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ANNUAL REPORT FOR EXPLORATION LICENCES EL 6509, KULGERA 1:250,000 MAP SHEET, NORTHERN TERRITORY

Period covering August 1989 to August1990

By

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SUMMARY

This report outlines the work undertaken during the first year (August 1989 to August 1990 period) of exploration in Exploration Licence EL 6509, located in KULGERA 1:250,000 map sheet area, Northern Territory. The investigations were aimed at providing geological and hydro-geochemical data bases, which could be used to assess the industrial mineral and brine resources in the licence areas. As with the adjoining licence areas, EL 5689 and EL 5801, the mineral groups targeted for investigation included dolomite, silica/silicate (zeolites, clays), and evaporite (sulphates, chlorides and mixed salts of sodium, calcium, magnesium, and potassium) deposits. Following discovery of highly concentrated brines in the adjoining tenements, particular emphasis was directed towards assessing the brine resources in the playa chains of this licence area. Recent field experiments and laboratory tests indicate the possibility for producing a wide variety of valuable industrial salts and liquids, from the playa brines. Because of current table pricing structure and increasing demand for industrial salt products for established and emerging new applications, on a short- to medium-term basis, these brines posses high potential for low-cost resource development.

The exploration work in the area commenced slowly because of flooding of the lakes due to a 50 year record rainfall in the region, in March_April 1989. Limited field investigation was undertaken in November 1989 in areas where access was possible. A more comprehensive field program, involving mapping, sediment and water sampling, and hydrological monitoring, was instigated in June - July 1990. All collected samples have been progressively subjected to detailed laboratory analysis.

The chain of playas in the licence area are part of a large drainage system extending from west of the Curtin Springs to Karinga Creek modern drainage in the area of Erldunda pastoral lease. The Karinga Creek drainage system forms part of a much larger palaeo-drainage basin, which during the Tertiary times discharged to Lake Eyre via the ancestral Finke River.

Geologically, the Cainozoic sediments in the area are several tens of metres thick, and comprised of alluvial-aeolian clay and sand units, that are interbedded with lacustrine deposits. Immediately underlying the playa beds are Devonian shale units; the latters are probably underlain by bedded dolomite, limestone, siltstone and evaporites (gypsum and anhydrite) of Proterozoic age.

Regional groundwater system appears to be two-layered, with Cainozoic sedimentary aquifers (clay-sand units and calcretes) overlying fractured bedrock aquifers. The playa lakes represent essentially outcrops of the shallow groundwater in the region, with groundwater discharge being mostly via marginal calcrete aquifers and the basement Devonian shale units. The playa brines are highly concentrated with respect to sodium,

chloride, sulphate, magnesium and potassium ions; the summer concentration of brines reach extremely high values (e.g., in excess of 400 g/l total dissolved solids), unmatched by any lake system in Australia.

Investigations so far indicate the presence of suitable brine types for production of high grade industrial salts. Selected number of the brine samples were recently subjected to a variety of laboratory and field experimentations to assess the technical feasibility of producing high-value industrial salts by using a combination of solar energy and chemical techniques. The resluts of these experiments have been very encouraging and work is now in progress towards a more comprehensive assessment of producing industrial-grade salts from the brines in the playa chains contained in Exploration Licences 5689, 5801 and 6509.

The investigations during the past two years in the adjoining tenement areas have indicated that, apart from presence of large volumes of highly concentrated magnesium- and potassium-enriched brines, the playa beds contain significant reserves of evaporite, carbonate and clay-mineral deposits with direct industrial application. The main industrial grade mineral types targeted for exploration in EL 6509 belong to the two groups of magnesio-aluminium silicates and bentonitic smectite clays. The available geological and hydro-chemical information also indicate favourable conditions for occurrences of zeolite deposits; for example, analcime associated with lacustrine dolomite deposits was recently reported from two BMR drill holes in the Curtin Springs area. Further field investigations, including shallow drilling, is recommended for assessing the silicate mineral resources in the area.

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1. INTRODUCTION

1.1 Aims and Scope of Study

This progress report presents the results of the first year (August1989 - August 1990) exploration work in the EL 6509 (Figs 1, 2 and 3, and Table 1), under licence to Norvale Pty Ltd and Emily Enterprises Pty Ltd. The investigation was aimed at developing geologicaland hydro-geochemical data bases for assessment of industrial minerals and brine resources in the licence area.

Exploration Licence 6509 is located in the Kulgera 1:250 000 map sheet of the Northern Territory, Australia (Figs 1 and 2). It forms part of the Erldunda Pastoral Lease. Access to the general area is via two sealed highways (Stuart Highway and Lasseter Highway).

Saline playa lakes and the Karinga Creek itself form major geomorphic and hydrologic components of the drainage system in the study area. The playa lakes in the general area are characterised by irregular outline but show an overall east-west arrangement of their longitudinal components. Some of the lakes can be reached along good graded bore tracks; however access to those isolated by dunefields becomes very difficult, particularly after a sustained rainfall.

TABLE 1

SUMMARY OF PHYSICAL DATA RELATED TO EXPLORATION LICENCE EL 6509, NORTHERN TERRITORY

Size	354 sq km (110 Blocks)
Adjoining/nearby Exploration Liceces	El 5689 and El 5801
Covering pastoral lease	Erldunda Station
Topographic elevation	390 - 460 m
Number of major playa lakes	9
Depth of groundwater in the playas	0 - 2.5 m

The climate in the study areas is arid; mean annual rainfall varies between 226 mm (35-year record at Curtin Springs) and 333 mm (23-year record at Ayers Rock). The mean annual evaporation is around 3000 mm. The mean monthly maximum temperature is 33 degree C in January and 20 degrees C in July; the mean monthly minimum temperature is 20 degrees C in January and 4 o C in July. During March-April 1989, the region experienced a 50 year record rainfall. As a result, over 85% of the lakes were flooded from runoff waters for several months. Some of the lakes were filled in with over a meter of water, and most of the tracks in the region were

KULGERA 1:250000, N.T.

R.F. 1:250 000
MINING TENURE

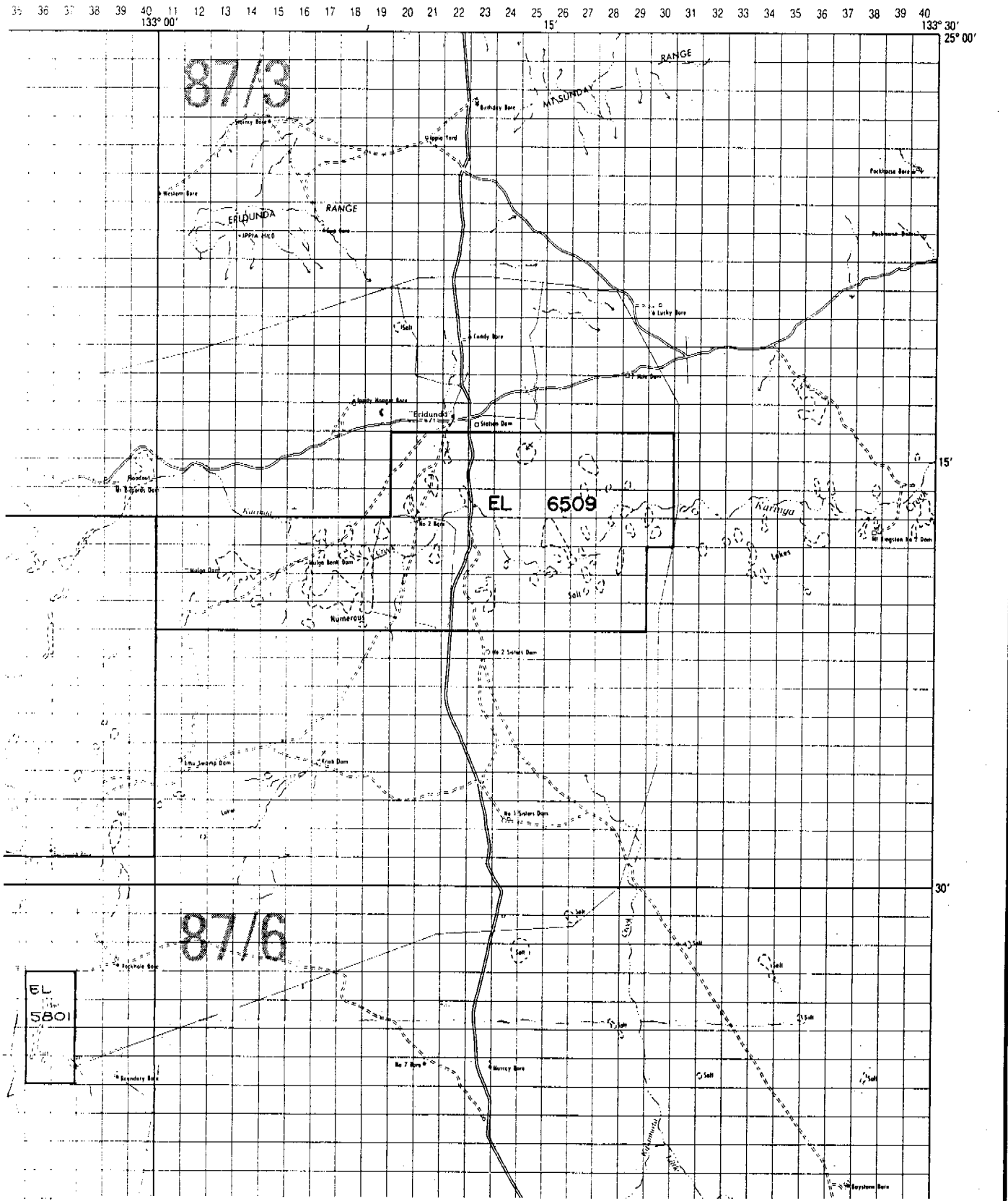
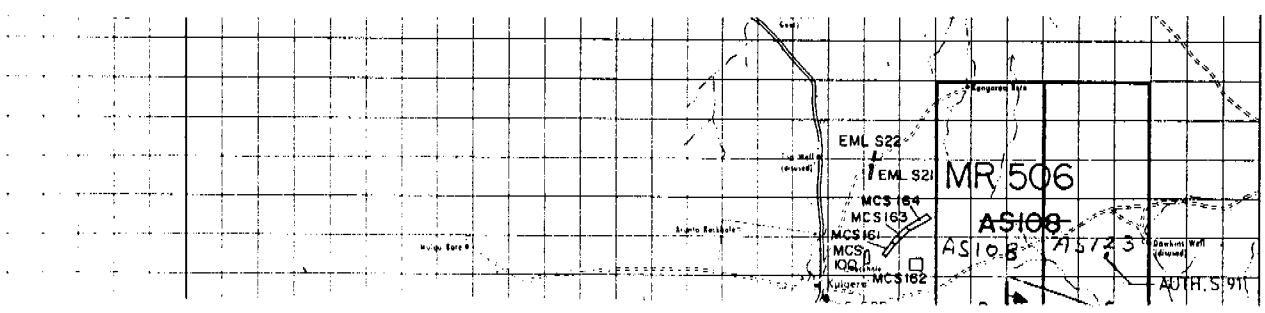


Figure 1. Map showing the distribution of exploration licence area in the Kulgera 1:250 000 map sheet.



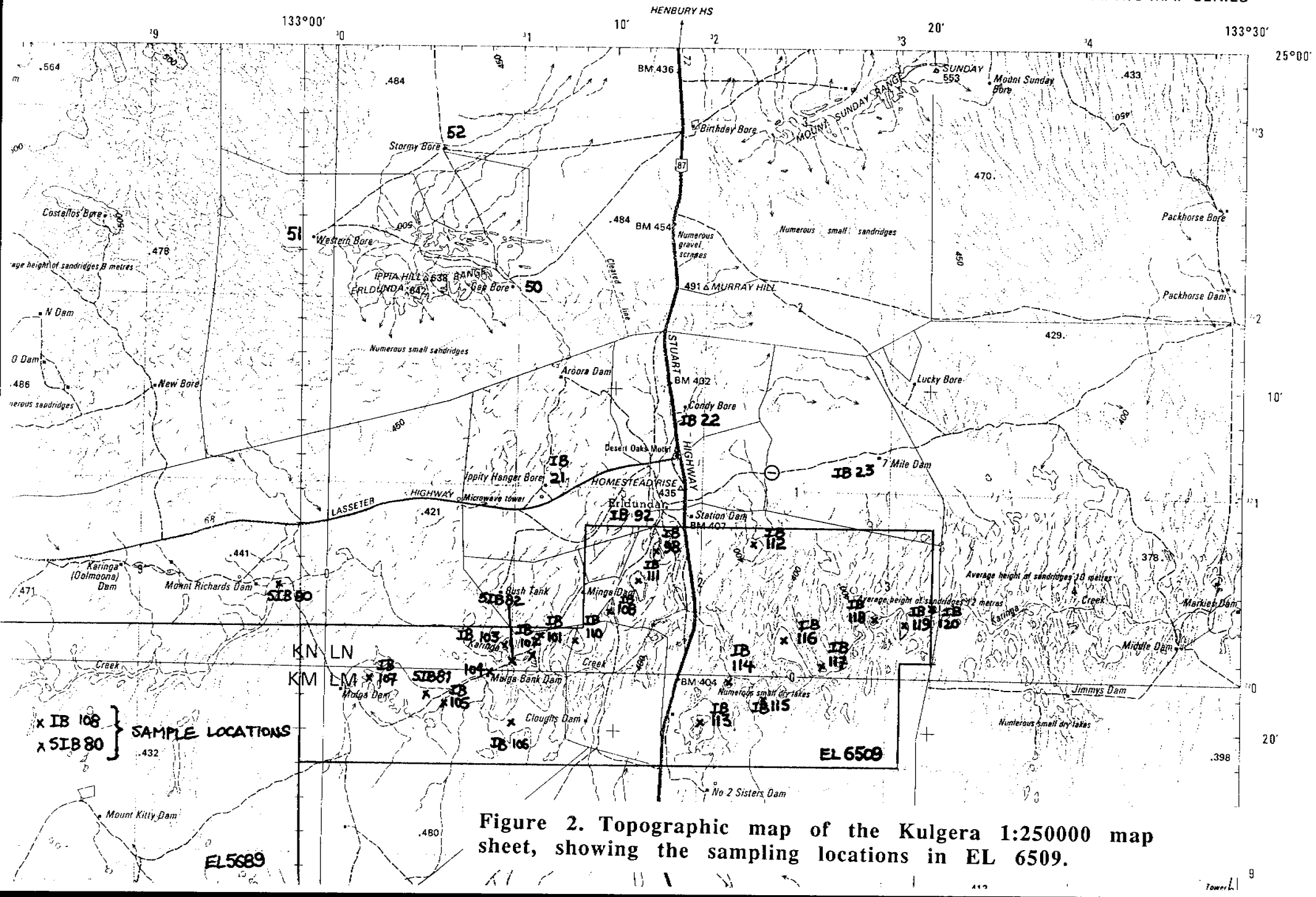


Figure 2. Topographic map of the Kulgera 1:250000 map sheet, showing the sampling locations in EL 6509.



Figure 3. Geological map of the study area, including the sampling locations.

Reference

CAINOZOIC	QUATERNARY	Q	*Undifferentiated (section only)*
		Qa	*Alluvium, conglomerate*
		Qs	*Sand*
		Ql	*Travertine*
		Qt	*Evaporites*
	TERTIARY	Tc	*Conglomerate*
		Tl	*Limestone, calcareous siltstone, si*
		Tt	*"Grey billy", silcrete*
		Ts	*Sandstone, siltstone*
MESOZOIC	LOWER CRETACEOUS	Rumbalara Shale — Klr	*White shale and siltstone*
	JURASSIC?	De Souza Sandstone — Md	*Sandstone, pebbly sandstone*
PALAEOZOIC	DEVONIAN TO CARBONIFEROUS	Finke Group: Idracowra Sandstone	*White kaolinitic sandstone*
		Finke Group: Horseshoe Bend Shale	*Red-brown biotitic shale, some fir*
		Finke Group: Polly Conglomerate	*Conglomerate*
		Pertnjara Group	*Red-brown sandstone, siltstone*
	SILURIAN(?) -DEVONIAN	Mereenie Sandstone	*Pale brown and yellow brown cro*
	UPPER ORDOVICIAN	Larapinta Group: Carmichael Sandstone	*Red-brown kaolinitic sandstone, si*
		Larapinta Group: Stokes Siltstone	*Siltstone, silty dolomite*
		Larapinta Group: Stairway Sandstone — Os	*Fossiliferous sandstone, phosphor*
	CAMBRIAN	Pertaoorrta Group — €p	*Conglomerate, greywacke, sandsto- siltstone and dolomite*
PROTEROZOIC		Winnall Beds — Puw	*White and purple-brown sandston*
		Inindia Beds — Pun	*Sandstone, kaolinitic siltstone and bedded chert, dolomite, tilloid and*
		Bitter Springs Formation	*Dolomite, interbeds of limestone, s*

degraded, making access to investigation sites impossible. The lakes became accessable by mid January 1990.

1.2 Materials and Methods of Study

Field investigations related to this project involved mapping, grab sampling, shallow coring, groundwater/brine sampling, monitoring, and on-site chemical analysis. Coring was done by hand tapping of PVC tubes in the playa beds; grab samples were collected from pits and bedrock material, outcropping in the playa margins. A total of 22 short core and grab samples were collected from pre-selected sites; additionally 8 surface and pit water samples were collected from the lakes and the creeks. The physico-chemical characteristics of warter samples were determined on site, by using field portable instruments, including Eh-pH, T, Conductivity meters and a digital voltammeter. The compositional characteristics of the sediment and sediment samples were determined in laboratory by a combination of microscopic examination, x-ray diffraction, atomic absorption, ICP, infrared and nuclear magnetic resonance spectroscopy. Details of samples and their compositions are given in Appendices 1 and 2.

2. GEOLOGY AND PHYSIOGRAPHIC SETTING

2.1 Regional Geology of the Amadeus Basin

Based on data from company exploration drillholes and water bore information, Cainozoic sediments are comprised of alluvial-aeolian clay and sand units interbedded with groundwater-deposited calcrete and gypcrete deposits; they form the main surficial sediments in the Amadeus Basin. The maximum thickness of Cainozoic sedimentary pile, recorded near Ayers Rock, is 100 m (Jacobson, 1988). Devonian age shale, form the main basement rocks directly underlying the Cainozoic sediments.

Proterozoic and Palaeozoic sedimentary rocks of the Amadeus Basin sequence (Wells et al., 1970), protrude as bedrock hills (eg, Ayers Rock and the Olgas) through the Cainozoic sediments. Late Precambrian Bitter Springs Formation, comprised of bedded dolomite, limestone, siltstone and evaporites (gypsum and anhydrite), is recorded at shallow depths from the Amadeus Basin region.

The Amadeus depression (which contains the palaeodrainages, Cainozoic sedimentary pile and its modern chain of playas) is a major linear feature on the topographic map of Australia, and according to Wells(1980), may have formed from the solution of Proterozoic evaporites formerly cropping out along an anticlinorial axis.

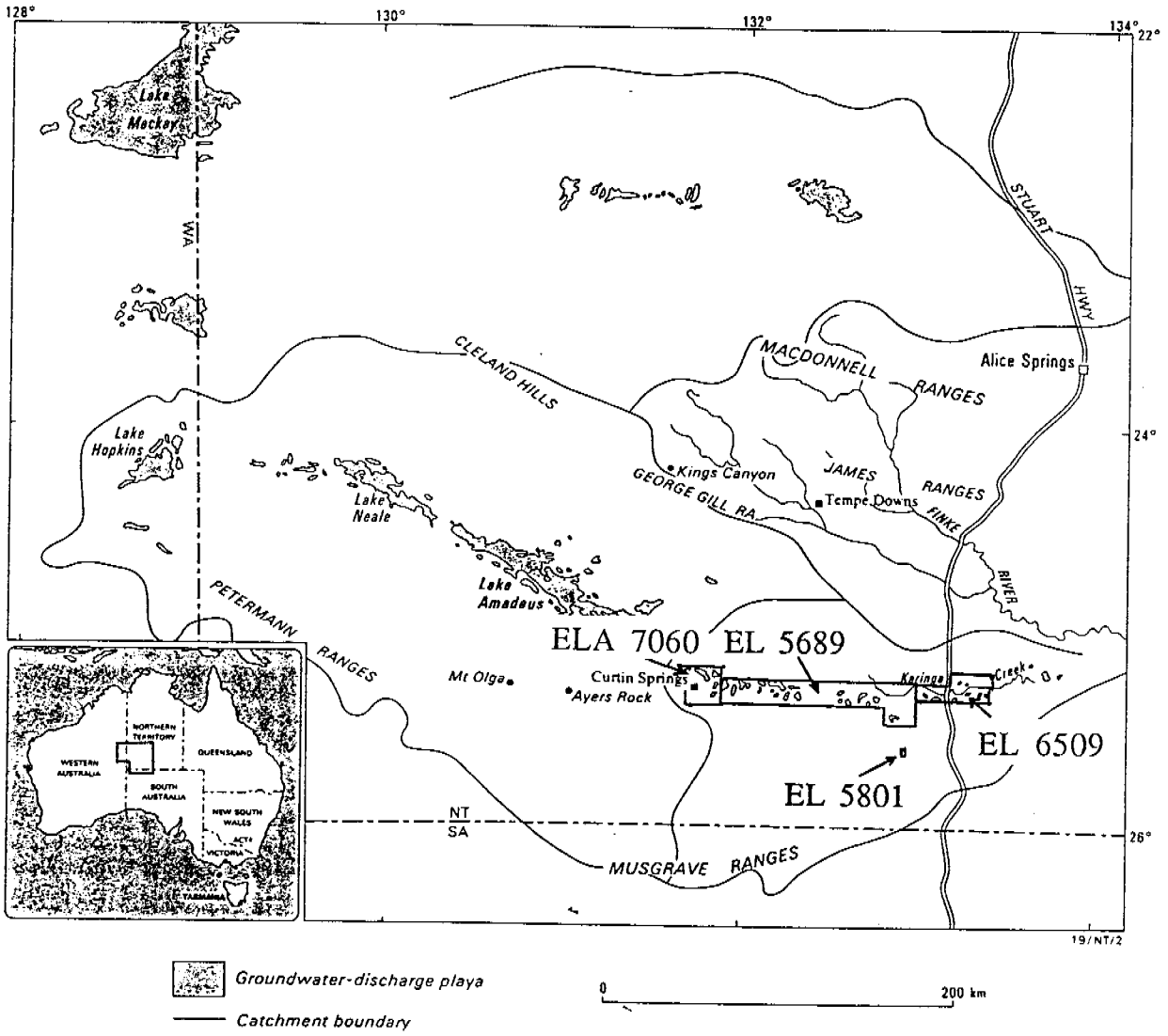


Figure 4. Regional map, showing the relationship between the study area and the central Australian Groundwater Discharge Zone.

2.2 Physiography of the Central Australian Groundwater Discharge Zone

The chain of playa lakes, representing the central Australian groundwater discharge zone, extend for over 500 km from Lake Hopkins through Lake Neale, Lake Amadeus to Finke River (Fig. 4). Based on available topographic information this major groundwater discharge zone can be devided into two physiographic domains (Fig. 5). The western domain, which includes Lakes Hopkins, Neale, and Amadeus, extending for over 400 km between the 450-500 m topographic contours, and covers the western one-quarter of the study area (Wakelin-King and Arakel, 1989). The eastern domain forms a valley which descends over 125 m in 180 km towards the Finke River; it includes the Karinga Creek drainage and most of the playas in the tenement areas.

Quaternary sand dunes, up to 30 m high, cover expansive areas of the basin depression; these dunes are mostly vegetated and stable. The playas occupy the lowermost topographic depressions, and are fringed with gypseous duricrusts (gypcretes). Low-relief gypsum-sand "islands" are also common in some of the playas.

Groundwater calcrete deposits of Quaternary and younger age (Arakel et al., 1988) are intermittently exposed in the interdunal depressions. They occupy the palaeo-drainage channels and show an overall centripetal distribution in relation to playa lakes. Quaternary calcrete and silcrete duricrusts (of vadose origin) are characteristically superimposed on bedrock oucrops, forming escarpments several meters high along the margins of the playa lakes.

2.3 History of Internal Drainage Basin Development

Since early Tertiary times, a major phase of rejuvenation of palaeo - river systems and reworking of the lateritic duricrusts in inland plateau areas, resulted in a marked incision into Tertiary sands and palaeosols. During Quaternary, the palaeo-drainage channels were filled in with fluvial (alluvial/colluvial) and lacustrine sediments. From Pleistocene onward, with the incidence of periods of aridity the drainages and lakes contracted, resulting in chemical sediment buildup. As a result 'internal drainage basins' were developed, where the playa lakes presently act as outlets for regional shallow and highly saline groundwater discharge (Arakel, 1988).

3. HYDROGEOLOGY

The Amadeus drainage basin is almost devoid of any major surface drainage; this applies particularly to the study area in the Kulgera map sheet. On the basis of a regional consideration, the groundwater system in the central Australian groundwater discharge zone is two-layered, with Cainozoic sedimentary aquifers overlying fractured bedrock aquifers (Jacobson, 1987). The groundwater flow system in the Cainozoic aquifers is

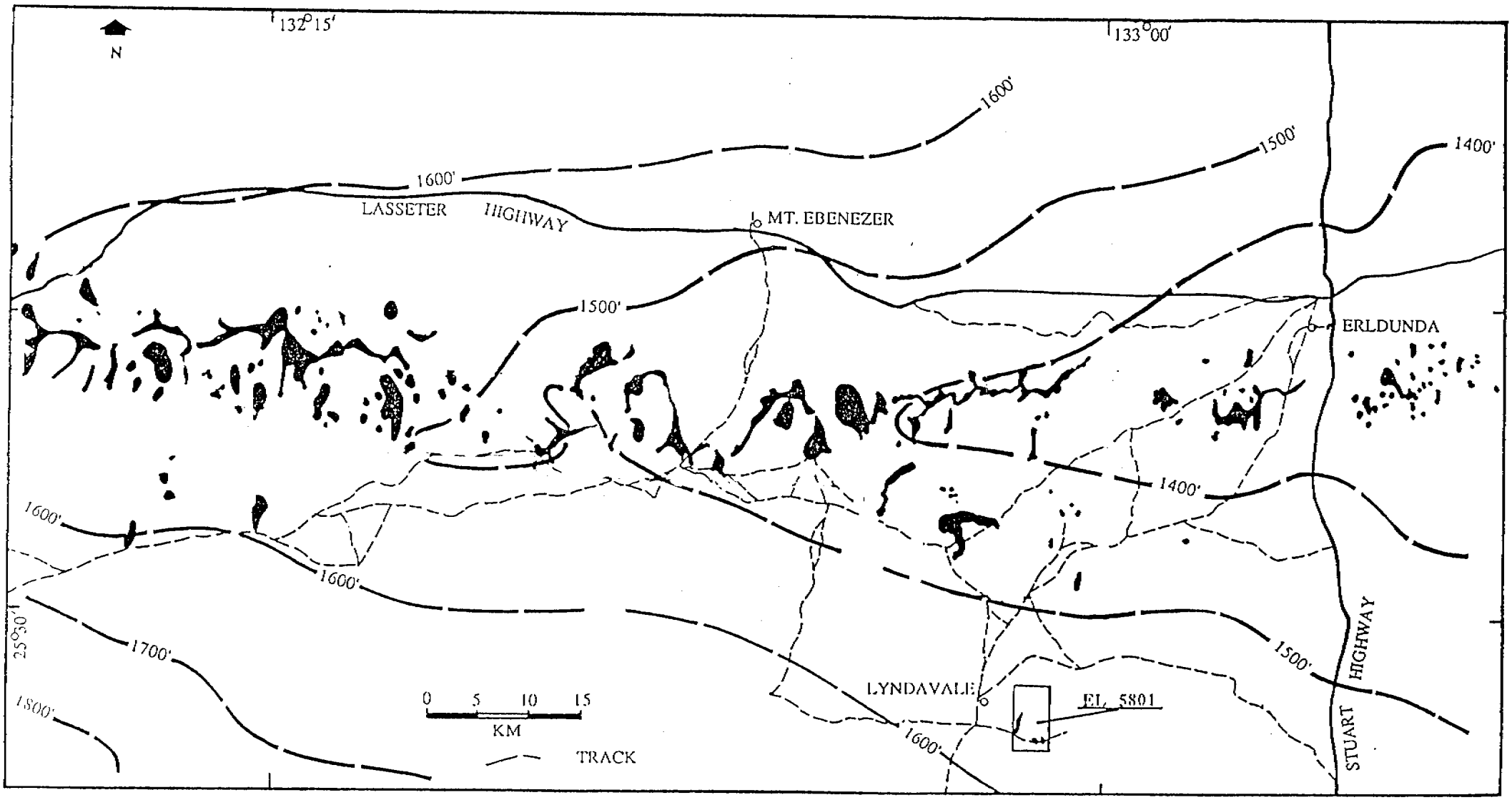


Figure 5. Map showing the distribution of physigraphic divisions in the general study area.

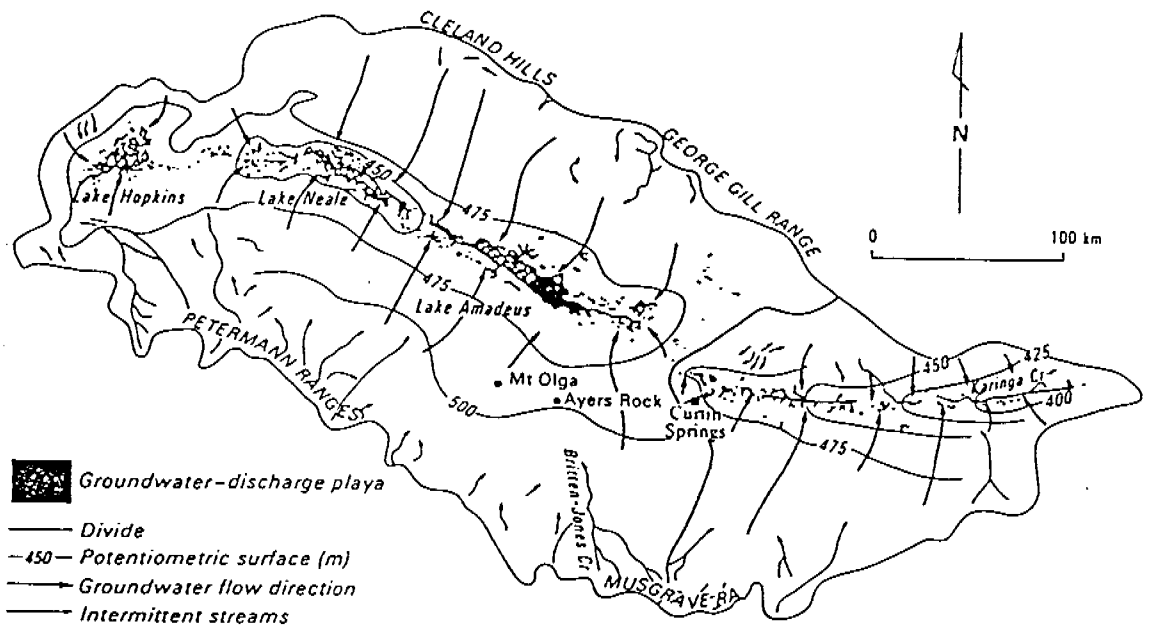


Figure 6. Groundwater flow system in Cainozoic aquifers of the Central Australian Groundwater Discharge Zone

shown in Figure 6. Recharge to the Cainozoic aquifers is by infiltration due to flooding in the catchment areas, and direct infiltration of rainfall through sand dunes and the karstified calcretes. Discharge from the groundwater system is almost entirely by evaporation in the chain of playas (Jacobson, 1987).

Recharge to bedrock aquifers is by infiltration through fractures in the hilly bedrock (Pacoota and Mereenie Sandstones) oucrop areas. A small amount of groundwater from bedrock aquifers is discharged via springs in the bed of Lake Amadeus.

The Cainozoic sediments, namely alluvial clay-sand units and calcretes are the main aquifers of the basin. In the Kulgera map sheet area, the shallow aquifers are mainly within or just below the groundwater calcrete. A number of fresh- to brackish-water springs, emanating from shallow calcrete aquifers, are located along the southern margins of the playa chain in the study area. In the eastern half of the study area, calcretes become less expansive and rather patchy in distribution. Here playas are devided into two groups: one following the Karinga Creek drainage system, and another group following the retreating edge of the southern calcretes. The only significant modern surface drainage in the licence areas relates to ephemeral Karinga Creek, which is associated with most of the eastern domain playas and drains eastward. When flowing, the Karinga Creek is saline upstream but changes abruptly to freshwater downstream. During most of first half of 1989, the karinga Creek maintained a continuous surface flow of higly saline waters; the salinity of both surface and groundwater during June-July 1989 was mostly in excess of 150 g/l TDS, indicating the effectiveness of dissolution of pre-existing salts and lateral seepage via the Creek.

Groundwater quality in Cainozoic calcretes and associated sediments of the study area is generally in the range of 1.5-9.7 g/l total dissolved solids. The fresher groundwaters (1.5-4.8 g/l TDS) in the study area are recorded mainly from the bedrock hilly areas and in the perched calcrete aquifers, which are away from direct influence of playa brines. Down the local hydrologic gradients, the groundwaters become increasingly saline, reaching salinities up to 15.7 g/l TDS. In the playa marginal areas, the brines become Cl-SO4 dominant, and Na is the major cation. Within the playas, intense evaporative concentration of near-surface solutions initially give rise to precipitation of gypsum at concentrations above 100 g/l TDS. As a result, the playa brines in the general area of Lake Amadeus are commonly Na-Cl waters and highly enriched in K, Mg and SO4.

4. SEDIMENTOLOGY

The loose gypsiferous and clay-sand fill in the playas contain the bulk of the brine from which a variety of evaporite minerals are precipitated. The vertical facies in the playas themeselves include an upper 1-2m of gypsum sand (gypsite) deposit confined to the playa capillary zone. The gypsite is

comprised of numerous clear gypsum crystals, up to few centimeters across and characterised by dicoidal forms. The overall intergrown- to - interlocking fabrics together with the presence of partially corroded larger gypsum crystals, reflect episodes of gypsum dissolution and reprecipitation, due to fluctuations in local pore-water chemistry. Glauberite crystals, forming nodules and discrete bands, are recorded from some of the playas below the halite efflorescent crusts.

Downward to a depth of few metres below surface, reddish-brown lacustrine clayey sand units alternate with gypsiferous bands. The gypsum crystals in these gypsiferous units are commonly confined to fenestral partings and pore spaces of the non-evaporitic host sediments, a feature attesting to direct precipitation from concentrated pore solutions and subsequent crystal growth by displacement. The playa gypsiferous units are commonly underlain at shallow depths by Mesozoic shales, which in most cases act as effective aquicludes, often causing ponding and subsequent concentration of groundwater solutions. In the Curtin Springs area, the playa facies are underlain by aeolian/colluvial sand facies, with the latter grading downward into a dolomitic unit of unknown thickness (Arakel, 1987). The unit contains zeolite minerals, with analcime forming up to 35wt% of the sediment mode.

Playa marginal facies are characterised by calcrete and gypcrete duricrusts. The calcrete deposits are several tens of meters thick and largely confined to the zone of groundwater flow in palaeo-drainage channels. Petrographic observation of drill cores indicate that the calcrete material, within the zone of active groundwater circulation, is invariably micritic, low-Mg calcite in composition (Jacobson et al., 1988; Arakel et al., 1989). On surface , the calcrete is commonly karstified, with solution voids and sink-holes providing conduits for effective recharge of the local aquifers.

5. INDUSTRIAL MINERALS AND BRINE RESOURCES

As indicated earlier, during 1989, because of adverse climatic conditions and flooding of the playa lakes, the exploration work was greatly hampered. As a result, the sediment/brine sampling and water quality tests were restricted mainly to areas with vehicular access. The investigations so far carried out in the tenement area indicate that main mineral groups with potential for economic occurrences include clays and zeolites. The main industrial clay variety in the area appears to belong to sepiolite - palygorskite group of clays, as identified by x-ray diffraction analysis. In some of the lakes, the basement shale dopsits of Devonian age exhibit bentonitic smectite characteristics, as evidenced by NMR and IR analytical results. Drilling would however be required to assess the depth of alteration of the clays and their reserves.

Othe chemical deposits, including the carbonate and evaporite minerals appear to have limited reserves in this licence area.

In the exploration licence area, the Karinga Creek is the main conduit for transfer of concentrated brines down the drainage system. Investigations have so far confirmed the presence of high quality brines in the western half of the tenement; however, further field investigation, including drilling followed by pump tests at selected localities would be required for proper assessment of the brine resources of the area.

Analysis of the brine samples collected from the area during consecutive winter and summer seasons of 1989-90, indicate that the salt content of the brines varies between 7.5wt% and 37wt%, respectively. These figures indicate up to 3 times dilution of the summer brines in the winter months. The seasonal variation in salinity, but more important in temperature and humidity, is well reflected in precipitation and distribution of "seasonal" glauber and potassium salts in the Karinga Creek playa lakes.

By considering the favourable climatic conditions and quality of brines in the Karinga Creek drainage system, a preliminary combined field and laboratory experimentation, involving precipitation of sulphate and choride salts from playa brines has been in progress since June 1990. A sequential evaporation-cooling technique was utilised to simulate variation in the crystallisation phases and mineral quality, under natural and simulated temperature and humidity conditions. The results of these experiments clearly confirm the high potential for yielding sulphate- and chloride- salts of sodium, magnesium and potassium from playas as well as the Karinga Creek brines in the licence area. Futher field investigations for assessing the brine resources, and laboratory tests to assess the feasibility of producing high grade industrial salt minerals from the brines of the area are planned for 1990-91 period.

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EXPLORATION EXPENDITURE - YEAR COMMENCED MARCH 1988

N.T. EVAPORITES - EXPLORATION LEASES 6509

	HYDROGEOLOGY GEOCHEMISTRY GEOLOGY GEOPHYSICS
EXPLORATION LICENCE FEES & CHARGES	550
VEHICLE PLANT & EQUIPMENT HIRE	5980
FREIGHT ON SAMPLES FIELD EQUIPMENT AND SUNDRIES	1420
CONSUMABLES	1240
CONSULTANT AND GEOLOGIST TRAVEL & ACCOMMODATION	2100
CONTRACTORS & CONSULTANTS FEES	6600
REPORTS AND ANNUAL RETURNS	2100
OFFICE EQUIPMENT & STATIONERY	340
ADMINISTRATION COSTS	920
TOTAL	21250

APPENDIX 1. SUMMARY OF CHEMISTRY OF BRINES AND GROUNDWATER SOLUTIONS IN THE EXPLORATION LICENCE AREA.

SAMPLE NO.	LOCATION / BORE NAME	WATER DEPTH	TEMPER.	pH	CONDUCTIVITY	TDS
		(cm)	(C)		(mS/cm)	
5IB 80	-	-98	15.1	6.98	88.5	74754
5IB 81	-	-161	16	-	-	-
5IB 82	-	-45	13.1	6.23	200	243100
IB 53	Birthday Bore	-	27.5	7.04	4.88	4356.4
IB 52	Stony Bore	-	26.5	7.51	1.35	814.4
IB 51	Western Bore	-	26.8	7.35	3.2	2439.1
IB 50	Gap Bore	-	27	7.3	2.28	1657.2
IB 46	Miningera L.	Surface	19.9	7.88	10.92	12922
IB 43	Miningera Bore	-	27	7.89	3.72	2747.8
IB 42	New Solar Bore	-	26.8	7.71	4.54	3640.4
IB 40	Old Pulcura Well	-	17.2	7.7	4.8	3222
IB 38	Arranja Lake	Surface	22.3	7.68	8.22	5707.8
IB 37	Mygoora Bore	-	27	7.55	4.86	3518.2
IB 33	Borewater Lyndavale Stn.	-40	26	7.61	2.5	1632.2
IB 28	Calatta Spring Water	Surface	24.3	8.04	2.33	1591.9
IB 25	Seepage Beefwood B.		26.6	7.68	5.06	3973.7
IB 24	Beefwood Bore	-	27.2	7.53	4.96	3779.5
IB 23	7 Mile Bore	-	27	5.73	5.38	5104
IB 22	Condy Bore	-	25.9	7.13	2.66	2719.4
IB 21	Ippity Hanger Bore	-	25.2	7.19	2.88	2755
	(ALL VALUES ARE IN PPM)					

APPENDIX 2

COMPOSITION OF SEDIMENT SAMPLES COLLECTED FROM THE EXPLORATION LICENCE AREA

(Determined by a combination of X-ray diffraction and Infrared Spectroscopy methods)

SAMPLE NO.	DEPTH (cm)	MINERALS (Ma:Major; Mi: Minor)
IB 103A	75	(Ma) Quartz, halite, smectite (Mi) Illite, microcline, bassanite, calcite, ankerite, hematite
IB 108A	92	(Ma) Gypsum, Quartz, Bassanite (Mi) Microcline, kaolinite, chlorite, illite, hematite
IB 110C	32	(Ma) Quartz, calcite, smectite (Mi) Mixed kaolinite, dolomite, hematite
IB 111B	40	(Ma) Gypsum, Quartz, bassanite, microcline (Mi) Chlorite, kaolinite-smectite
IB 119C	85	(Ma) Glauberite, Quartz (Mi) Kaolinite, hematite
IB 120C	75	(Ma) Quartz, gypsum, halite, smectite (Mi) Microcline, bassanite, kaolinite-smectite, glauberite, kaolinite, hematite
S 2019A	20	(Ma) Gypsum, quartz (Mi) Calcite
S 2019B	20-25	(Ma) Gypsum, quartz (Mi) Starkeyite, calcite
S 2040	20	(Ma) Gypsum, quartz (Mi) Halite, calcite
S 2045	Surface	(Ma) Gypsum, quartz, halite (Mi) Microcline, calcite, smectite, illite
S 2046	Kopi?	(Ma) Gypsum, quartz (Mi) Calcite, halite
S 2048A	Surface	(Ma) Halite, quartz
S 2048B	20	(Ma) Gypsum, calcite, quartz (Mi) Halite, polyhalite, kaolinite
S 2071	Kopi	(Ma) Gypsum (Mi) Calcite
S 2120	Surface	(Ma) Halite, gypsum, quartz, kainite (Mi) Anhydrite, calcite, bassanite
S 2143	Surface	(Ma) Halite, quartz, gypsum (Mi) Calcite
5IB 80	980	(Ma) Gypsum, quartz (Mi) Kaolinite

5IB 81	1610	(Ma) Kaolinite
		(Mi) Quartz, gypsum
5IB 82	450	(Ma) Kaolinite
		(Mi) Gypsum, quartz