0.63	68.5	19.1	3.15	0.09	0.03
L9 2.15-2.42	0.27	74.8	17.0	2.41	0.08	0.03
L10 0.02-1.05	1.03	3.43	64.1	12.5	0.28	0.13
L10 1.05-2.82	1.77	3.09	74.7	3.94	0.19	0.08
L11 0.02-0.65	0.63	79.8	7.44	3.50	0.04	0.03
L11 0.65-1.54	0.89	75.9	12.5	2.70	0.05	0.02
L11 1.54-2.00	0.46	68.2	20.8	2.42	0.08	0.04
L11 2.00-2.89	0.89	71.8	18.0	2.19	0.10	0.03
L12 0-1.65	1.65	69.9	14.7	3.88	0.07	0.03
L12 1.65-2.23	0.58	72.5	16.7	2.66	0.09	0.02
L13 0.02-1.15	1.13	76.8	12.2	2.85	0.07	0.05
L13 1.15-1.78	0.63	63.9	21.4	3.52	0.07	0.03
L13 1.78-2.31	0.53	64.8	23.1	3.58	0.08	0.03
L13 2.31-2.71	0.40	64.0	22.0	3.47	0.13	0.05
L14 0-0.91	0.91	62.4	19.1	7.42	0.11	0.09
L14 0.91-1.60	0.69	35.2	49.1	5.78	0.13	0.04
E[illegible]ION LIMIT:		0.01	0.01	0.01	0.01	0.01

MMENTS:
a) Samples dried at 45'C before pulverising.
b) Analysis carried out on acid digest (1:1HCl).
c) CaSO4.2H2O calculated from S content.
d) Excess Ca reported as CaCO3.

[illegible] Laboratory
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[illegible]owers Laboratory
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[illegible]e Laboratory
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[illegible]boratory
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Perth Laboratory
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Kalgoorlie Laboratory
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Southern Cross Laboratory
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All pages of this report have been checked and approved for release.

G. A[illegible]
Signed

AUSTRALIAN LABORATORY SERVICES P/L
A.C.N. 009 936 029

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Brisbane Head Office and Laboratory
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ANALYTICAL REPORT

CLIENT: OLLIVER GEOLOGICAL SERVICES
ADDRESS: P O BOX 24
MCLAREN VALE
SA 5171

CONTACT: MR J OLLIVER

LABORATORY: STAFFORD
BATCH NUMBER: ST3285-0

No. of SAMPLES: 106
DATE RECEIVED: 10/03/92
DATE COMPLETED: 24/03/92

DER No: LETTER   SAMPLE TYPE: ROCK CHIP   PROJECT No:

SAMPLE NUMBER	ELEMENT UNIT METHOD	CaSO4 2H2O % M277A	CaCO3 % M277A	MgCO3 % M277A	Fe2O3 % M277A	Al2O3 % M277A
L14 1.60-1.86	0.26	46.9	39.0	4.17	0.14	0.05
L15 0.02-0.75	0.73	80.3	9.96	2.79	0.04	0.03
L15 0.75-2.21	1.46	36.6	43.8	6.30	0.09	0.05
L16 0.05-0.75	0.70	82.7	6.82	2.54	0.06	0.05
L16 0.75-1.39	0.64	24.1	57.9	6.28	0.15	0.05
L16 1.39-1.97	0.58	46.4	37.4	4.88	0.19	0.12
L17 0.03-0.75	0.72	84.1	6.77	2.37	0.04	0.04
L17 0.75-1.94	1.19	32.1	49.3	5.74	0.14	0.09
L18 0-0.60	0.60	79.9	9.59	3.14	0.05	0.05
L18 0.60-1.50	0.90	21.3	57.6	7.08	0.12	0.05
L18 1.50-1.99	0.49	3.43	29.2	3.18	0.45	0.80
L19 0-0.90	0.90	79.8	10.3	2.57	0.04	0.03
L19 0.90-1.60	0.70	67.3	20.7	2.77	0.06	0.03
L19 1.60-2.18	0.58	80.2	14.1	1.69	0.04	0.02
L20 0-0.60	0.60	81.2	7.92	2.82	0.04	0.02
L20 0.60-1.95	1.35	50.8	33.9	4.25	0.08	0.04
L20 1.95-2.47	0.52	58.6	28.2	3.17	0.09	0.05
L20 2.47-3.08	0.61	31.5	44.4	4.88	0.24	0.12
L21 0-0.65	0.65	84.0	5.39	2.92	0.04	0.04
L21 0.65-1.55	0.90	52.0	32.5	3.23	0.07	0.05
L21 1.55-2.43	0.88	53.1	33.7	2.39	0.09	0.06
L21 2.43-3.50	1.07	35.7	58.0	3.79	0.26	0.16
L22 0.02-0.80	0.78	79.1	10.6	2.74	0.05	0.04
L22 0.80-1.19	0.39	4.69	73.5	7.14	0.12	0.03
L22 1.19-2.80	1.61	52.3	31.6	4.48	0.14	0.06
L23 0.03-0.81	0.78	64.8	22.4	4.14	0.06	0.03
L23 0.81-1.25	0.44	53.1	32.3	5.82	0.07	0.02
L23 1.25-2.34	1.09	59.9	26.6	3.94	0.11	0.05
L24 0-0.85	0.85	68.4	17.1	4.30	0.09	0.07
L24 0.85-1.60	0.75	68.2	21.1	2.42	0.06	0.02
E ION LIMIT:		0.01	0.01	0.01	0.01	0.01

MENTS:

vil Laboratory
: ( ) 79 9155 Fax: (077) 79 9729
wers Laboratory
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AUSTRALIAN LABORATORY SERVICES P/L

A.C.N. 009 936 029

ANALYTICAL REPORT

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Facsimile: (07) 352 5109

CLIENT: OLLIVER GEOLOGICAL SERVICES
ADDRESS: P O BOX 24
MCLAREN VALE
SA 5171

CONTACT: MR J OLLIVER

LABORATORY: STAFFORD
BATCH NUMBER: ST3285-0

No. of SAMPLES: 106
DATE RECEIVED: 10/03/92
DATE COMPLETED: 24/03/92

ORDER No: LETTER SAMPLE TYPE: ROCK CHIP PROJECT No:

SAMPLE NUMBER	ELEMENT UNIT METHOD	CaSO4 2H20 % M277A	CaCO3 % M277A	MgCO3 % M277A	Fe2O3 % M277A	Al2O3 % M277A
L24 1.60-2.79	1.19	47.6	37.1	4.57	0.10	0.04
L25 0-1.04	1.04	73.7	12.9	4.14	0.08	0.06
L25 1.04-1.90	0.86	22.1	57.7	7.31	0.14	0.04
L26 0-0.70	0.70	82.6	8.29	2.11	0.06	0.06
L26 0.70-1.40	0.70	20.4	60.8	4.83	0.17	0.06
L27 0-0.85	0.85	63.9	19.8	5.25	0.07	0.06
L27 0.85-1.60	0.75	4.64	72.8	5.71	0.35	0.05
L28 0-0.50	0.50	60.8	21.9	5.73	0.10	0.09
L28 0.50-1.00	0.50	32.1	51.0	4.95	0.11	0.04
L28 1.00-1.60	0.60	7.95	47.5	3.67	0.21	0.12
L29 0-0.75	0.75	69.2	14.4	4.74	0.08	0.04
L29 0.75-0.45	0.70	75.6	12.0	3.45	0.05	0.02
L29 1.45-2.04	0.59	72.8	14.1	3.66	0.08	0.03
L30 0-0.90	0.90	68.5	14.9	5.38	0.11	0.09
L30 0.90-1.78	0.88	5.90	69.1	5.00	0.11	0.05
L30 1.78-2.07	0.29	6.09	68.0	4.17	0.24	0.13
L31 0-0.22	0.22	5.14	51.8	19.8	0.38	0.42
L32 0-0.55	0.55	2.46	31.8	8.91	0.54	0.17
L33 0-0.90	0.90	67.7	16.8	4.82	0.10	0.05
L33 0.90-1.86	0.96	69.3	19.0	3.12	0.07	0.01
L34 0.02-0.88	0.86	72.7	13.9	3.00	0.08	0.05
L34 0.88-1.76	0.88	51.8	31.0	4.84	0.11	0.05
L34 1.76-2.60	0.84	51.2	30.7	4.20	0.18	0.06
L35 0-0.80	0.80	50.8	30.9	5.62	0.18	0.14
L36 0.02-0.83	0.81	8.92	56.1	12.8	0.24	0.21
L37 0.02-0.35	0.33	24.9	44.1	11.1	0.20	0.15
L38 0.02-0.65	0.63	6.36	72.4	5.62	0.75	0.14
L39 0.02-0.60	0.58	73.4	14.1	3.57	0.12	0.05
L39 0.60-1.42	0.82	56.2	27.9	4.26	0.07	0.03
L39 1.42-1.67	0.25	12.7	65.6	4.19	0.15	0.06
DETECTION LIMIT:		0.01	0.01	0.01	0.01	0.01

COMMENTS:

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ANALYTICAL REPORT

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CLIENT: OLLIVER GEOLOGICAL SERVICES
ADDRESS: P O BOX 24
MCLAREN VALE
SA 5171

CONTACT: MR J OLLIVER

LABORATORY: STAFFORD
BATCH NUMBER: ST3285-0

No. of SAMPLES: 106
DATE RECEIVED: 10/03/92
DATE COMPLETED: 24/03/92

ORDER No: LETTER
SAMPLE TYPE: ROCK CHIP
PROJECT No:

SAMPLE NUMBER	ELEMENT UNIT METHOD	CaSO4 2H2O % M277A	CaCO3 % M277A	MgCO3 % M277A	Fe2O3 % M277A	Al2O3 % M277A
L40 0.05-0.60	0.55	42.7	33.9	6.59	0.13	0.10
L41 0.02-1.50	1.48	4.31	58.9	11.2	0.36	0.20
L41 1.50-2.50	1.00	3.84	73.9	5.13	0.22	0.08
L42 0-069	0.60	3.06	71.4	10.8	1.06	0.17
L43 0-0.50	0.50	3.70	60.8	14.2	1.28	0.19
L43 0.50-1.10	0.60	3.28	79.2	5.46	2.01	0.03
L44 0.02-0.85	0.83	3.76	64.8	12.3	0.88	0.24
L45 0.02-0.35	0.33	4.92	66.2	6.57	1.68	0.45
L46 0-065	0.65	41.8	42.2	4.13	1.59	0.08
L47 0.02-0.80	0.78	3.79	71.1	9.52	1.10	0.10
L48 0-0.84	0.84	2.56	71.0	7.95	0.94	0.21
L2 0-0.33	0.33	75.9	1.30	2.85	0.11	0.07
L3 0.82-1.12	0.30	59.6	24.1	4.47	0.06	0.02
WS27 0.10-1.09	0.99	86.9	<0.01	2.12	0.03	0.03
WS34 1.00-1.50	0.50	89.0	2.07	2.18	0.08	0.02
WS35 0.55-1.26	0.71	87.4	1.67	2.24	0.05	0.03
DETECTION LIMIT:		0.01	0.01	0.01	0.01	0.01

COMMENTS:

Laboratory
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Kalgoorlie Laboratory
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Southern Cross Laboratory
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AUSTRALIAN LABORATORY SERVICES P/L

A.C.N. 009 936 029

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ANALYTICAL REPORT

CLIENT: OLLIVER GEOLOGICAL SERVICES
ADDRESS: P O BOX 24
MCLAREN VALE
SA 5171

CONTACT: MR J OLLIVER

LABORATORY: STAFFORD
BATCH NUMBER: ST3285-0

No. of SAMPLES: 106
DATE RECEIVED: 10/03/92
DATE COMPLETED: 24/03/92

ER No: LETTER
SAMPLE TYPE: ROCK CHIP
PROJECT No:

SAMPLE NUMBER	ELEMENT UNIT METHOD	Na as NaCl % M277A	K as KCl % M277A			
L4 0-1.79	1.79	4.66	0.09			
L4 1.79-2.98	1.19	2.85	0.08			
L5 0-0.84	1.84	5.16	0.17			
L5 0.84-2.50	1.66	4.46	0.11			
L5 2.50-3.58	1.08	4.82	0.14			
L0 0.02-0.85	0.83	3.14	0.10			
L0 0.85-2.49	1.64	2.91	0.14			
L7 0.02-0.98	0.96	3.17	0.11			
L7 0.98-2.45	1.47	3.03	0.09			
L8 0-0.80	0.78	4.09	0.12			
L8 0.80-1.62	0.82	3.78	0.05			
L8 1.62-2.76	1.14	3.22	0.07			
L9 0.02-0.94	0.92	4.22	0.09			
L9 0.94-1.52	0.58	3.68	0.04			
L9 1.52-2.15	0.63	3.63	0.08			
L9 2.15-2.42	0.27	2.22	0.03			
L10 0.02-1.05	1.03	7.14	0.16			
L10 1.05-2.82	1.77	6.12	0.10			
L11 0.02-0.65	0.63	4.41	0.10			
L11 0.65-1.54	0.89	4.06	0.16			
L11 1.54-2.00	0.46	3.19	0.06			
L11 2.00-2.89	0.89	2.92	0.05			
L12 0-1.65	1.65	5.52	0.07			
L12 1.65-2.23	0.58	3.42	<0.01			
L13 0.02-1.15	1.13	3.62	0.08			
L13 1.15-1.78	0.63	5.32	0.05			
L13 1.78-2.31	0.53	3.61	0.06			
L13 2.31-2.71	0.40	4.10	0.08			
L14 0-0.91	0.91	4.54	0.08			
L14 0.91-1.60	0.69	3.97	0.06			
ON LIMIT:		0.01	0.01			

MENTS:

Il Laboratory
(0 79 9155 Fax: (077) 79 9729
s wers Laboratory
(077) 87 4155 Fax: (077) 87 4220
Laboratory
(063) 63 1722 Fax: (063) 63 1189
oratory
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CONTACT: MR J OLLIVER

LABORATORY: STAFFORD
BATCH NUMBER: ST3285-0

No. of SAMPLES: 106
DATE RECEIVED: 10/03/92
DATE COMPLETED: 24/03/92

IDER No: LETTER SAMPLE TYPE: ROCK CHIP PROJECT No:

SAMPLE NUMBER	ELEMENT UNIT METHOD	Na as NaCl % M277A	K as KCl % M277A			
L14 1.60-1.86	0.26	3.84	0.07			
L15 0.02-0.75	0.73	3.56	0.06			
L15 0.75-2.21	1.46	4.80	0.09			
L16 0.05-0.75	0.70	3.71	0.08			
L16 0.75-1.39	0.64	3.74	0.09			
L16 1.39-1.97	0.58	3.42	0.11			
L17 0.03-0.75	0.72	3.29	0.06			
L17 0.75-1.94	1.19	3.86	0.07			
L18 0-0.60	0.60	3.20	0.08			
L18 0.60-1.50	0.90	4.96	0.09			
L18 1.50-1.99	0.49	2.90	0.29			
L19 0-0.90	0.90	2.75	0.12			
L19 0.90-1.60	0.70	3.39	0.09			
L19 1.60-2.18	0.58	1.57	0.02			
L20 0-0.60	0.60	3.80	0.10			
L20 0.60-1.95	1.35	4.44	0.09			
L20 1.95-2.47	0.52	3.45	0.04			
L20 2.47-3.08	0.61	4.78	0.07			
L21 0-0.65	0.65	3.87	0.01			
L21 0.65-1.55	0.90	3.89	0.06			
L21 1.55-2.43	0.88	2.71	0.07			
L21 2.43-3.50	1.07	4.04	0.08			
L22 0.02-0.80	0.78	2.61	0.02			
L22 0.80-1.19	0.39	3.13	0.06			
L22 1.19-2.80	1.61	3.77	0.07			
L23 0.03-0.81	0.78	2.65	0.08			
L23 0.81-1.25	0.44	2.38	0.06			
L23 1.25-2.34	1.09	3.74	0.06			
L24 0-0.85	0.85	3.74	0.06			
L24 0.85-1.60	0.75	2.54	0.02			
T TION LIMIT:		0.01	0.01			

IMMENTS:

AUSTRALIAN LABORATORY SERVICES P/L

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SA 5171

CONTACT: MR J OLLIVER

LABORATORY: STAFFORD
BATCH NUMBER: ST3285-0

No. of SAMPLES: 106
DATE RECEIVED: 10/03/92
DATE COMPLETED: 24/03/92

ER No: LETTER SAMPLE TYPE: ROCK CHIP PROJECT No:

SAMPLE NUMBER	ELEMENT UNIT METHOD	Na as NaCl % M277A	K as KCl % M277A			
L24 1.60-2.79	1.19	3.52	0.08			
L25 0-1.04	1.04	3.02	0.10			
L25 1.04-1.90	0.86	4.03	0.09			
L26 0-0.70	0.70	2.32	0.08			
L26 0.70-1.40	0.70	3.50	0.08			
L27 0-0.85	0.85	4.00	0.08			
L27 0.85-1.60	0.75	5.24	0.09			
L28 0-0.50	0.50	4.08	0.10			
L28 0.50-1.00	0.50	2.52	0.07			
L28 1.00-1.60	0.60	2.73	0.09			
L29 0-0.75	0.75	4.95	0.09			
L29 0.75-0.45	0.70	3.73	0.07			
L29 1.45-2.04	0.59	3.46	0.08			
L30 0-0.90	0.90	4.25	0.09			
L30 0.90-1.78	0.88	5.99	0.12			
L30 1.78-2.07	0.29	5.92	0.14			
L31 0-0.22	0.22	6.41	0.22			
L32 0-0.55	0.55	4.86	0.14			
L33 0-0.90	0.90	3.75	0.08			
L33 0.90-1.86	0.96	2.78	0.28			
L34 0.02-0.88	0.86	3.78	0.30			
L34 0.88-1.76	0.88	3.93	0.10			
L34 1.76-2.60	0.84	4.36	0.08			
L35 0-0.80	0.80	3.64	0.08			
L36 0.02-0.83	0.81	6.91	0.17			
L37 0.02-0.35	0.33	6.50	0.08			
L38 0.02-0.65	0.63	4.87	0.08			
L39 0.02-0.60	0.58	3.42	0.04			
L39 0.60-1.42	0.82	3.92	0.03			
L39 1.42-1.67	0.25	5.00	0.05			
ION LIMIT:		0.01	0.01			

IMENTS:

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ANALYTICAL REPORT

CLIENT: OLLIVER GEOLOGICAL SERVICES
ADDRESS: P O BOX 24
MCLAREN VALE
SA 5171

CONTACT: MR J OLLIVER

LABORATORY: STAFFORD
BATCH NUMBER: ST3285-0

No. of SAMPLES: 106
DATE RECEIVED: 10/03/92
DATE COMPLETED: 24/03/92

DER No: LETTER   SAMPLE TYPE: ROCK CHIP   PROJECT No:

SAMPLE NUMBER	ELEMENT UNIT METHOD	Na as NaCl % M277A	K as KCl % M277A			
L40 0.05-0.60	0.55	6.04	0.06			
L41 0.02-1.50	1.48	6.09	0.07			
L41 1.50-2.50	1.00	4.49	0.04			
L42 0-069	0.60	3.82	0.06			
L43 0-0.50	0.50	5.58	0.07			
L43 0.50-1.10	0.60	3.43	0.03			
L44 0.02-0.85	0.83	4.94	0.07			
L45 0.02-0.35	0.33	4.52	0.11			
L46 0-065	0.65	3.17	0.05			
L47 0.02-0.80	0.78	4.46	0.06			
L48 0-0.84	0.84	4.38	0.08			
L2 0-0.33	0.33	5.70	0.05			
L3 0.82-1.12	0.30	4.03	0.03			
WS27 0.10-1.09	0.99	5.37	0.03			
WS34 1.00-1.50	0.50	2.17	0.03			
WS35 0.55-1.26	0.71	3.78	0.03			
E[illegible]ION LIMIT:		0.01	0.01			

MMENTS:

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ANALYTICAL REPORT

CLIENT: OLLIVER GEOLOGICAL SERVICES
ADDRESS: P O BOX 24
MCLAREN VALE
SA 5171

CONTACT: MR J OLLIVER

LABORATORY: AMENDED
BATCH NUMBER: AM3386-0

No. of SAMPLES: 46
DATE RECEIVED: 11/06/92
DATE COMPLETED: 12/06/92

DER No: LETTER SAMPLE TYPE: GYPSUM PROJECT No:

SAMPLE NUMBER	ELEMENT UNIT METHOD	CaS04 2H20 % M277A	CaC03 % M277A	MgC03 % M277A	Fe203 % M277A	A1203 % M277A
WS121 0-0.88	0.88	77.4	4.75	2.14	0.09	0.07
WS122 0-0.32	0.32	85.8	2.74	1.92	0.05	0.04
WS122 0.32-1.05	0.73	69.9	6.30	2.21	0.14	0.09
WS123 0-0.50	0.50	82.6	3.79	3.08	0.09	0.09
WS124 0-0.99	0.99	66.7	7.17	2.98	0.13	0.10
WS124 0.99-2.76	1.77	81.2	4.29	1.52	0.11	0.09
WS125 0.04-0.95	0.91	85.4	2.93	1.80	0.03	0.02
WS125 0.95-1.67	0.72	81.5	4.54	2.64	0.05	0.02
WS126 0.05-0.84	0.79	85.6	2.33	2.64	0.03	0.02
WS126 0.84-1.13	0.29	63.1	14.0	6.29	0.13	0.16
WS126 1.13-1.60	0.47	64.7	16.8	3.45	0.07	0.05
WS127 0-0.40	0.40	74.5	4.50	1.89	0.13	0.11
L49 0-0.99	0.99	59.2	16.6	6.97	0.16	0.16
L49 0.99-1.42	0.43	62.3	19.0	3.45	0.08	0.05
L49 1.42-2.00	0.58	41.4	37.1	4.11	0.08	0.06
L49 2.00-3.00	1.00	7.45	59.6	5.14	0.27	0.10
L50 0-0.60	0.60	3.32	70.2	8.99	0.45	0.14
L50 0.60-1.20	0.60	3.41	74.1	4.97	0.39	0.05
L51 0-0.60	0.60	4.11	60.5	17.3	0.15	0.16
L51 0.60-1.00	0.40	3.55	65.8	14.5	0.11	0.07
L51 1.00-2.20	1.20	3.85	67.3	8.84	0.10	0.07
L51 2.20-3.48	1.28	4.44	66.1	5.23	0.40	0.19
L52 0.04-0.67	0.63	2.62	65.4	9.03	0.77	0.18
L53 0.03-0.97	0.94	57.7	17.9	8.38	0.12	0.12
L53 0.97-1.80	0.83	70.7	15.7	3.34	0.07	0.02
L53 1.80-2.72	0.92	53.2	28.4	3.85	0.15	0.06
L54 0.05-0.64	0.59	18.8	46.6	14.1	0.23	0.21
L54 0.64-1.93	1.29	4.48	67.7	7.45	0.13	0.11
L54 1.93-2.65	0.72	3.10	76.8	3.02	0.27	0.06
L54 2.65-3.15	0.50	4.17	46.1	4.10	0.46	0.48
E TION LIMIT:		0.01	0.01	0.01	0.01	0.01

MMENTS: *** DUPLICATE ASSAYS.
a). Samples dried at 45'C before pulverising.
b). Analysis carried out on acid digest. (1:1HCl)
c). CaS04.2H20 calculated from S content.
D). Excess Ca reported as CaC03.

Laboratory
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e Laboratory
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aboratory
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Phone: (090) 49 1292 Fax: (090) 49 1374

All pages of this report have been checked and approved for release.

G. Allen
Signed

AUSTRALIAN LABORATORY SERVICES P/L

A.C.N. 009 936 029

ANALYTICAL REPORT

Brisbane Head Office and Laboratory
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Telephone: (07) 352 5577
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CLIENT: OLLIVER GEOLOGICAL SERVICES
ADDRESS: P O BOX 24
MCLAREN VALE
SA 5171

CONTACT: MR J OLLIVER

LABORATORY: AMENDED
BATCH NUMBER: AM3386-0

No. of SAMPLES: 46
DATE RECEIVED: 11/06/92
DATE COMPLETED: 12/06/92

DER No: LETTER

SAMPLE TYPE: GYPSUM

PROJECT No:

SAMPLE NUMBER	ELEMENT UNIT METHOD	CaSO4 2H2O % M277A	CaCO3 % M277A	MgCO3 % M277A	Fe2O3 % M277A	Al2O3 % M277A
L56 0.05-1.00	0.95	5.48	59.9	15.7	0.16	0.17
L56 1.00-1.36	0.36	3.72	66.7	7.20	0.12	0.06
L56 1.36-2.00	0.64	4.03	73.5	5.22	0.21	0.05
L57 0.04-0.65	0.61	80.1	8.72	2.23	0.02	0.02
L57 0.65-1.20	0.55	28.8	47.8	6.76	0.09	0.03
L57 1.20-1.72	0.52	46.1	38.6	4.83	0.13	0.04
L57 1.72-2.21	0.49	66.8	22.1	3.64	0.12	0.07
L58 0-1.17	1.17	82.2	8.40	2.24	0.06	0.03
L58 1.17-1.47	0.30	55.9	29.1	3.84	0.05	0.02
L58 1.47-2.28	0.81	52.3	33.0	4.69	0.10	0.02
L59 0-0.93	0.93	10.5	57.8	12.0	0.33	0.10
L59 0.93-1.22	0.29	3.61	68.9	7.87	0.48	0.04
L60 0-0.80	0.80	78.3	7.23	3.35	0.06	0.03
L60 0.80-1.94	1.14	72.9	12.1	3.70	0.06	0.02
L61 0-0.30	0.30	37.1	38.4	6.05	0.16	0.14
L63 0.25-0.56	0.31	4.86	65.4	7.68	0.23	0.10
ON LIMIT:		0.01	0.01	0.01	0.01	0.01

IMENTS:

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No. of SAMPLES: 46
DATE RECEIVED: 11/06/92
DATE COMPLETED: 12/06/92

DER No: LETTER

SAMPLE TYPE: GYPSUM

PROJECT No:

SAMPLE NUMBER	ELEMENT UNIT METHOD	Na as NaCl % M277A	K as KCl % M277A			
WS121 0-0.88	0.88	3.34	0.06			
WS122 0-0.32	0.32	4.16	0.09			
WS122 0.32-1.05	0.73	2.96	0.07			
WS123 0-0.50	0.50	3.85	0.07			
WS124 0-0.99	0.99	3.24	0.07			
WS124 0.99-2.76	1.77	3.21	0.06			
WS125 0.04-0.95	0.91	3.71	0.05			
WS125 0.95-1.67	0.72	4.59	0.06			
WS126 0.05-0.84	0.79	4.22	0.04			
WS126 0.84-1.13	0.29	6.56	0.12			
WS126 1.13-1.60	0.47	5.84	0.10			
WS127 0-0.40	0.40	3.44	0.09			
L49 0-0.99	0.99	4.70	0.09			
L49 0.99-1.42	0.43	5.00	0.07			
L49 1.42-2.00	0.58	5.92	0.09			
L49 2.00-3.00	1.00	7.68	0.15			
L50 0-0.60	0.60	5.63	0.14			
L50 0.60-1.20	0.60	5.30	0.11			
L51 0-0.60	0.60	6.53	0.14			
L51 0.60-1.00	0.40	6.29	0.10			
L51 1.00-2.20	1.20	6.10	0.11			
L51 2.20-3.48	1.28	5.17	0.14			
L52 0.04-0.67	0.63	6.42	0.19			
L53 0.03-0.97	0.94	5.94	0.12			
L53 0.97-1.80	0.83	3.94	0.06			
L53 1.80-2.72	0.92	5.09	0.10			
L54 0.05-0.64	0.59	7.06	0.20			
L54 0.64-1.93	1.29	5.06	0.11			
L54 1.93-2.65	0.72	3.63	0.06			
L54 2.65-3.15	0.50	3.61	0.19			
...ON LIMIT:		0.01	0.01			

...MENTS:

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CONTACT: MR J OLLIVER

LABORATORY: AMENDED
BATCH NUMBER: AM3386-0

No. of SAMPLES: 46
DATE RECEIVED: 11/06/92
DATE COMPLETED: 12/06/92

D.. No: LETTER   SAMPLE TYPE: GYPSUM   PROJECT No:

SAMPLE NUMBER	ELEMENT UNIT METHOD	Na as NaCl % M277A	K as KCl % M277A
L56 0.05-1.00	0.95	6.16	0.19
L56 1.00-1.36	0.36	6.82	0.18
L56 1.36-2.00	0.64	5.43	0.15
L57 0.04-0.65	0.61	2.76	0.11
L57 0.65-1.20	0.55	4.03	0.15
L57 1.20-1.72	0.52	3.58	0.06
L57 1.72-2.21	0.49	2.79	0.08
L58 0-1.17	1.17	3.01	0.06
L58 1.17-1.47	0.30	2.72	0.07
L58 1.47-2.28	0.81	3.16	0.06
L59 0-0.93	0.93	6.82	0.13
L59 0.93-1.22	0.29	5.79	0.11
L60 0-0.80	0.80	4.00	0.06
L60 0.80-1.94	1.14	5.00	0.06
L61 0-0.30	0.30	7.09	0.18
L63 0.25-0.56	0.31	6.15	0.14
..TE..TION LIMIT:		0.01	0.01

..MMENTS:

ADJUSTMENT OF CLASSICAL ANALYSES TO FIT ALS ANALYSES

The following samples were analysed by both laboratories:

GYPSUM CONTENT (%)				
SAMPLE			CLASSIC	ALS
Warnes	WS27	0.10 - 1.09	89.3	86.9
	WS34	1.00 - 1.50	89.8	89.0
	WS35	0.55 - 1.26	81.2	87.4
Lihou	L2	0 - 0.33	87.4	75.9
	L3	0.82 - 1.12	66.4	59.6

Based on the above, the Classic analyses have been converted to the following by checking the core samples and comparing with adjacent holes.

			CLASSIC	ADJUSTED
Warnes	WS27	0.10 - 1.09	89.3	86.9
		1.09 - 1.40	86.5	83.9
	WS28	0.20 - 0.87	82.7	84.0
		0.87 - 1.25	85.5	81.5
	WS34	0.20 - 1.00	80.7	91.1
		1.00 - 1.50	89.8	89.0
		1.50 - 2.00	87.9	87.0
	WS35	0 - 0.55	82.2	75.8
		0.55 - 1.26	81.2	87.4
	WS36	0.20 - 0.49	81.7	91.7
		0.49 - 1.62	82.2	89.1
Lihou	L1	0 - 0.21	78.8	74.1
		0.21 - 0.77	80.3	79.2
	L2	0 - 0.33	87.4	75.9
		0.33 - 1.18	70.7	71.0
		1.18 - 1.40	67.4	56.9
	L3	0 - 0.82	76.4	76.4
		0.82 - 1.12	66.4	59.6
		1.12 - 1.73	58.3	53.0

APPENDIX C

CALCULATION OF AVERAGE GYPSUM CONTENT

(1) Warnes Main Lake - Drillholes - Weighted Average

(2) Warnes Main Lake - Areas of Influence

(3) Lihou - Drillholes - Weighted Average

(4) Lihou - Areas of Influence

APPENDIX C

WARNES SWAMP - MAIN LAKE

WEIGHTED AVERAGE GYPSUM AND SALT CONTENT OF DRILLHOLE SAMPLES

HOLE NO	GYPSUM INTERVAL (m)	GYPSUM THICKNESS (m)	GYPSUM PERCENTAGE	NaCl + KCl PERCENTAGE
WS 27	0.10 - 1.09	0.99	86.9	
	1.09 - 1.40	0.31	83.9	
		Σ 1.30	Av 86.2	Av 4.6
WS 28	0.20 - 0.87	0.67	84.0	
	0.87 - 1.25	0.38	81.5	
		Σ 1.05	Av 83.1	Av 4.4
WS 34	0.20 - 1.00	0.80	91.1	
	1.00 - 1.50	0.50	89.0	
	1.50 - 2.00	0.50	87.0	
		Σ 1.80	Av 89.4	Av 5.5
WS 35	0.00 - 0.55	0.55	75.8	
	0.55 - 1.26	0.71	87.4	
		Σ 1.26	Av 82.3	Av 4.1
WS 36	0.03 - 0.49	0.46	91.7	
	0.49 - 1.62	1.13	89.1	
		Σ 1.59	Av 89.9	Av 3.8
WS 38	0.00 - 0.45	0.45	89.9	4.8
WS 39	0.00 - 0.78	0.78	88.1	5.5
	0.78 - 2.17	1.39	77.0	6.0
		Σ 2.17	Av 81.0	Av 5.8
WS 40	0.08 - 0.80	0.72	84.8	5.3
	0.80 - 2.05	1.25	79.6	5.2
		Σ 1.97	Av 81.5	Av 5.2
WS 41	0.05 - 0.90	0.85	82.7	5.7
WS 44	0.05 - 1.00	0.95	87.4	5.1
WS 45	0.05 - 1.00	0.95	88.2	3.6
	1.00 - 1.69	0.69	71.6	4.7
		Σ 1.64	Av 81.2	Av 4.1
WS 46	0.05 - 1.10	1.05	89.4	4.9
	1.10 - 2.00	0.90	87.5	4.6
		Σ 1.95	Av 88.5	Av 4.8

HOLE NO	GYPSUM INTERVAL (m)	GYPSUM THICKNESS (m)	GYPSUM PERCENTAGE	NaCl + KCl PERCENTAGE
WS 47	0.05 - 1.20	1.15	86.9	5.7
WS 48	0.00 - 0.70	0.70	85.9	6.0
WS 49	0.00 - 0.60	0.60	83.4	4.1
WS 50	0.05 - 0.70	0.65	77.2	6.0
WS 52	0.05 - 1.30	1.25	58.3	5.5
WS 54	0.00 - 1.15	1.15	84.4	5.2
WS 55	0.00 - 1.55	1.55	82.0	4.8
WS 56	0.02 - 0.95	0.93	86.1	4.9
	0.95 - 1.38	0.43	87.0	4.8
		Σ 1.36	Av 86.3	Av 4.9
WS 57	0.00 - 1.46	1.46	82.3	4.9
	1.46 - 2.20	0.74	83.0	4.0
		Σ 2.20	Av 82.5	Av 4.6
WS 58	0.00 - 0.80	0.80	86.6	4.5
	0.80 - 2.00	1.20	83.6	3.9
		Σ 2.00	Av 84.8	Av 4.1
WS 62	0.00 - 1.35	1.35	85.3	4.0
WS 63	0.05 - 0.95	0.90	87.4	4.1
	0.95 - 1.46	0.51	83.2	3.9
		Σ 1.41	Av 85.9	Av 4.0
WS 64	0.05 - 0.90	0.85	87.3	5.1
	0.90 - 1.73	0.83	86.1	4.5
	1.73 - 2.40	0.67	88.6	4.0
		Σ 2.35	Av 87.2	Av 4.6
WS 65	0.03 - 0.95	0.92	88.5	4.7
	0.95 - 1.40	0.45	86.1	5.0
	1.40 - 2.65	1.25	87.8	3.6
		Σ 2.62	Av 87.8	Av 4.2
WS 66	0.00 - 0.75	0.75	67.5	4.9
WS 68	0.00 - 1.45	1.45	82.6	3.6
WS 69	0.05 - 1.05	1.00	90.0	3.9
	1.05 - 2.34	1.29	90.3	3.8
	2.34 - 3.00	0.66	87.0	3.7
		Σ 2.95	Av 89.5	Av 3.8

HOLE NO	GYPSUM INTERVAL (m)	GYPSUM THICKNESS (m)	GYPSUM PERCENTAGE	NaCl + KCl PERCENTAGE
WS 70	0.00 - 1.25	1.25	90.2	3.3
WS 71	0.00 - 0.62	0.62	89.0	2.4
WS 73	0.00 - 1.00	1.00	88.1	4.2
	1.00 - 1.81	0.81	83.2	4.7
	1.81 - 2.87	1.06	73.8	4.0
	2.87 - 3.40	0.53	71.6	3.5
		Σ 3.40	Av 79.9	Av 4.2
WS 74	0.00 - 1.25	1.25	88.9	3.5
	1.25 - 1.86	0.61	85.8	3.8
	1.86 - 3.05	1.19	77.5	3.5
	3.05 - 3.72	0.67	67.1	4.0
		Σ 3.72	Av 80.8	Av 3.7
WS 75	0.00 - 1.10	1.10	86.8	3.7
	1.10 - 2.10	1.00	74.4	3.9
	2.10 - 2.34	0.24	85.6	3.4
		Σ 2.34	Av 81.4	Av 3.8
WS 76	0.05 - 1.48	1.43	84.2	4.1
	1.48 - 2.10	0.62	71.4	4.2
		Σ 2.05	Av 80.3	Av 4.1
WS 77	0.00 - 0.90	0.90	78.6	4.6
WS 78	0.00 - 1.03	1.03	82.8	3.7
WS 79	0.00 - 1.53	1.53	86.2	3.2
WS 80	0.00 - 1.24	1.24	85.2	3.4
WS 81	0.00 - 1.35	1.35	84.7	3.7
WS 82	0.02 - 1.00	0.98	82.2	3.7
WS 83	0.00 - 0.95	0.95	77.4	4.4
WS 85	0.00 - 0.40	0.40	61.6	6.1
WS 86	0.00 - 1.25	1.25	76.0	5.0
	1.25 - 1.54	0.29	80.5	4.5
		Σ 1.54	Av 76.8	Av 4.9
WS 87	0.00 - 1.05	1.05	82.7	3.5
WS 88	0.00 - 0.41	0.41	75.7	4.1
WS 91	0.05 - 0.80	0.75	86.7	6.8

HOLE NO	GYPSUM INTERVAL (m)	GYPSUM THICKNESS (m)	GYPSUM PERCENTAGE	NaCl + KCl PERCENTAGE
WS 98	0.00 - 0.75	0.75	61.8	3.4
WS 100	0.00 - 1.40	1.40	82.7	5.2
WS 101	0.00 - 0.40	0.40	69.5	5.5
WS 104	0.00 - 1.00	1.00	71.5	3.9
WS 121	0.00 - 0.88	0.88	77.4	3.4
WS 122	0.00 - 0.32	0.32	85.8	4.3
	0.32 - 1.05	0.73	69.9	3.0
		Σ 1.05	Av 74.7	Av 3.4
WS 123	0.00 - 0.50	0.50	82.6	3.9
WS 124	0.00 - 0.99	0.99	66.7	3.3
	0.99 - 2.76	1.77	81.2	3.3
		Σ 2.76	Av 76.0	Av 3.3
WS 125	0.04 - 0.95	0.91	85.4	3.8
	0.95 - 1.67	0.72	81.5	4.7
		Σ 1.63	Av 83.7	Av 4.2
WS 126	0.05 - 0.84	0.79	85.6	4.3
	0.84 - 1.13	0.29	63.1	6.7
	1.13 - 1.60	0.47	64.7	5.9
		Σ 1.55	Av 75.1	Av 5.2
WS 127	0.00 - 0.40	0.40	74.5	3.5

WARNES - AREAS OF INFLUENCE					
HOLE	THICKNESS (m)	AREA (m^2)	VOLUME (m^3)	RAW GYPSUM (%)	VOLUME %
27	1.30	30,000	39,000	86.2	3,361,800
28	1.05	40,800	42,840	83.1	3,560,004
34	1.80	30,000	54,000	89.4	4,827,600
35	1.26	41,000	51,660	82.3	4,251,618
36	1.60	53,600	85,760	89.9	7,709,824
38	0.45	7,800	3,510	89.9	315,549
39	2.17	23,200	50,344	81.0	4,077,864
40	2.00	32,200	64,400	81.5	5,248,600
41	0.85	11,000	9,350	82.7	773,245
44	0.95	13,833	13,141.35	87.4	1,148,533.99
45	1.64	33,400	54,776	81.2	4,447,811.2
46	1.95	34,600	67,470	88.5	5,971,095
47	1.15	25,250	29,037.5	86.9	2,523,358.75
48	0.70	17,800	12,460	85.9	1,070,314
49	0.60	14,800	8,880	83.4	740,592
50	0.65	12,000	7,800	77.2	602,160
52	1.25	27,600	34,500	58.3	2,011,350
54	1.15	43,600	50,140	84.4	4,231,816
55	1.55	41,200	63,860	82.0	5,236,520
56	1.36	41,000	55,760	86.4	4,817,664
57	2.20	37,000	81,400	82.5	6,715,500
58	2.00	42,800	85,600	84.8	7,258,880
62	1.35	65,600	88,560	85.3	7,554,168
63	1.41	49,750	70,147.5	85.9	6,025,670.25
64	2.35	57,600	135,360	87.2	11,803,392
65	2.62	73,200	191,784	87.8	16,838,635.2
66	0.75	44,750	33,562.5	67.5	2,265,468.75
68	1.45	68,250	98,962.5	82.6	8,174,302.5
69	2.95	73,200	215,940	89.5	19,326,630
70	1.64	51,200	83,968	82.7	6,944,153.6
71	0.62	30,000	18,600	89.0	1,655,400
72	1.57	42,400	66,568	82.1	5,465,232.8

WARNES - AREAS OF INFLUENCE					
HOLE	THICKNESS (m)	AREA (m^2)	VOLUME (m^3)	RAW GYPSUM (%)	VOLUME %
73	3.40	57,000	193,800	79.9	15,484,620
74	3.72	50,000	186,000	80.8	15,028,800
75	2.34	44,600	104,364	81.4	8,495,229.6
76	2.05	58,000	118,900	80.3	9,547,670
77	0.90	48,600	43,740	78.6	3,437,964
78	1.03	42,800	44,084	82.8	3,650,155.2
79	1.53	39,600	60,588	86.2	5,222,685.6
80	1.24	34,400	42,656	85.2	3,634,291.2
81	1.35	58,800	79,380	84.7	6,723,486
82	1.30	40,600	52,780	76.2	4,021,836
83	0.95	36,333	34,516.35	77.4	2,671,565.49
85	0.40	10,000	4,000	61.6	246,400
86	1.54	31,500	48,510	76.8	3,725,568
87	1.05	48,200	50,610	82.7	4,185,447
88	0.41	16,600	6,806	75.7	515,214.2
91	0.75	13,200	9,900	86.7	858,330
98	0.35	12,400	4,340	78.9	342,426
100	1.40	33,000	46,200	82.7	3,820,740
101	0.40	34,400	13,760	69.5	956,320
102	0.52	22,250	11,570	70.0	809,900
103	0.93	36,166	33,634.38	42.9	1,442,914,902
104	1.00	26,400	26,400	71.5	1,887,600
121	0.88	26,000	22,880	77.4	1,770,912
122	1.05	43,400	45,570	74.7	3,404,079
123	0.50	32,000	16,000	82.6	1,321,600
124	2.76	23,200	64,032	76.0	4,866,432
125	1.63	22,200	36,186	83.7	3,028,768.2
126	1.55	25,200	39,060	75.1	2,933,406
Total	83.27	2,177,282	3,409,408.05		280,989,132.40
Average	1.39			82.4	

APPENDIX C

LIHOU SWAMP

WEIGHTED AVERAGE GYPSUM AND SALT CONTENT OF DRILLHOLE SAMPLES

HOLE NO	GYPSUM INTERVAL (m)	GYPSUM THICKNESS (m)	GYPSUM PERCENTAGE	NaCl + KCl PERCENTAGE
L 1	0.00 - 0.21	0.21	74.1	
	0.21 - 0.75	0.54	79.2	
		Σ 0.75	Av 77.8	Av
L 2	0.00 - 0.33	0.33	75.9	
	0.33 - 1.18	0.85	71.0	
	1.18 - 1.40	0.22	56.9	
		Σ 1.40	Av 69.9	Av
L 3	0.00 - 0.82	0.82	76.4	
	0.82 - 1.12	0.30	59.6	
	1.12 - 1.73	0.61	53.0	
		Σ 1.73	Av 65.2	Av
L 4	0.00 - 1.79	1.79	58.1	4.8
	1.79 - 2.98	1.19	61.8	2.9
		Σ 2.98	Av 59.6	Av 4.0
L 6	0.02 - 0.85	0.83	70.4	3.2
L 7	0.02 - 0.98	0.96	75.0	3.3
	0.98 - 2.45	1.47	63.0	3.1
		Σ 2.43	Av 67.7	Av 3.2
L 8	0.00 - 0.80	0.80	73.0	4.2
	0.80 - 1.62	0.82	78.1	3.8
	1.62 - 2.76	1.14	69.5	3.3
		Σ 2.76	Av 73.1	Av 3.7
L 9	0.02 - 0.94	0.92	75.4	4.3
	0.94 - 1.52	0.58	72.4	3.7
	1.52 - 2.15	0.63	68.5	3.7
	2.15 - 2.42	0.27	74.8	2.3
		Σ 2.40	Av 72.8	Av 3.8
L 11	0.02 - 0.65	0.63	79.8	4.5
	0.65 - 1.54	0.89	75.9	4.2
	1.54 - 2.00	0.46	68.2	3.3
	2.00 - 2.89	0.89	71.8	3.0
		Σ 2.87	Av 74.3	Av 3.7

HOLE NO	GYPSUM INTERVAL (m)	GYPSUM THICKNESS (m)	GYPSUM PERCENTAGE	NaCl + KCl PERCENTAGE
L 12	0.00 - 1.65	1.65	69.9	5.6
	1.65 - 2.23	0.58	72.5	3.4
		Σ 2.23	Av 70.6	Av 5.0
L 13	0.02 - 1.15	1.13	76.8	3.7
	1.15 - 1.78	0.63	63.9	5.4
	1.78 - 2.31	0.53	64.8	3.7
	2.31 - 2.71	0.40	64.0	4.2
		Σ 2.69	Av 69.5	Av 4.1
L 14	0.00 - 0.91	0.91	62.4	4.6
L 15	0.02 - 0.75	0.73	80.3	3.6
L 16	0.05 - 0.75	0.70	82.7	3.8
L 17	0.03 - 0.75	0.72	84.1	3.4
L 18	0.00 - 0.60	0.60	79.9	3.3
L 19	0.00 - 0.90	0.90	79.8	2.9
	0.90 - 1.60	0.70	67.3	3.5
	1.60 - 2.18	0.58	80.2	1.6
		Σ 2.18	Av 75.9	Av 2.7
L 20	0.00 - 0.60	0.60	81.2	3.9
	0.60 - 1.95	1.35	50.8	4.5
	1.95 - 2.47	0.52	58.6	3.5
		Σ 2.47	Av 59.8	Av 4.2
L 21	0.00 - 0.65	0.65	84.0	3.9
	0.65 - 1.55	0.90	52.0	4.0
	1.55 - 2.43	0.88	53.1	2.8
		Σ 2.43	Av 61.0	Av 3.5
L 22	0.02 - 0.80	0.78	79.1	2.6
L 23	0.03 - 0.81	0.78	64.8	2.7
	0.81 - 1.25	0.44	53.1	2.4
	1.25 - 2.34	1.09	59.9	3.8
		Σ 2.31	Av 60.3	Av 3.2
L 24	0.00 - 0.85	0.85	68.4	3.8
	0.85 - 1.60	0.75	68.2	2.6
		Σ 1.60	Av 68.3	Av 3.2
L 25	0.00 - 1.04	1.04	73.7	3.1
L 26	0.00 - 0.70	0.70	82.6	2.4
L 27	0.00 - 0.85	0.85	63.9	4.1

HOLE NO	GYPSUM INTERVAL (m)	GYPSUM THICKNESS (m)	GYPSUM PERCENTAGE	NaCl + KCl PERCENTAGE
L 28	0.00 - 0.50	0.50	60.8	4.2
L 29	0.00 - 0.75	0.75	69.2	5.0
	0.75 - 1.45	0.70	75.6	3.8
	1.45 - 2.04	0.59	72.8	3.5
		Σ 2.04	Av 72.4	Av 4.2
L 30	0.00 - 0.90	0.90	68.5	4.3
L 33	0.00 - 0.90	0.90	67.7	3.8
	0.90 - 1.86	0.96	69.3	3.1
		Σ 1.86	Av 68.5	Av 3.4
L 34	0.02 - 0.88	0.86	72.7	4.1
	0.88 - 1.76	0.88	51.8	4.0
	1.76 - 2.60	0.84	51.2	4.4
		Σ 2.58	Av 58.6	Av 4.2
L 35	0.00 - 0.80	0.80	50.8	3.7
L 39	0.02 - 0.60	0.58	73.4	3.5
	0.60 - 1.42	0.82	56.2	4.0
		Σ 1.40	Av 63.3	Av 3.7
L 49	0.00 - 0.99	0.99	59.2	4.8
	0.99 - 1.42	0.43	62.3	5.1
		Σ 1.42	Av 60.1	Av 4.9
L 53	0.03 - 0.97	0.94	57.7	6.1
	0.97 - 1.80	0.83	70.7	4.0
	1.80 - 2.72	0.92	53.2	5.2
		Σ 2.69	Av 60.2	Av 5.2
L 57	0.04 - 0.65	0.61	80.1	2.6
	0.65 - 1.20	0.55	28.8	4.2
	1.20 - 1.72	0.52	46.1	3.6
	1.72 - 2.21	0.49	66.8	2.9
		Σ 2.17	Av 55.9	Av 3.3
L 58	0.00 - 1.17	1.17	82.2	3.1
	1.17 - 1.47	0.30	55.9	2.8
	1.47 - 2.28	0.81	52.3	3.2
		Σ 2.28	Av 68.1	Av 3.1
L 60	0.00 - 0.80	0.80	78.3	4.1
	0.80 - 1.94	1.14	72.9	5.1
		Σ 1.94	Av 75.1	Av 4.7

LIHOU - AREAS OF INFLUENCE					
HOLE	THICKNESS (m)	AREA (m^2)	VOLUME (m^3)	RAW GYPSUM (%)	VOLUME %
1	0.75	23,600	17,700	77.8	1,377,060
2	1.40	31,600	44,240	69.9	3,092,376
3	1.73	29,200	49,932	65.1	3,250,573
4	2.98	23,600	70,328	59.6	4,191,549
5	2.50	17,200	43,000	49.3	2,119,900
6	0.83	16,400	13,612	70.4	958,285
7	2.43	23,000	55,890	67.7	3,783,753
8	2.76	24,400	67,344	73.1	4,922,846
9	2.40	29,000	69,000	72.8	5,066,880
11	2.87	26,600	76,342	74.3	5,672,211
12	2.23	25,600	57,088	70.6	4,030,413
13	2.69	27,600	74,244	69.5	5,159,958
14	0.91	24,200	22,022	62.4	1,374,173
15	0.73	19,000	13,870	80.3	1,113,761
16	0.70	17,200	12,040	82.7	995,708
17	0.72	21,200	15,264	84.1	1,283,702
18	0.60	12,200	7,320	79.9	584,868
19	2.18	23,600	51,448	75.9	3,904,903
20	2.47	25,600	15,360	59.8	3,781,274

LIHOU SWAMP - RESERVES					
HOLE	THICKNESS (m)	AREA (m^2)	VOLUME (m^3)	RAW GYPSUM %	VOLUME %
21	2.43	22,800	55,404	61.0	3,379,644
22	0.78	23,000	17,940	79.1	1,419,054
23	2.31	23,800	54,978	60.3	3,315,173
24	1.60	23,600	37,760	68.3	2,579,008
25	1.04	35,800	37,232	73.7	2,743,998
26	0.70	19,000	13,300	82.6	1,098,580
27	0.85	12,200	10,370	63.9	662,643
28	0.50	23,000	11,500	60.8	699,200
29	2.04	26,000	53,040	72.4	3,840,096
30	0.90	16,400	14,760	68.5	1,011,060
33	1.86	22,000	40,920	68.5	2,803,020
34	2.58	16,600	42,828	58.6	2,509,721
35	0.80	11,400	9,120	50.8	463,296
39	1.40	14,000	19,600	63.3	1,240,680
49	1.42	14,200	20,164	60.1	1,211,856
53	2.69	15,000	40,350	60.2	2,429,070
57	2.17	23,800	51,646	55.9	2,887,011
58	2.28	23,200	52,896	68.1	3,602,218
60	1.94	25,000	48,500	75.1	3,642,350
Total	64.15	831,600	1,457,408	2,605.1	98,679,379
Average	1.68			67.4	

APPENDIX D

CALCULATION OF GYPSUM RESERVES

1. Warnes Main Lake From Figure 8
2. Warnes Dunes
3. Lihou From Figure 9
4. Lihou From Figure 10

WARNES SWAMP RESERVE CALCULATIONS

THICKNESS m	GROSS AREA m^2	NETT AREA m^2	AVERAGE THICKNESS m	NETT VOLUME m^3
+ 3.5	8,800	8,800	3.75	33,000
3.0 - 3.5	74,400	65,600	3.25	213,200
2.5 - 3.0	236,200	161,800	2.75	444,950
2.0 - 2.5	481,000	244,800	2.25	550,800
1.5 - 2.0	935,200	454,200	1.75	794,850
1.0 - 1.5	1,591,200	635,200	1.25	820,000
0.5 - 1.0	2,143,200	552,000	0.75	414,000
Total		2,143,200	1.39	3,270,800

∴ 3.271 x $10^6 m^3$ gypsum over 214.3 hectares at density of 1.35 gives 4.42 x 10^6 tonnes gypsum.

WARNES SWAMP

ESTIMATE OF GYPSUM IN DUNES

DUNE	RELEVANT DRILL HOLES	ESTIMATED HEIGHT (m)	ESTIMATED AREA (m^2)	VOLUME OF GYPSUM (m^3)
LARGE	WS 119,120	0.65	48,000	31,200
C	WS 111	0.5	3,000	1,500
E	WS 113	0.5	3,500	1,750
F	WS 114	0.7	8,500	5,950
G	WS 115	0.5	12,000	6,000
I	WS 117	0.5	12,500	6,250
J	WS 118	0.5	7,500	3,750
Σ MINOR		0.5	20,000	10,000
Total			115,000	66,400

∴ 66,400m^3 gypsum at density of 1.35 gives 90,000 tonnes of gypsum.

LIHOU SWAMP RESERVE CALCULATIONS
(INCLUDING LOW GRADE)

THICKNESS m	GROSS AREA m^2	NETT AREA m^2	AVERAGE THICKNESS m	NETT VOLUME m^3
2.5 - 3.0	61,600	61,600	2.75	169,400
2.0 - 2.5	221,000	159,400	2.25	358,650
1.5 - 2.0	408,400	187,400	1.75	327,950
1.0 - 1.5	562,600	154,200	1.25	192.750
0.5 - 1.0	865,600	303,000	0.75	227,250
Total		865,600	1.47	1,276,000

∴ $1.276 \times 10^6 m^3$ gypsum over 86.6 hectares at density of 1.35 gives 1.72×10^6 tonnes gypsum.

LIHOU SWAMP RESERVE CALCULATIONS
(INCLUDING LOW GRADE)

THICKNESS m	GROSS AREA m^2	NETT AREA m^2	AVERAGE THICKNESS m	NETT VOLUME m^3
2.5 - 3.0	16,000	16,000	2.75	44,000
2.0 - 2.5	106,900	90,900	2.25	204,525
1.5 - 2.0	188,600	81,700	1.75	142,975
1.0 - 1.5	325,200	136,600	1.25	170,750
0.5 - 1.0	668,200	343,000	0.75	257,250
Total		668,200	1.23	819,500

∴ $8.195 \times 10^5 m^3$ gypsum over 66.8 hectares at density of 1.35 gives 1.11×10^6 tonnes gypsum.

Plate 1 WARNES - view eastwards from Crosby Road 4.5 km east of Princes Highway. January 1992.

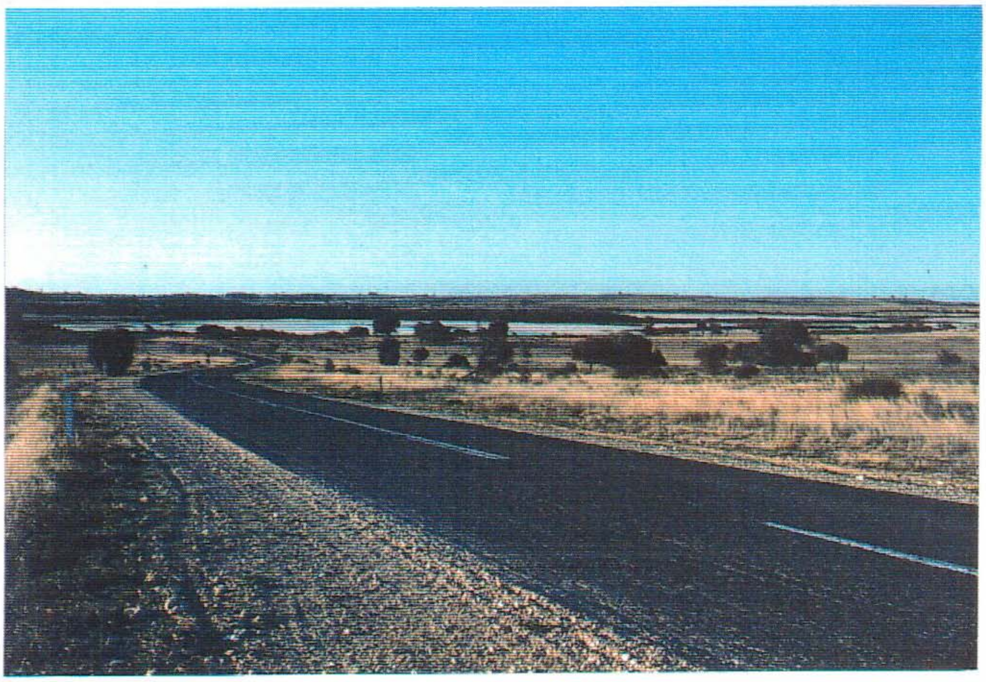


Plate 2 LIHOU - view north eastwards of south western portion from Princes Highway. April 1992.

Plate 3 WARNES - panoramic view eastwards January 1992. Scrub land at far right is between edge of lake and Crosby Road (obscured). Vegetated island is in centre right background. Lake surrounds have been mainly cleared for farming.

Plate 4 LIHOU - view westwards across northern portion to Princes Highway February 1992. Surface mainly salt crust. Fence separates Warnes' property in foreground from Lihou's. Vegetated island at centre left.

Plate 5 WARNES - sampling team during pattern drilling. January 1992. Approaching Hole WS40 in south western corner.

Plate 6 WARNES - PVC tube being hammered January 1992. Hole WS40. Aluminium dolly in top of tube and numbered pin marker used to identify each hole.

Plate 7 WARNES - completion of first length of PVC tube. January 1992. Hole WS40. Tube is filled with water and rubber bung inserted.

Plate 8 WARNES - extraction of PVC tube full of gypsum. January 1992. Hole WS40.

Plate 9 LIHOU - hand augering. February 1992. Hole L9 view westwards to Princes Highway.

Plate 10 LIHOU - removing sample from hand auger February 1992. Hole L9. Hammering gypsum out of slotted auger tube.

Plate 11 Sawing PVC tube. February 1992. Sealed tube is pushed along guide. Vertical circular saw is set to cut PVC but not disturb sample. Two cuts are placed diametrically opposite.

Plate 12 Splitting PVC tube. February 1992. A wire splitting device is pulled through the sawn tube thereby splitting the core sample in half.

Plate 13 Logging and sampling. February 1992. Split core is logged lithologically and half core is bulked over appropriate intervals and submitted for chemical analyses.

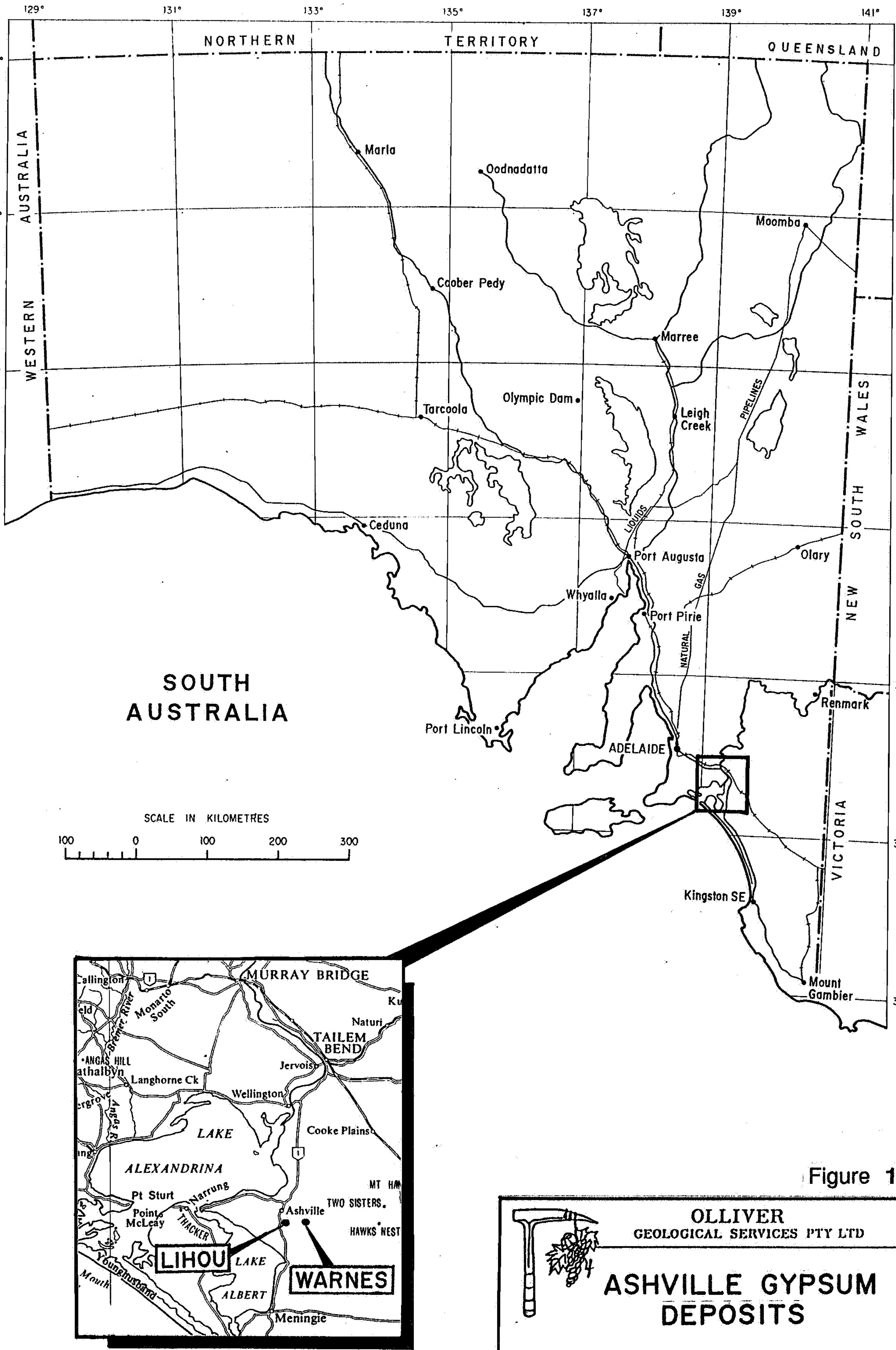
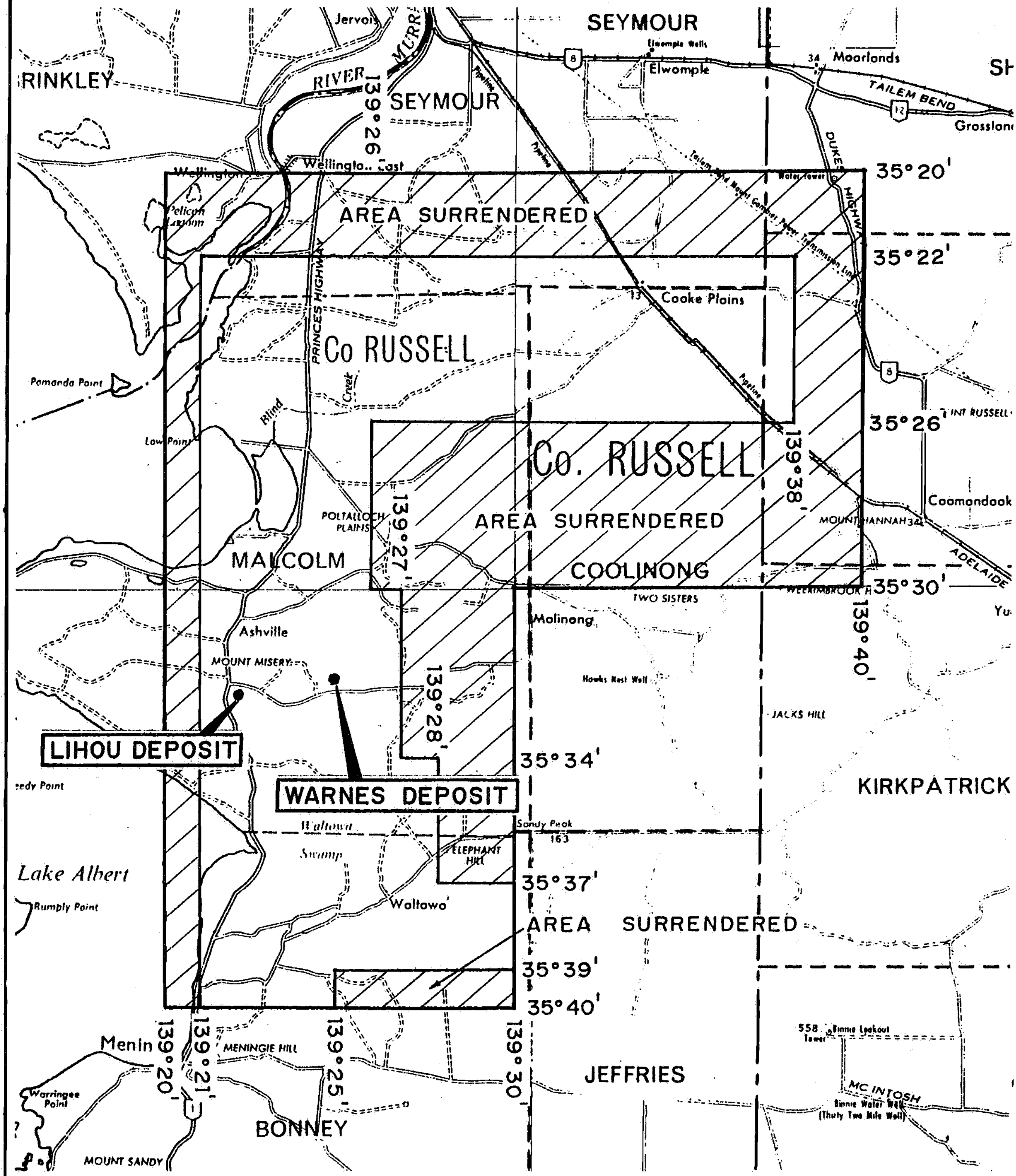


Figure 1

OLLIVER
GEOLOGICAL SERVICES PTY LTD

ASHVILLE GYPSUM DEPOSITS

LOCALITY PLAN



SCALE 1:250,000

5 0 5 10
KILOMETRES

Figure 2

OLLIVER
GEOLOGICAL SERVICES PTY LTD

EL 1628

OLLIVER GEOLOGICAL SERVICES PTY LTD

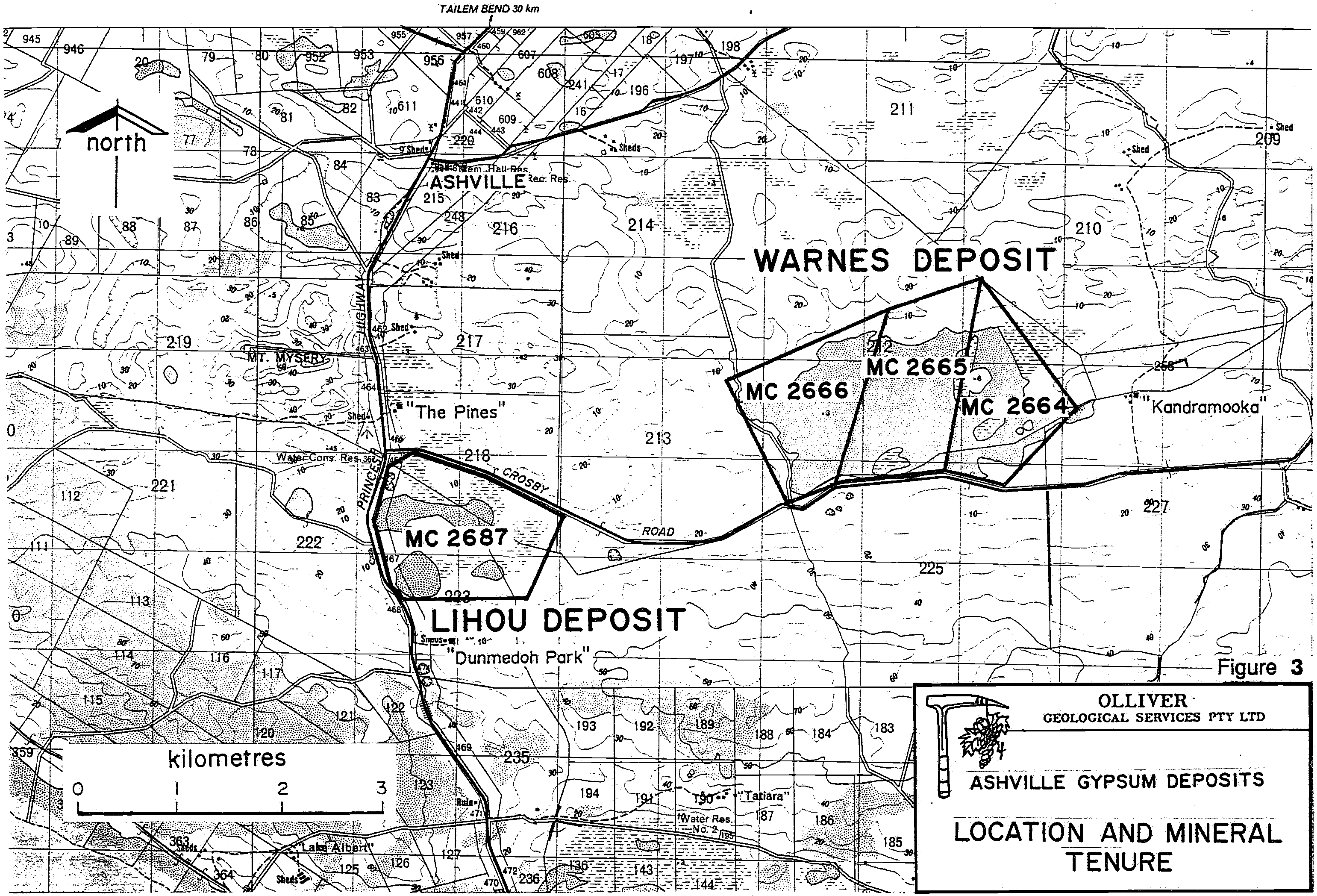


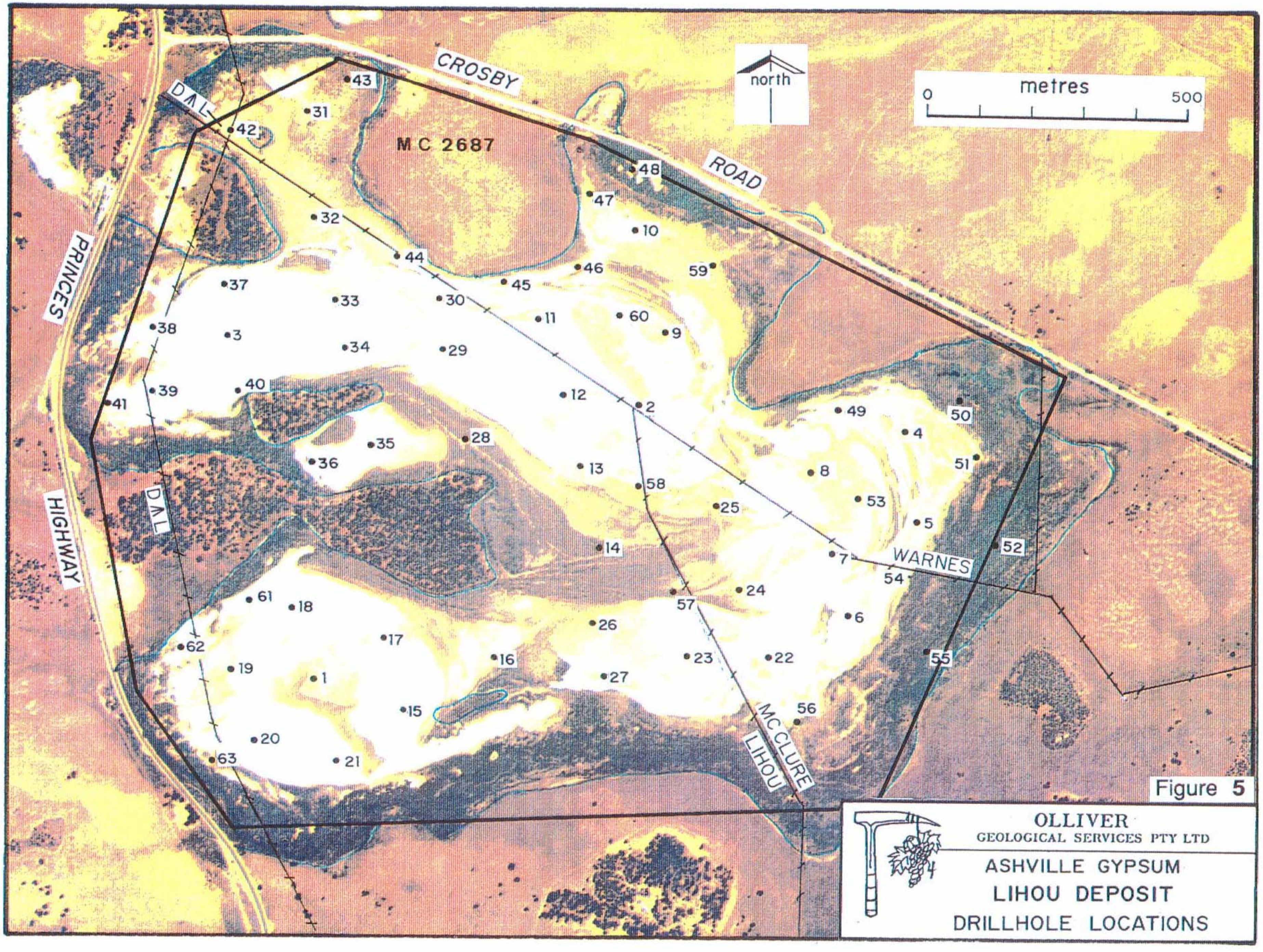
Figure 3

OLLIVER
GEOLOGICAL SERVICES PTY LTD

ASHVILLE GYPSUM DEPOSITS

LOCATION AND MINERAL TENURE


north
MC2665
MC2666
MC2664
WARNES
PLENK
CROSBY
ROAD
metres
0
500
106
127
84
83
85
90
67
53
91
28
126
82
66
111
114
72
81
119
29
54
52
92
68
35
93
47
55
80
48
73
79
89
65
120
86
34
49
69
78
124
51
56
74
117
88
50
45
110
46
36
87
104
116
105
64
70
77
44
94
118
57
75
123
38
39
27
62
103
125
63
122
76
102
71
95
121
101
100
58
98
41
40
61
115
99
113
96
60
97
59
112
109
43
42
OLLIVER
GEOLOGICAL SERVICES PTY LTD
ASHVILLE GYPSUM
WARNES DEPOSIT
DRILLHOLE LOCATIONS
Figure 4



CROSBY ROAD
north
metres
0
500
M C 2687
PRINCES HIGHWAY
D.A.L.
WARNES
MC CLURE
LIHOU
43
31
42
32
44
37
33
30
45
46
47
48
10
59
11
60
9
38
3
34
29
39
40
41
12
2
49
50
4
28
35
36
13
58
8
51
53
25
5
52
14
7
54
24
57
61
18
6
62
17
26
16
23
22
55
19
1
27
15
56
20
63
21
OLLIVER
GEOLOGICAL SERVICES PTY LTD
ASHVILLE GYPSUM
LIHOU DEPOSIT
DRILLHOLE LOCATIONS

Figure 5

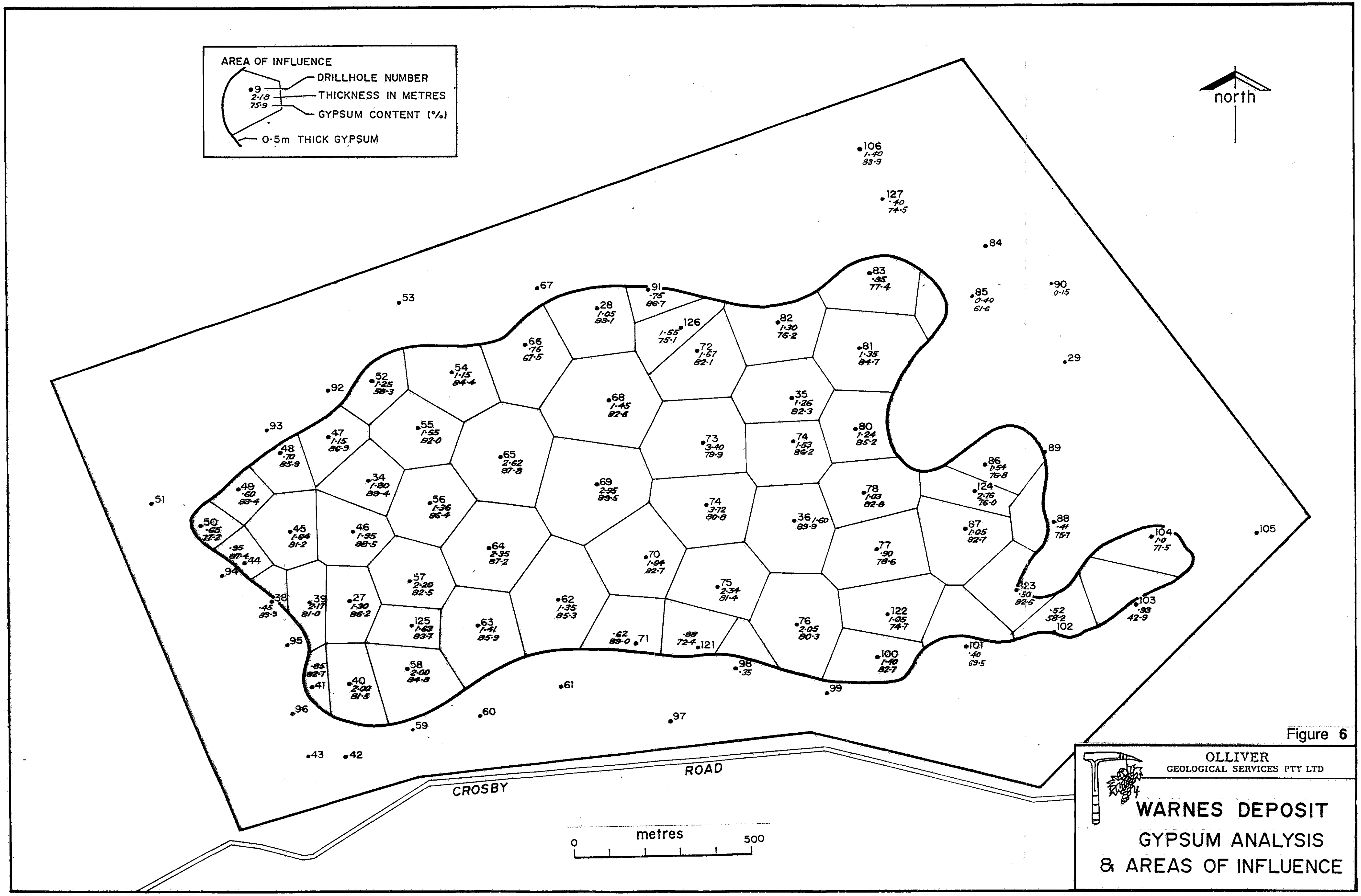

AREA OF INFLUENCE
DRILLHOLE NUMBER
THICKNESS IN METRES
GYPSUM CONTENT (%)
0·5m THICK GYPSUM
north
CROSBY
ROAD
metres
0
500
OLLIVER
GEOLOGICAL SERVICES PTY LTD
WARNES DEPOSIT
GYPSUM ANALYSIS
& AREAS OF INFLUENCE

Figure 6

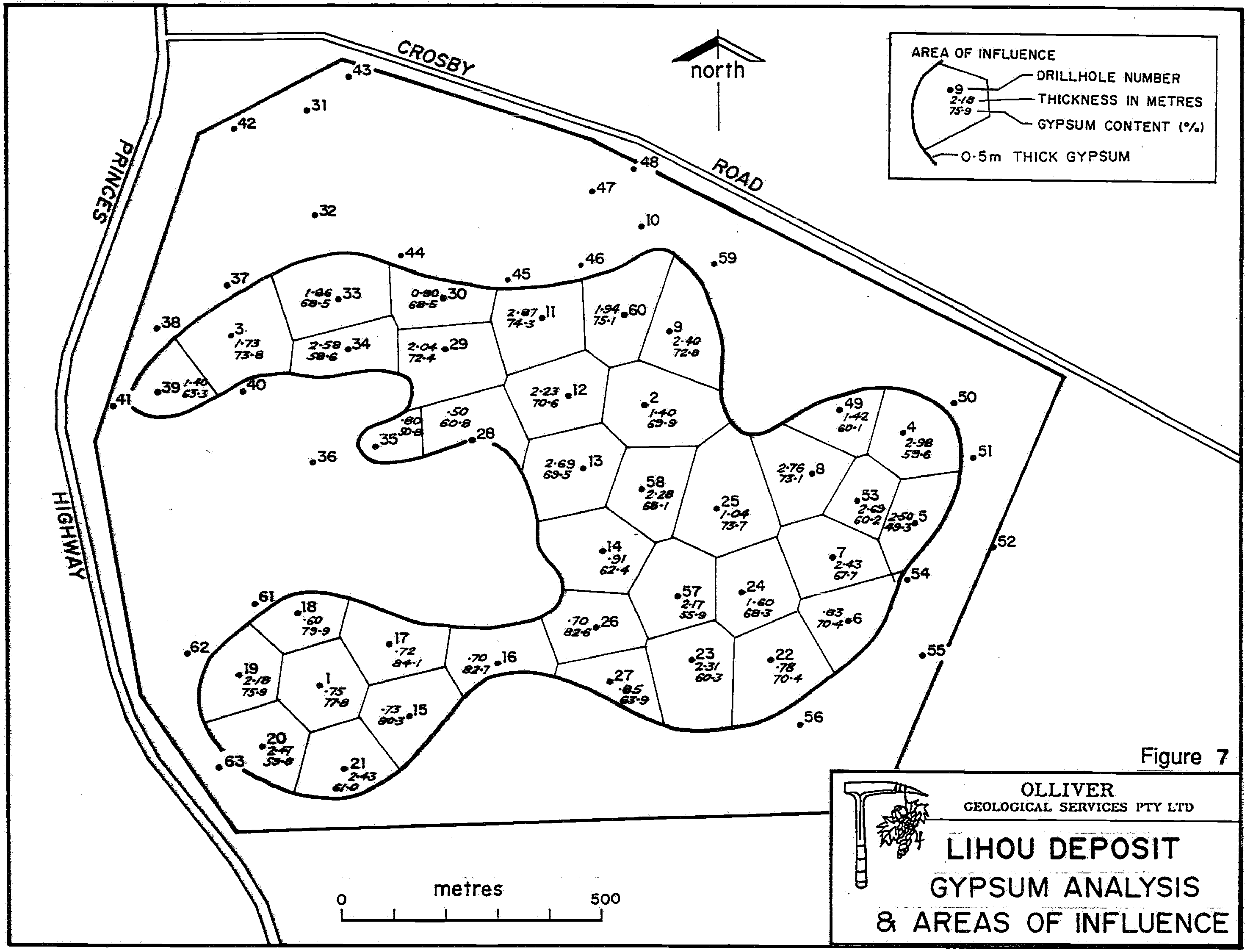


Figure 7

LIHOU DEPOSIT
GYPSUM ANALYSIS
& AREAS OF INFLUENCE

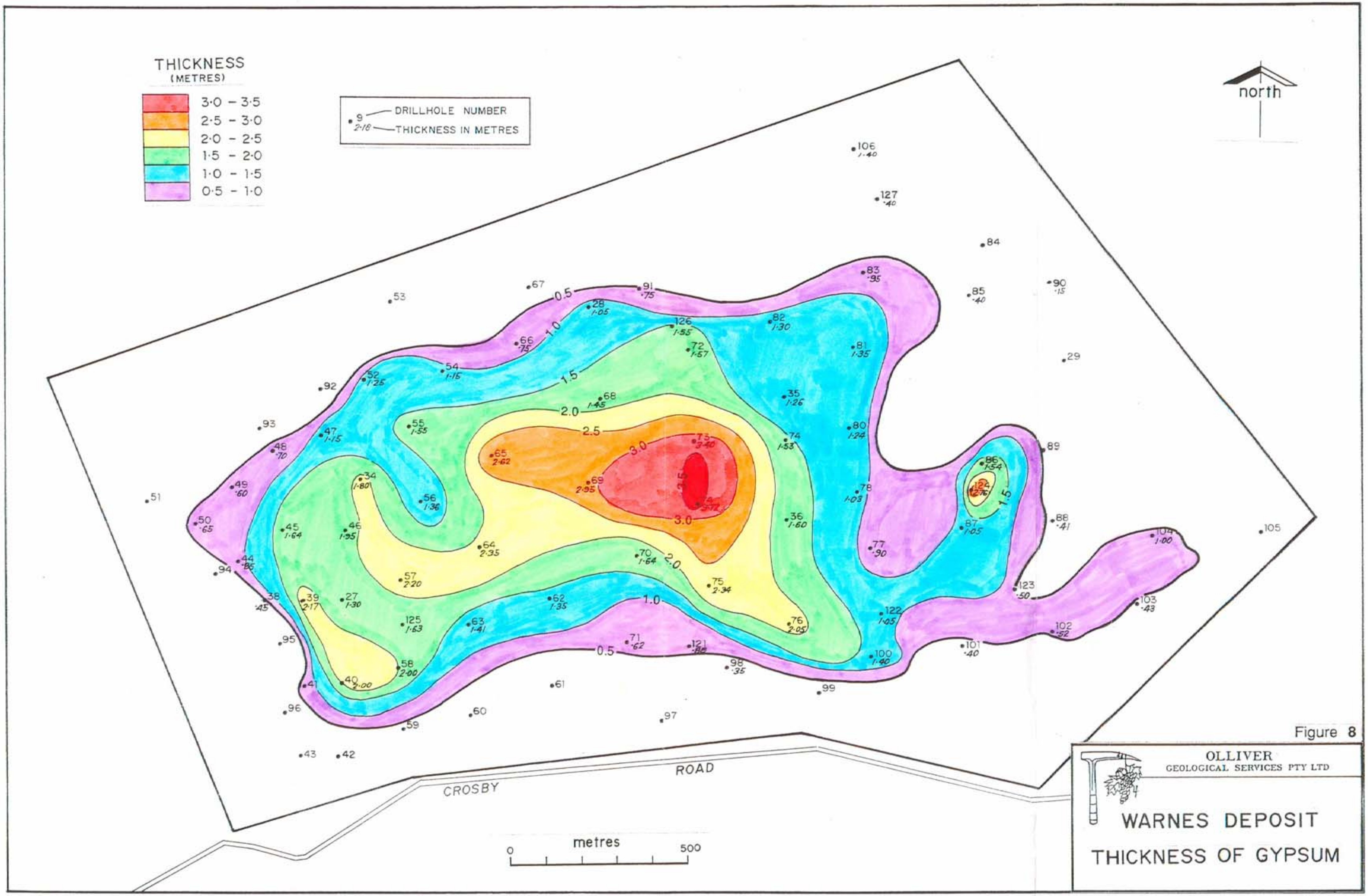


Figure 8

OLLIVER GEOLOGICAL SERVICES PTY LTD

WARNES DEPOSIT
THICKNESS OF GYPSUM

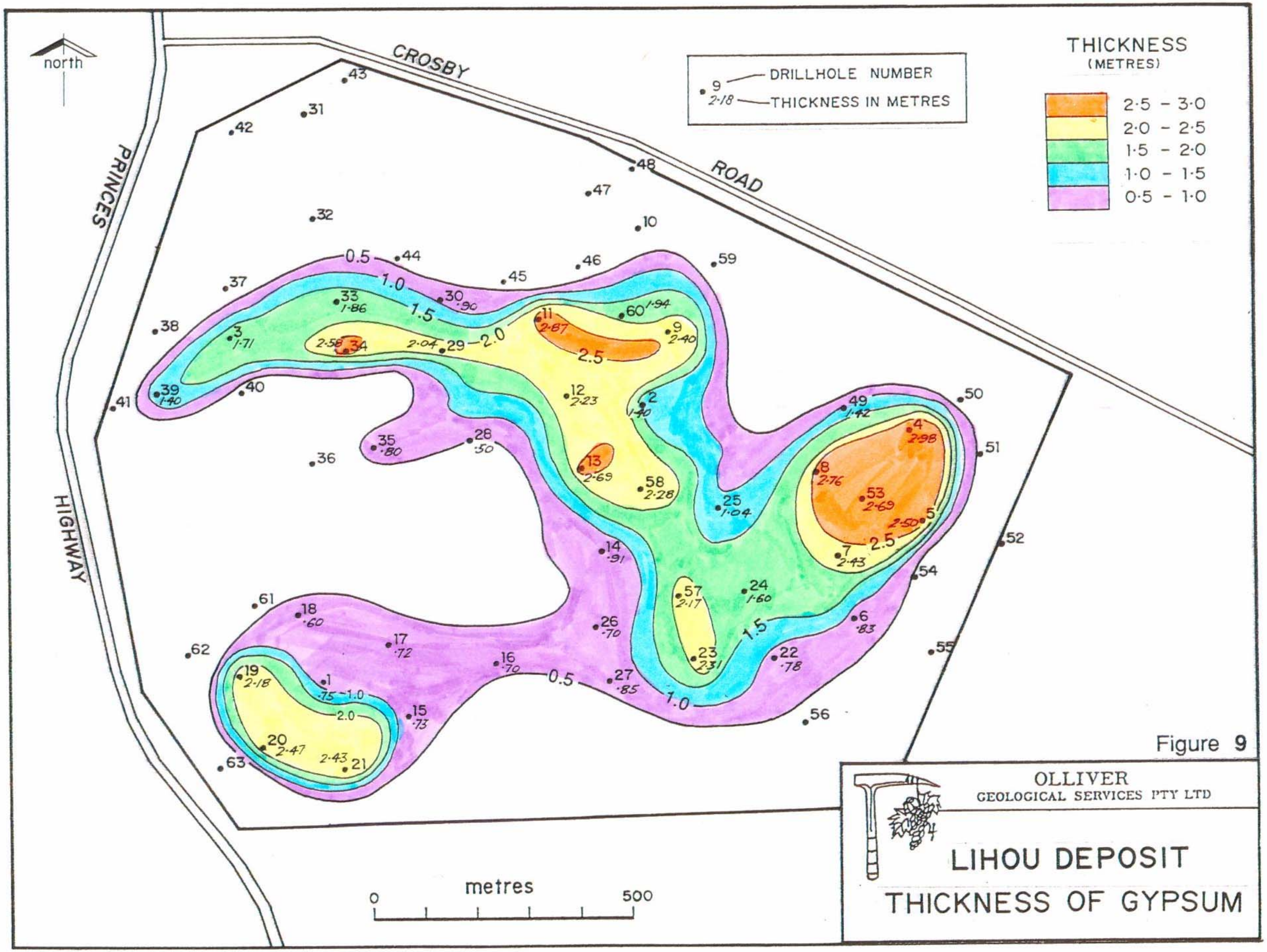
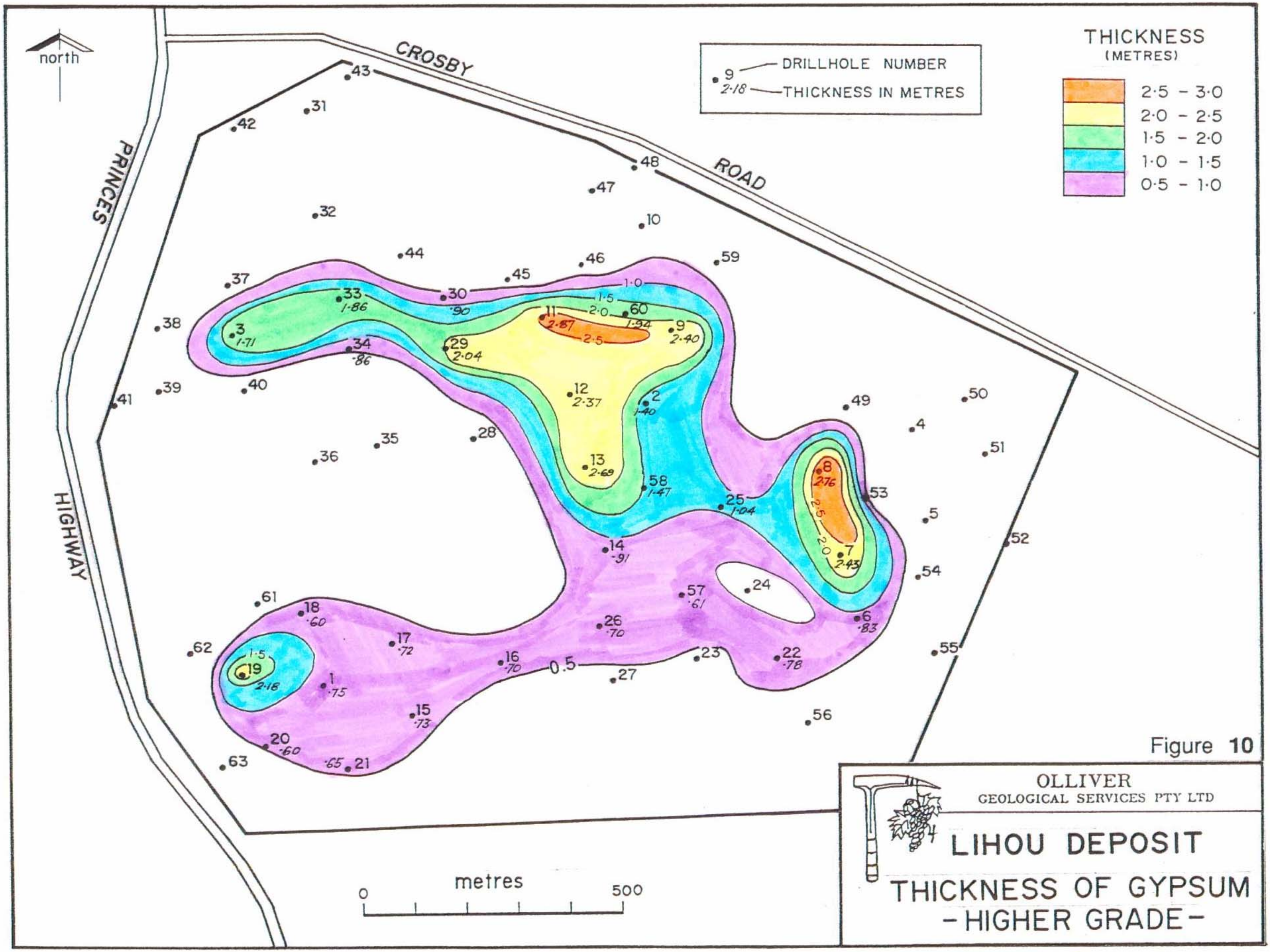


Figure 9

LIHOU DEPOSIT

THICKNESS OF GYPSUM



north
CROSBY ROAD
PRINCES HIGHWAY
9 — DRILLHOLE NUMBER
2·18 — THICKNESS IN METRES
THICKNESS (METRES)
2·5 - 3·0
2·0 - 2·5
1·5 - 2·0
1·0 - 1·5
0·5 - 1·0
metres
0
500
Figure 10
OLLIVER
GEOLOGICAL SERVICES PTY LTD
LIHOU DEPOSIT
THICKNESS OF GYPSUM
-HIGHER GRADE-

ASHVILLE GYPSUM DEPOSITS
REPORT ON ACTIVITIES
SEPTEMBER 1992 - MAY 1993

JOINT VENTURE

The geological investigation of Ashville Gypsum is covered by an Agreement between Olliver Geological Services Pty Ltd of McLaren Vale SA and Churchill Exploration NL of South Perth WA, part of the Churchill - Union - McRaes Group. Olliver identifies projects and conducts/supervises investigations and Churchill earns 80% by providing funds for approved programs.

SALE OF THE DEPOSITS

On completion of geological investigations, it was decided not to become gypsum miners but to sell the two deposits to a major producer/consumer of gypsum in Australia.

Under supervision of Tor Theunissen (Marketing Director), Churchill prepared an Information Memorandum which was forwarded to the following companies.

Adelaide Brighton Cement -	Neville Brighton Raw Materials Manager Birkenhead
Pioneer Plaster Board -	John Harris Adelaide Manager Cavan
Gypsum Resources of Aust - (GRA)	Dennis Squire Mining Manager Gilman
CSR -	Ian Downie State Manager Wingfield
David Linke Contractors -	Cyril Linke Angaston Operators of Blanchetown Gypsum
Michael Cobb -	Consultant Geologist as advisor to Adelaide Brighton Cement and Pioneer
Keum Kang & Korea Chemical -	D.C. Yang Manager, Planning & Co-ordination met at Conference in Sydney in Nov 1992.

Numerous telephone conversations and faxes ensued.

Apart from GRA and Keum Kang, the reactions were that they were not interested in purchasing because of some or all of the following reasons.

- too small
- too much salt/chloride
- too low grade

There has been no reaction from Korea.

GRA NEGOTIATIONS

4 Nov 1992 - Dennis Squire requested samples for testing and was provided with 10 quarter core subsamples (see attached letter & plan of 9 November 1992).

11 Dec 1992 - Squire advised that satisfactory plaster had been produced and requested initial meeting.

18 Dec 1992 - Meeting in Adelaide with Squire, Theunissen and Sean Kennedy (Consultant Geologist).

18 Jan 1992 - Site inspection Squire with JG & S Olliver. Squire advised that he will prepare a report recommending purchase to GRA Board.

31 Mar 1992 - GRA rejected purchase - 16 years supply remains at Marion and Spider Lakes, Southern Yorke Peninsula.
Similar response from related Victorian cement factory.

20 May 1993 - Renegotiations at lower price - again no from GRA Board.

CURRENT NEGOTIATIONS

Pioneer Plasterboard - Ian Webster, Sydney being contacted direct

Wiston Wallboard - largest gypsum consumer in NZ, offer under consideration.

PROPOSED ACTION

Patterson Bros - supply agricultural gypsum to Adelaide and interstate from Cooke Plains deposit - may have problem with long term reserves.

Bordertown sodic soil reclamation scheme - A potential major user of gypsum. Ashville is closest gypsum deposit (about 160km) so need to determine timing and requirements.

RECALCULATION OF RESERVES

The following higher grade zones have been defined in Warnes Deposit (see attached figs 6A and 6B) within the overall resource of 4.4 million at 82.4% raw gypsum which would wash to 86.1% gypsum.

Central Zone - holes WS 27, 34, 36, 46, 56-58, 62-65, 69-71, 73-76, 78-81, 125 and reduced intervals in 73-76 (fig 6A),
Cut off 82.7% except WS 57
1.66m average thickness
2.5 million tonnes
86.5% raw gypsum
90.6% washed product
23 holes.

High grade zone - delete holes WS 57, 70 and 78 from above
Cut off 83%
1.66m average thickness
2.0 million tonnes
87.0% raw gypsum
91.1% washed product
20 holes

Cut off 84.5% - Delete WS 76 & 125
18 holes
1.68m thick
2.00 million tonnes
87.3% raw gypsum
91.4% washed product

Cut off 85.0% - Delete WS 58 & 81
16 holes
1.68m thick
1.85 million tonnes
87.5% raw gypsum
91.7% washed product

SUMMARY

By the end of May 1993, total expenditure will approximate $70 000.

Ashville gypsum has the following advantages

- comprehensive geological report available
- proven reserves
- 40km closer to Adelaide than Blanchetown or southern Yorke Peninsula
- excellent access
- no houses nearby
- Aboriginal clearance
- excellent adjacent sites for stockpiles etc
- plaster has been made from drill samples
- similar to Spider Lake in grade and geology.

Main disadvantage is that 4.5% salt requires 4 years of rain water leaching to reduce to the ideal of 0.025% for plaster manufacture. However salt content is similar at Lake MacDonnell, Bielamah, Marion Lake, Spider Lake and formerly on Kangaroo Island and was treated by simple rain water leaching.

JEFF OLLIVER
May 1993

RESERVES - WARNES GYPSUM

	HOLES	THICKNESS m	MILL TONNES	% GYP	WASHED
Total Geological	60	1.39	4.4	82.4	86.1
	53	1.47	4.2	83.4	87.1
Cut off 82.7% except WS57	23	1.66	2.5	86.5	90.6
83.0%	20	1.66	2.2	87.0	91.1
84.5%	18	1.68	2.0	87.3	91.4
85.0%	16	1.68	1.85	87.5	91.7

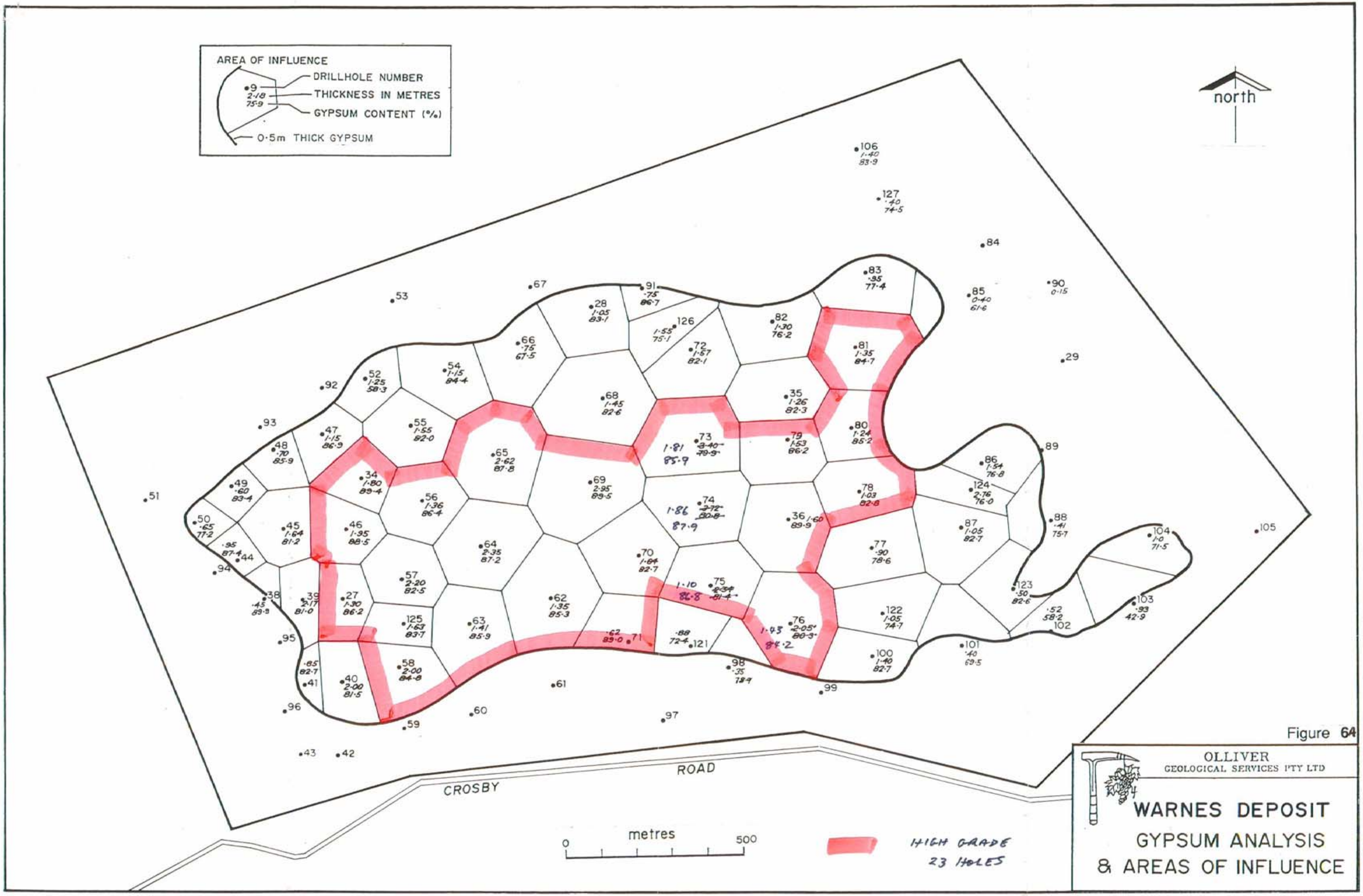


Figure 64

WARNES DEPOSIT
GYPSUM ANALYSIS
& AREAS OF INFLUENCE

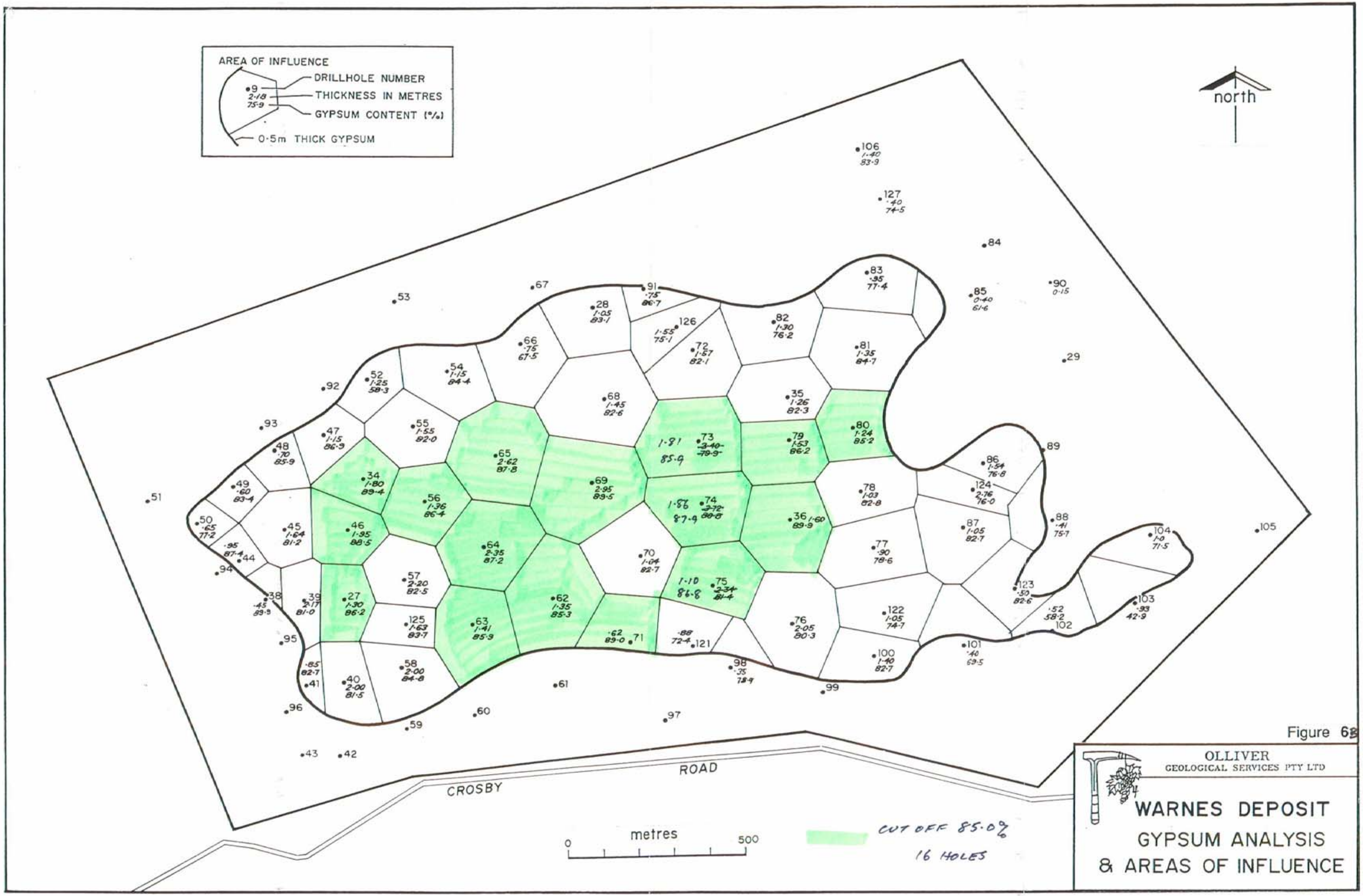


Figure 6

OLLIVER GEOLOGICAL SERVICES PTY LTD

WARNES DEPOSIT
GYPSUM ANALYSIS
& AREAS OF INFLUENCE

OLLIVER GEOLOGICAL SERVICES PTY LTD
ACN 008 201 616

OFFICE — CHALK HILL ROAD, McLAREN VALE SA 5171
POST — PO BOX 24 McLAREN VALE SA 5171
TELEPHONE — (08) 323 8682
FAX — (08) 323 9084

9 November 1992

Mr Dennis Squires
Mining Manager
GRA Pty Ltd
PO Box 321
ALBERTON SA 5014

Dear Dennis,

ASHVILLE GYPSUM

Further to our telephone conversation, I have forwarded the following ten quarter core sub-samples from our drilling program on Warnes Swamp, Ashville.

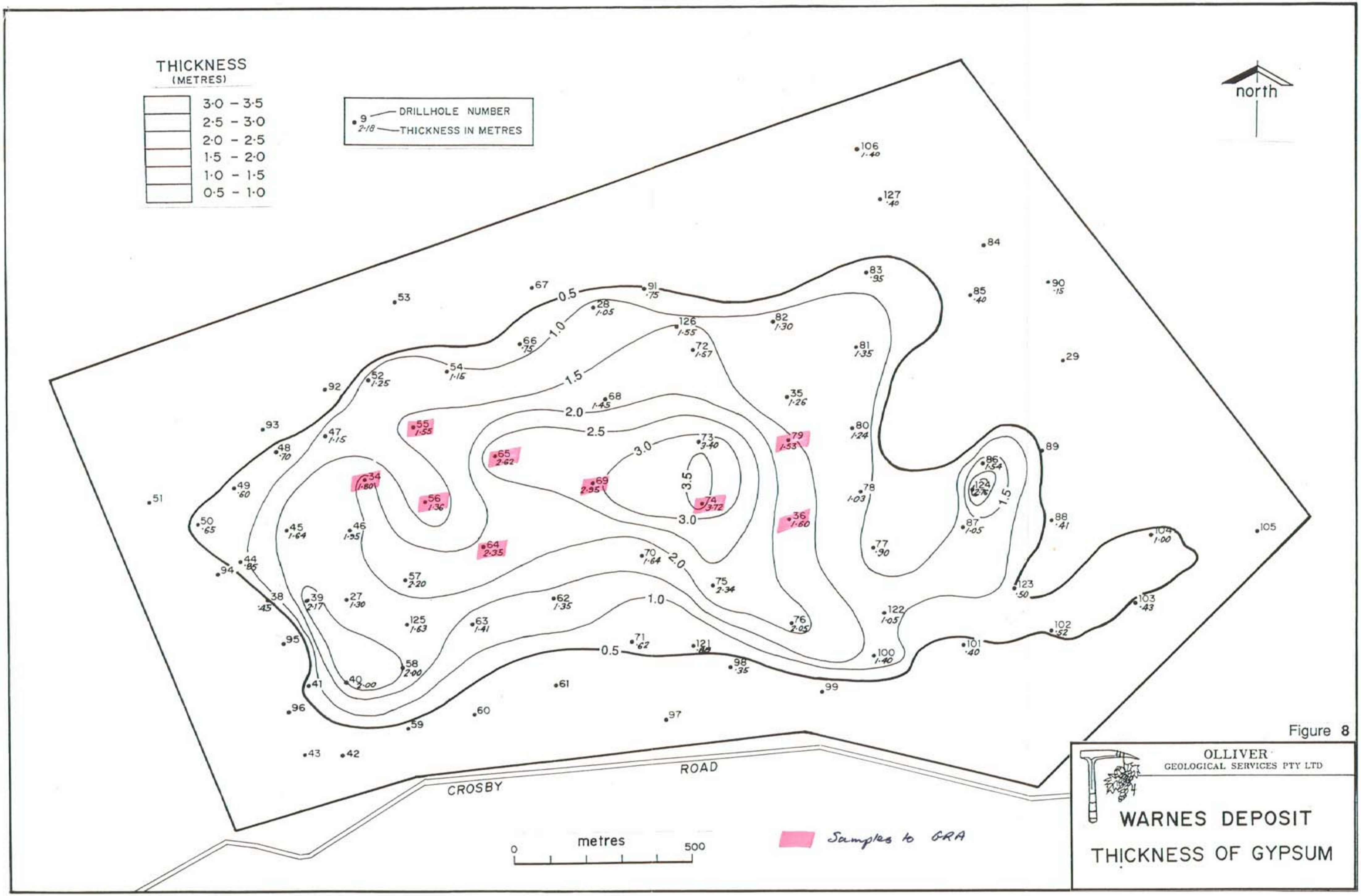
Hole no WS	Interval (m)		% Raw Gypsum	% Raw Salt
34	0.02 - 2.00	1.98	89.4	5.5
36	0.03 - 1.62	1.59	89.9	3.8
55	0.00 - 1.55	1.55	82.0	4.8
56	0.02 - 1.38	1.36	86.3	4.9
64	0.05 - 1.73	1.68	86.7	4.8
	1.73 - 2.40	0.67	88.6	4.0
65	1.40 - 2.58	1.18	87.8	3.6
69	0.05 - 3.00	2.95	89.5	3.8
74	0.00 - 1.86	1.86	87.9	3.6
79	0.00 - 1.53	1.53	86.2	3.2

Chemical analyses were conducted by Australian Laboratory Services, Brisbane.

These samples provide a representative suite through the centre of the deposits as highlighted on the attached copy of Figure 8 from the Geological Report.

Yours faithfully,

JEFFREY G. OLLIVER


THICKNESS
(METRES)
3·0 – 3·5
2·5 – 3·0
2·0 – 2·5
1·5 – 2·0
1·0 – 1·5
0·5 – 1·0
9 DRILLHOLE NUMBER
2·18 THICKNESS IN METRES
north
CROSBY ROAD
metres
0
500
Samples to GRA
OLLIVER
GEOLOGICAL SERVICES PTY LTD
WARNES DEPOSIT
THICKNESS OF GYPSUM
Figure 8