TECHNICAL REPORT ON THE LAKE MACKAY POTASH PROJECT WESTERN AUSTRALIA

Final Report

For Agrimin Limited.

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SUMMARY

Location and physiography

The project is located in Central Australia, where topography is subdued outside of mountain ranges such as the McDonnell Ranges that extend west from Alice Springs towards the project. Lake Mackay itself is located in further west of the range, where topography is generally dominated by the extensive longitudinal dune fields developed there.

The project is accessed by an established unsealed road that passes Papunya and Kintore, before reaching the settlement of Kiwirrkurra. A vehicle access track leaves this road near the settlement, crossing sand dunes to Lake Mackay and the Toro Energy campsite that was used by Agrimin for this drilling program.

Climate

The project area is characterised by seasonal extremes in temperature. Summer temperatures can reportedly exceed 50°C, while winter overnight temperatures can fall below zero. A weather station was installed on the southern margin of the lake in August 2015, however only minor information available over the period between installation and this report. The nearest long term weather station is at Kintore approximately 115 km to the SE.

The average annual rainfall over the period 1998 to 2015 is reported as 281 mm/year at Kintore. Lake Mackay is located on the margin of the highest interpreted solar radiation zone, and is in one of the highest evaporation zones at >3200 mm/year, based on Australian Bureau of Meteorology pan data.

Geological setting

Lake Mackay is the low point in the surrounding catchment and is interpreted as the discharge point for a series of extensive paleochannels which drain from the Northern Territory into Western Australia. The lake sediments date from the Miocene until recent. The size of the catchment is extremely large and generally poorly defined, at up to 87,000 km^2, which relates to the paleovalley system. The immediate catchment for runoff, except in extreme events that over-ride local low points, is closer to half this area, although it is also poorly defined. The lake covers 3500 km^2 in both WA and the NT.

Salt lake Geology

The lake surface has a surface salt crust <1 cm thick, with a layer of coarse to fine gypsum sand developed over the lake, which is thicker in the east. This unit has interbedded silt layers and grades downward into sandy clay. Beneath approximately 2 m red sandy clay and clay extends to the underlying bedrock. The lake depth is approximately 16 metres in the west at the shallowest point, deepening to over 30 m on the Northern Territory border. The lake surface displays different geomorphological zones, consisting of major north to northwest trending channels, and topographically higher areas of gypsum ground – where gypsum and halite form a surface crust.

Exploration

Reward Minerals previously drilled 24 vibracore holes to an average depth of 2.7 m. Agrimin drilled 27 aircore holes to an average depth of 24.7 m, 34 power auger holes – typically to 1.5 m; and 5 hand auger samples. These defined a consistent stratigraphy over the lake

sediments. PVC well casing was installed in 17 holes for pump testing or water sampling. Five 1000 litre pods of brine sample were taken for evaporation and process test work.

Brine assays and QA/QC

Auger holes were sampled with a single sample collected and assayed per hole. Brine samples were taken during aircore drilling by airlifting and subsequently from monitoring wells installed in the holes. All the results of samples from the aircore holes were used to produce an average for the hole, with the only assays excluded being the upper sample in Hole MA10, which was drilled on the side of a gypsum island. The results from the aircore and auger sampling show very similar average results and ranges. The auger results do have a larger standard deviation, due to lower grade samples in the eastern area of the project and isolated samples > 5,000 mg/l. The distribution of the analyte concentrations is very similar spatially between the aircore and auger samples. There is distinct chemical zoning across the lake, with the highest potassium grades, and most other elements, in the west – with lower values in the east. This probably reflects recharge of the sediments.

The original assay results from the ALS laboratory were investigated by re-analyzing all available samples at the Intertek laboratory at Perth. This confirmed the written advice from ALS that results produced were overstated (and of poor quality). The ALS results showed very high differences in the ionic balance. However, the difference between ALS and subsequent laboratories where re-analyses were undertaken hinted at a larger problem. To investigate the influence of the analytical method on results some of the original ALS samples were analysed by the Bureau Veritas laboratory in Perth and by the University of Antofagasta laboratory in Chile.

This latter laboratory was used as they have extensive experience analyzing brines and use Atomic Absorption spectrometry – which is believed to suffer less from interference in the mineral spectra associated with very high concentrations of sodium in the brine. High sodium concentrations are known to amplify the potassium results. It was concluded that the Intertek results are slightly higher than the University results, and future analyses should be using the AA method, using a new set of standards to be certified by AA analyses.

Resource Estimate

The resource estimate was undertaken using the aircore average of hole assays and the power auger assays, which show an average hole spacing of 7.2 km. The stratigraphy was split into two units, an upper unit of sand, some silt and sandy clay and the lower dominant clay unit. The thickness of both units was based on the drilling, with porosities based on laboratory results.

A total contained brine volume was estimated based on the total porosity values. However, as most of the brine occupying pores is bound water on clays or held by capillary forces this is not considered an appropriate measure of brine which can be potentially extracted. Operating lithium and potassium brine operations use the specific yield (Sy) as a measure of brine that can be drained under gravity to trenches or bores. This is considered best practice, as discussed by Houston et. al., 2011.

The resource was broken into an upper and a lower layer, with the upper layer subdivided to extend to 2.7 m and from 2.7 m to 6 metres, to reflect the potential extraction of brine from trenches to 6 m deep. A higher Sy value was assigned to the sediments in the east of the lake for the upper 2.7 m. progressively lower Sy values were used for 2.7 m to 6 m and from 6 m to the base of the sediments. This reflects a lower sand content in the sediments with depth and also increasing compaction of the sediments. The estimated brine resource is presented in the table below.

Resource Category	Zone	Depth (m)	Volume (million m³)	Average Total Porosity	SOP Grade (K_2SO_4 kg/m³)	Contained SOP (Mt)
Indicated	Upper	0.4 – 2.7	4,036	45.0%	8.41	15
Inferred		0.4 – 6.0	7,047	45.0%	8.25	26
Inferred	Lower	6.0 – 24.7	33,004	45.0%	8.23	122
Total	**Upper & Lower**	**0.4 – 24.7**	**44,088**	**45.0%**	**8.25**	**164**

Resource Category	Zone	Depth (m)	Volume (million m³)	Average Specific Yield	SOP Grade (K_2SO_4 kg/m³)	Contained SOP (Mt)
Indicated	**Upper**	0.4 – 2.7	1,993	10.0%	8.79	1.8
Indicated		0.4 – 2.7	2,043	15.0%	8.04	2.5
Inferred		0.4 – 2.7	89	10.0%	8.26	0.1
Inferred		0.4 – 2.7	427	15.0%	7.39	0.5
Inferred		2.7 – 6.0	6,531	9.0%	8.31	4.9
Total		**0.4 – 6.0**	**11,083**	**10.5%**	**8.31**	**9.7**
Inferred	**Lower**	6.0 – 24.7	33,004	5.0%	8.23	13.6
Total	**Upper & Lower**	**0.0 – 24.7**	**44,088**	**6.4%**	**8.25**	**23.2**

Islands and ecosystems

The islands in the east of the lake are composed of gypsum sand, which is porous in places and allows for infiltration of rainwater. An important portion of the annual rainfall is likely to infiltrate into the gypsum sand on these islands, forming a lens of fresh water grading deeper to brackish water and overlying the principal brine body underlying the lake. Pumping from the brine body will potentially influence and possibly destabilize the fresh to brackish water lenses on islands (which are topographically higher than the lake brine) where the gypsiferous sands hosting brine are hydraulically connected to the brine underlying the islands. Consequently a baseline environmental assessment of the gypsum islands should be conducted should the project advance beyond the scoping study stage.

1 INTRODUCTION

1.1 Background

Lake Mackay is the largest salt lake in Western Australia, located on the border with the Northern Territory, with over 75% of the lake in Western Australia. The lake is occassionally subject to partial seasonal inundation, commencing in late December and continuing through to March, after which seasonal drying of the lake occurs.

The lake hosts hypersaline brines in the sediments which form the base of the lake. The area has been subject to very sparse human activity and mineral exploration. The earliest known systematic mineral exploration was vibracore sampling conducted on the lake by the company Reward Minerals in 2009. This sampling involved collecting cores to an average depth of 2.7 m and brine samples for test work, to evaluate whether the lake sediments host brine suitable for the production of Sulphate of Potash (SOP) fertilisers. This initial sampling returned sufficiently interesting potassium and sulphate concentrations that Agrimin Limited acquired the tenements, with the purpose of conducting a more detailed resource assessment and scoping study into potential SOP production.

1.2 Differences between brine and hard rock prospects

There are important differences between brine and hard rock base or precious metal projects. Brine is a fluid hosted in an aquifer (porous rock) and thus has the ability to move and mix with adjacent fluids once pumping of the brine commences. An initial in-situ <u>resource</u> estimate is based on knowledge of the geometry of the aquifer, and the variations in porosity and brine grade within the aquifer. However, as with hard rock resources only a portion of this can be extracted – in this case by pumping. In order to assess the recoverable <u>reserve</u>, further information on the permeability and flow regime in the aquifer and the surrounding area is necessary to be able to predict how the resource will change over the project life. These considerations are examined more fully in Houston et. al., (2011) and the reader is referred to that document for a comprehensive discussion of issues related to the extraction of brine from salt lakes.

Sections 6, 10 and 11 discuss characteristics of the host lithologies geometry, permeability and porosity. Sections 12 and 13 of this report discuss the characteristics of the mineralized brine. Sections 15 through 17 deal with the mineral resource estimate, potential mining method and simulation of brine extraction by pumping (the mining method). Section 18 summarises aspects of Mineral Processing and Metallurgical Testing that are being overseen by process consultants Ehren Gonzalez.

Hydrogeology is a specialist discipline which involves the use of a number of specialized terms which are used frequently throughout this document. The reader is referred to the glossary at the end of this report for a definition of terms.

2 PROPERTY LOCATION AND INFRASTRUCTUCTURE

2.1 Location and access

The project is located in Central Australia, where topography is subdued outside of mountain ranges such as the McDonnell Ranges that extend west from Alice Springs towards the project. Lake Mackay itself is located in further west of the range (Figure 2.1), where topography is dominated by the extensive longitudinal dune fields that are developed there.

The project is accessed by an established dirt road that passes Papunya and Kintore, before reaching the settlement of Kiwirrkurra. A 4WD vehicle access dirt track leaves this road near the settlement, crossing sand dunes to Lake Mackay and the Toro Energy campsite that was used by Agrimin for this drilling program.

2.2 Infrastructure

The area encompassing Lake Mackay has very limited development or infrastructure and is largely undisturbed. No mining or brine extraction has been undertaken in the vicinity of the Project. A single lane unsealed road, which traverses the western edge of Lake Mackay, connects the Project with the communities of Kiwirrkurra in the south and Balgo to the north. The local settlement of Kiwirrkurra has a shop, electricity generation, health clinic, community centre and housing for local aboriginal inhabitants.

Development of the Lake Mackay project would require upgrading of roads, installation of a power station (solar or diesel), construction of a borefield for fresh and brackish water extraction and construction of a processing plant and associated potash production facilities.

The Kiwirrkurra community, located 60km to the southwest, has a population of approximately 200 people. Kiwirrkurra provides basic supplies and services including general store, fuel, medical station, road maintenance and accommodation. The town relies on diesel generators for its power supply and sources water from a local bore field. The community is also serviced by an unsealed airstrip that is approximately 1.6km in length.

More extensive services and supplies can be sourced from Alice Springs, which has a population of approximately 29,000 people; with rail links to Darwin and Adelaide, both of which have international shipping terminals.

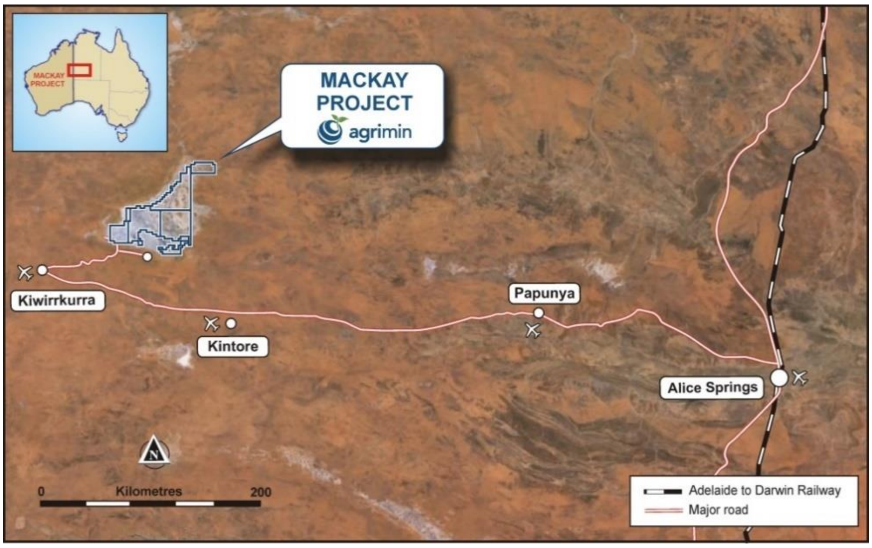


Figure 2.1: Location of the Mackay project, settlements and tenements

3 EXPLORATION LICENCES AND HISTORY

3.1 Exploration licenses

The Agrimin Lake Mackay tenements consist of five granted exploration licences in Western Australia; numbered E80/4887, E80/4888, E80/4889, E80/4890 and E80/4893 and one tenement application in the Northern Territory (EL30651). Four of these tenements were granted in January 2015, with the fifth granted shortly thereafter. These tenements cover the vast majority of Lake Mackay to the Western Australia (Figure 3.1), for a total of 2,268.6 km^2, with the tenement application in the Northern Territory covering the northeast corner of the lake.

The remainder of the lake in the Northern Territory is covered by existing tenements held by companies not exploring for potash or areas believed to be held under an embargo on exploration licences. Between the southern margin of the lake and Agrimin tenements are tenements held by Toro Energy, in which Rum Jungle has earned an interest by exploring for potash.

Tenement	Area km2	Grant date	End date
E 80/4889	272	2015/01/22	2020/01/21
E 80/4890	632.7	2015/01/22	2020/01/21
E 80/4893	113.7	2015/01/22	2020/01/21
E 80/4887	616.7	2015/01/22	2020/01/21
E 80/4888	633.5	2015/04/28	2020/04/27
Total granted	2,268.6		
EL30651	180.1	Awaiting grant	

Table 3.1: Agrimin exploration licences and areas

3.2 Pre-Agrimin history

The project was previously explored by the company Reward Minerals, who in 2009 conducted a vibracore sampling program across the lake (Figure 3.2). In this program they drilled 24 shallow core holes to an average depth of 2.7 m. Brine samples taken from 22 of these holes returned an average of 6.83 kg of SOP (3064 mg/l of K) over the drill holes. The project was subsequently acquired by Agrimin in 2014, following a period of inactivity by Reward Minerals.

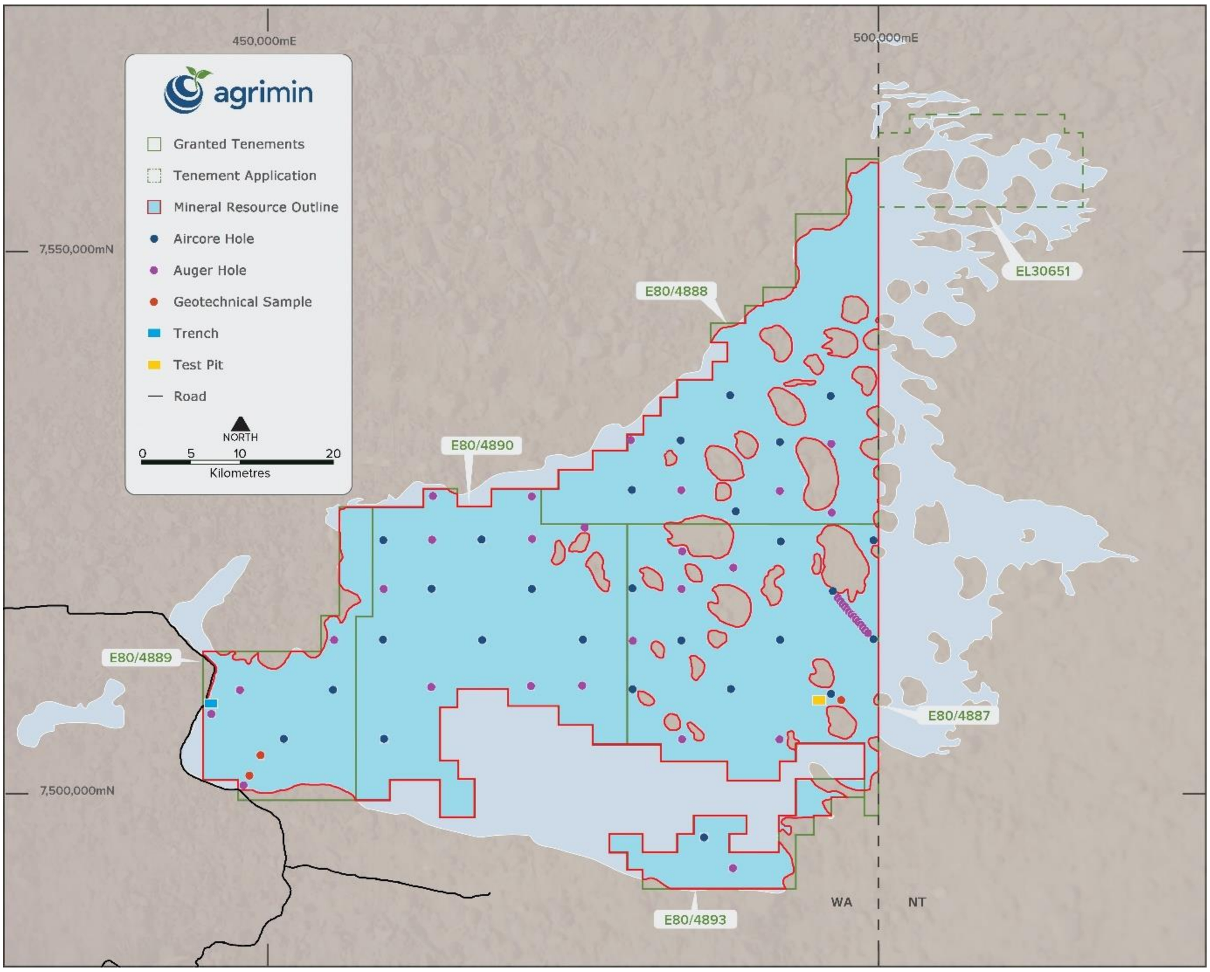


Figure 3.1: Tenements held by Agrimin Ltd in Western Australia with 2015 drilling program

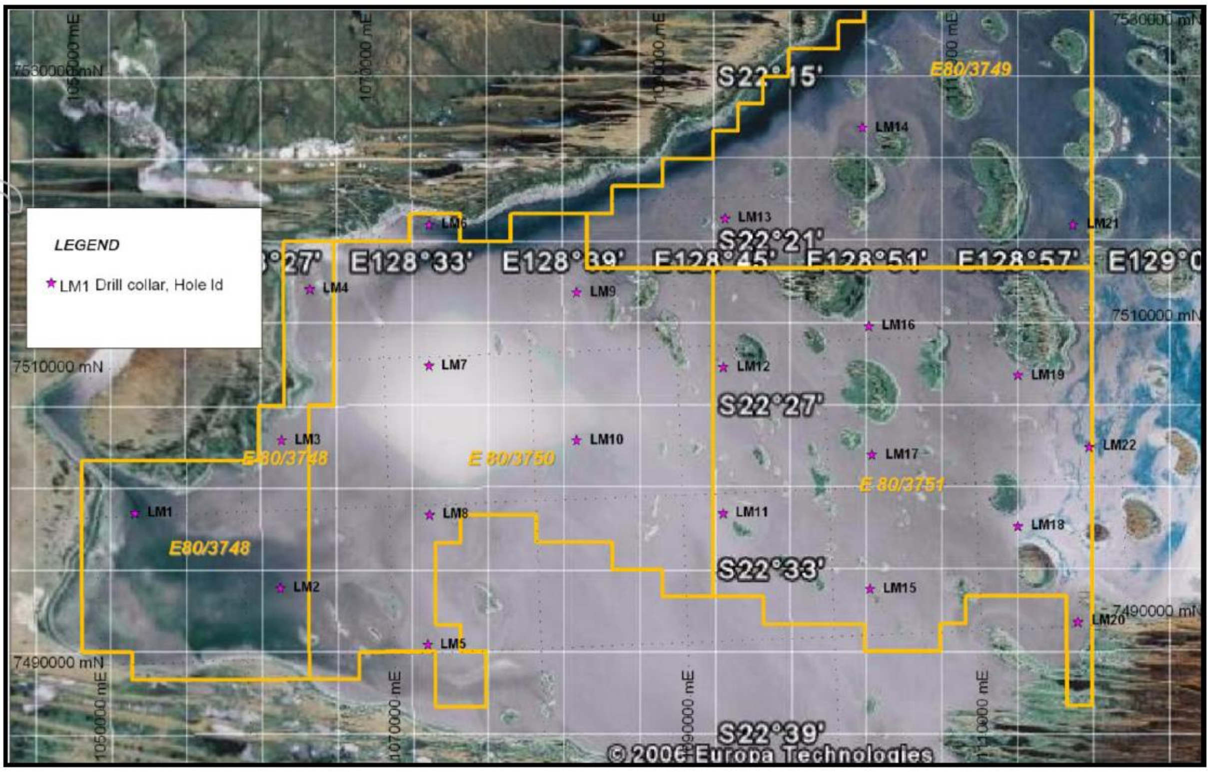


Figure 3.2: Location of Reward drill holes in 2009

4 CLIMATE AND VEGETATION

4.1 Climate

The project area is characterised by seasonal extremes in temperature. Summer temperatures can reportedly exceed 50^{o}C, while winter overnight temperatures can fall below zero. A weather station was installed on the southern margin of the lake in August 2015, however only minor information avialable over the period between installation and this report.

The nearest long term weather station is at Kintore and this information is presented in the following sections and Table 4.1. Although this station is located approximately 115 km SE of Lake Mackay conditions are expected to be similar, with variations over the lake and the catchment due to the local nature of storm cells that generate periods of intense rainfall.

Statistic Element	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Mean maximum temperature (Degrees C) for years 2001 to 2015	39.7	38.6	36.2	33	27.3	23.1	23.3	26.7	32	35.9	37.5	38.3	32.6
Highest temperature (Degrees C) for years 2001 to 2015	46.7	45.5	43.8	41.1	34.9	31.3	32.3	35	39	43	44.9	45.3	46.7
Date of Highest temperature for years 2001 to 2015	9-Jan-13	9-Feb-07	4-Mar-07	3-Apr-12	4-May-13	7-Jun-05	30-Jul-08	31-Aug-02	27-Sep-12	22-Oct-02	26-Nov-06	24-Dec-12	9-Jan-13
Mean minimum temperature (Degrees C) for years 2001 to 2015	26.2	25.7	24	20.5	15.4	11	10.4	12.3	16.9	20.8	23.3	24.8	19.3
Lowest temperature (Degrees C) for years 2001 to 2015	16.1	18	16	12	6.2	2.4	3.1	3.9	8.6	10.9	12	16.8	2.4
Date of Lowest temperature for years 2001 to 2015	11-Jan-15	2-Feb-04	30-Mar-07	26-Apr-15	31-May-06	13-Jun-06	10-Jul-12	2-Aug-12	4-Sep-10	16-Oct-10	14-Nov-01	4-Dec-11	13-Jun-06
Mean rainfall (mm) for years 1998 to 2015	50.5	35.8	50.1	11.2	15.5	8.7	15.8	4.7	7.9	17.5	19.6	43.1	281.2
Highest rainfall (mm) for years 1998 to 2015	179.2	116.8	252	126.8	136	40.2	70	29	103.4	85.8	51.2	161.2	500.8
Date of Highest rainfall for years 1998 to 2015	2014	2006	2007	2014	2004	2005	2010	2005	2010	2010	2003	2003	2014
Lowest rainfall (mm) for years 1998 to 2015	0	0	0.4	0	0	0	0	0	0	0	0	0	98.4
Mean daily solar exposure (MJ/(m*m)) for years 1990 to 2015	27.2	25.1	23.1	20.1	16.5	14.9	16.2	19.4	22.9	25.7	26.9	26.3	22

Table 4.1: Average monthly temperature (°C), rainfall and solar radiation data at the Kintore weather station (Bureau of meteorology data)

4.1.1 Temperature

Seasonal temperature changes are shown in the following graph, with a low in July and a high in in temperatures in December and January (Figure 4.1).

4.1.2 Rainfall

Due to the remote nature of the area the nearest meteorological station is that at Kintore, approximately 115 km south east of the southern lake shore. The rainfall is predominantly in the period of the tropical wet season that affects the north of Australia (Figure 4.2), with rainfall derived from large storms and cyclones which push inland from the northern coastline and produce periods of intense rainfall. It is evident from the rainfall data there that although precipitation is higher in the summer months, there is year-round precipitation. Records also show that single day events can significantly exceed the average annual rainfall in any month of the year, which has implications for the concentration of brine in evaporation ponds. The average annual rainfall over the period 1998 to 2015 is reported as 281 mm/year at Kintore, compared to rainfall of up to ~130 mm/year on average in Chilean and Argentine brine projects (such as Atacama, Hombre Muerto, Olaroz and Cauchari).

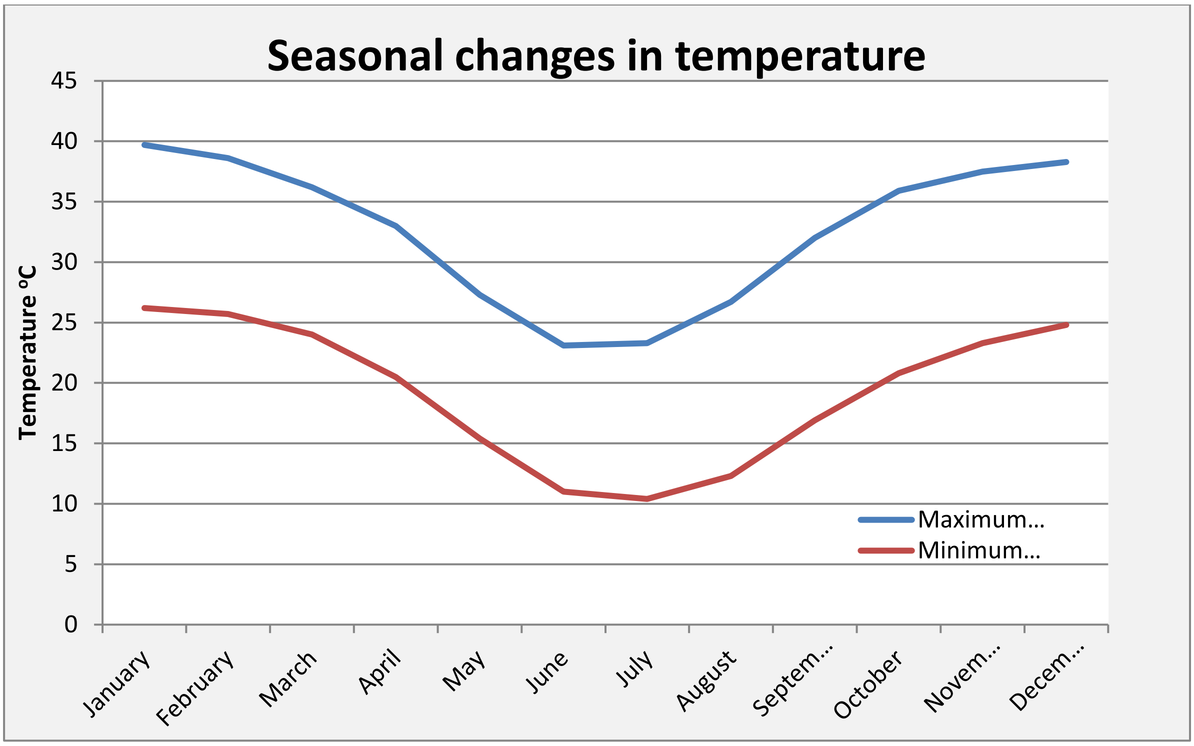


Figure 4.1: Average monthly temperatures

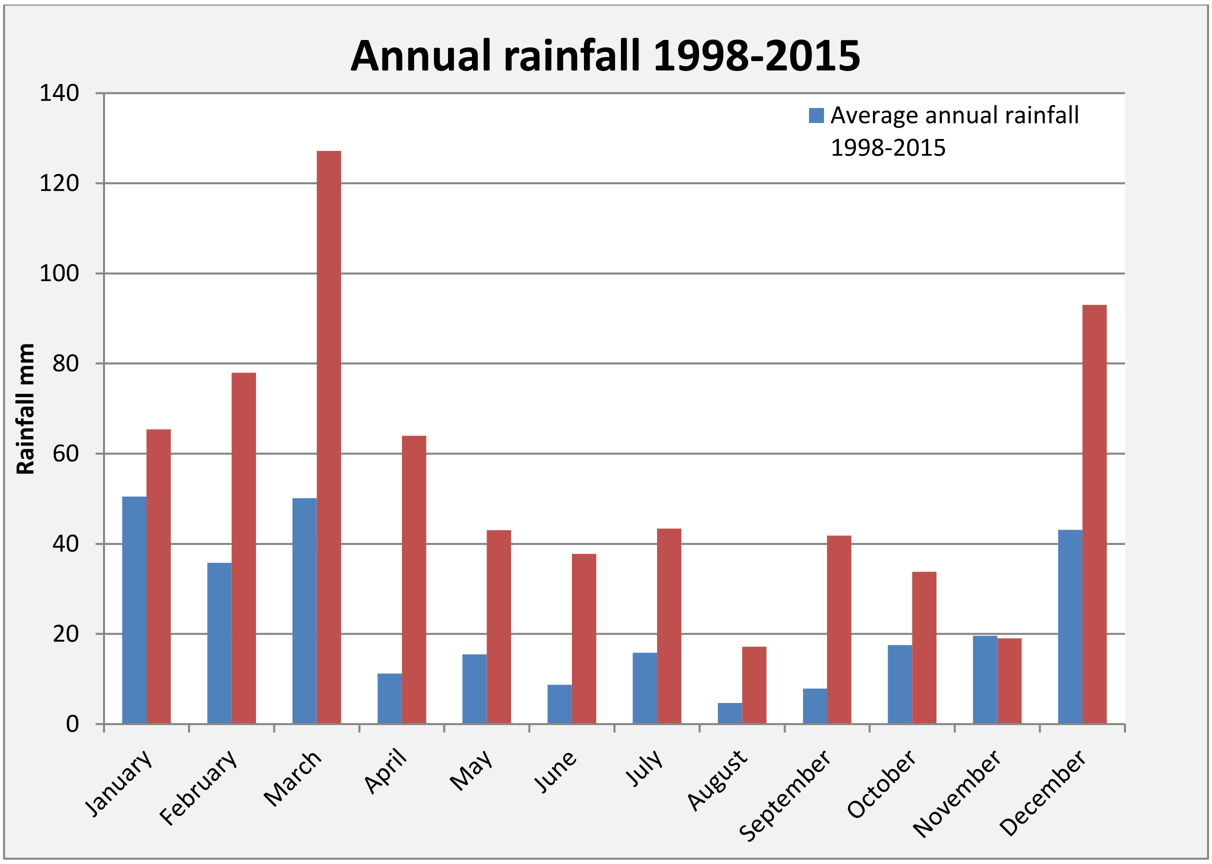


Figure 4.2: Rainfall figures from the Kintore meteorological station

4.1.3 Wind

Wind is predominantly from the east and south east. This is related to formation of a number of landforms associated with the lake that are discussed in detail in later sections. The wind, in addition to the solar radiation is an important contributor to evaporation in the project area.

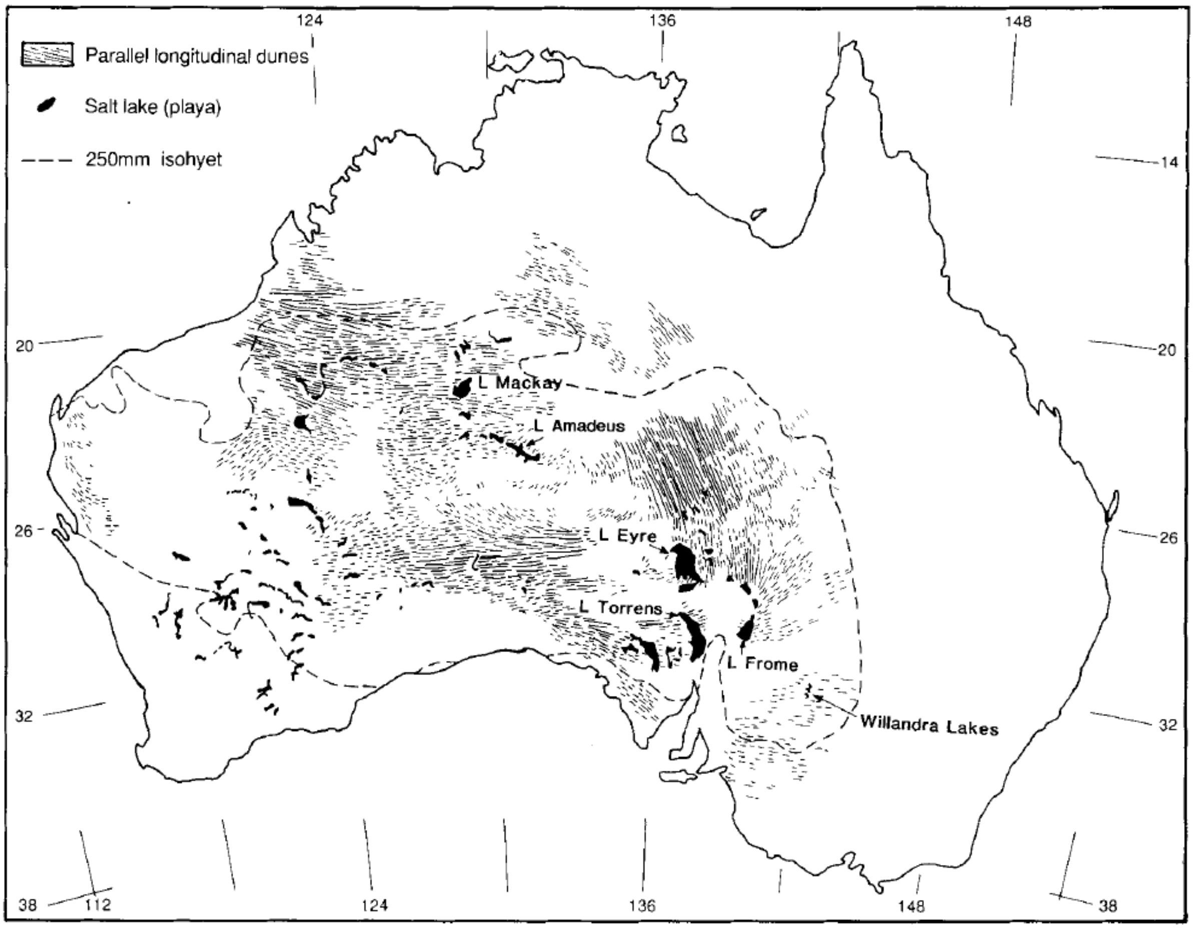


Fig. 1. Arid and semi-arid zones of Australia, showing the anticlockwise dunefield whorl and playa lakes. Modified from Bowler (1976).

Figure 4.3: Dune fields and playa lakes of Central Australia (after Bowler, 1976)

4.1.4 Evaporation

Evaporation data is not collected directly at the Kintore weather station, but solar radiation as MJ/(m*m) is collected at the weather station. This shows a low in June and a high in January. Insufficient public information is available to compare these data to measurements from other projects. The Kintore data is presented in Table 4.1.

Lake Mackay is located on the margin of the highest interpreted solar radiation, shown in Figure 4.4 and is in one of the highest evaporation zones, based on Australian Bureau of Meteorology pan data (Figure 4.5).

4.2 Vegetation

There is no vegetation on the salt lake itself, with the exception of islands developed in the east of the lake. Vegetation on these islands shows a transition from very salt tolerant shrubs growing on the margins of the islands, giving way to grasses and larger shrubs on the margins of the islands and trees several metres high in the central parts of the islands.

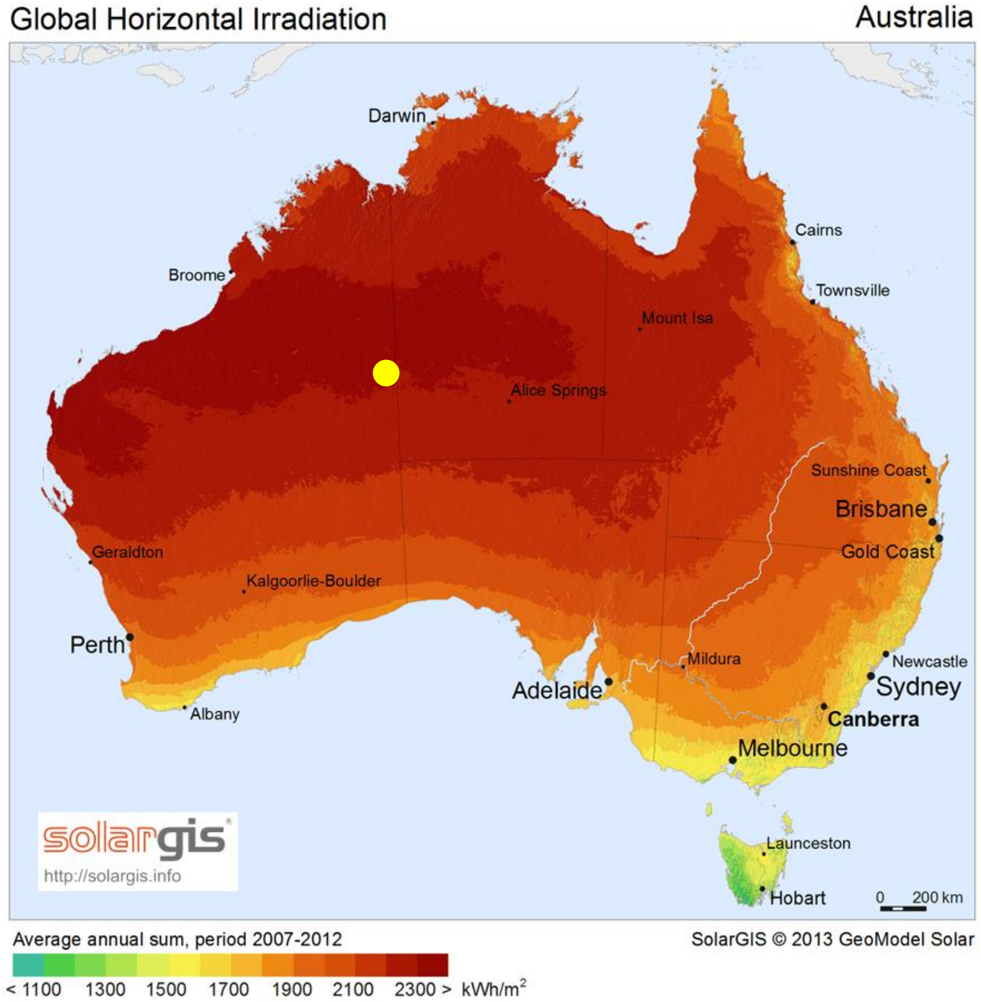


Figure 4.4: Interpreted solar radiation data for Australia

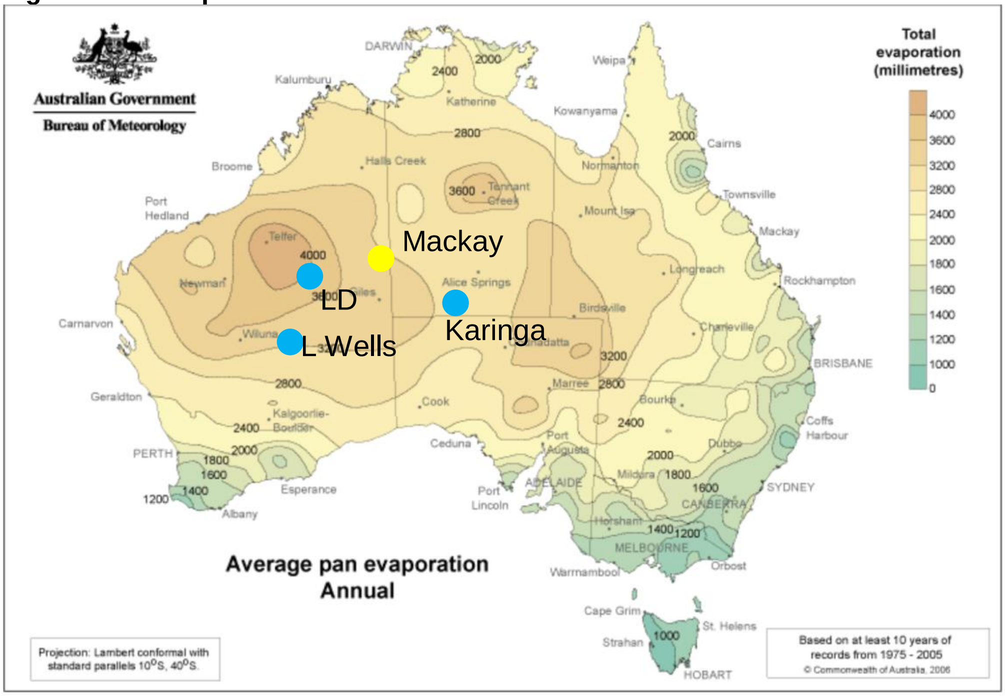


Figure 4.5: Pan evaporation data for Australia

This vegetation is thought to exist due to fresh to brackish water that is hosted in the porous gypsiferous sands that form the islands and overlies the larger brine body coincident with the salt lake.

Figure 4.6: Salt resistant grasses on the margins of an island, giving way to larger vegetation up slope

Figure 4.7: Larger vegetation developed on an island

5 PHYSIOGRAPHY

5.1 Lake Mackay catchment

The size of the catchment is extremely large and extends principally to the east of the lake, through the valley between the McDonnell Range and the range to the south. The exact limit of the catchment to the east is difficult to determine, due to the flat terrain in this valley in the area and the difficulties GIS software has determining drainages within this catchment. The catchment may be as large as ~87,000 km^2.

However, this is probably only the contributing catchment for the groundwater paleochannel system and for surface water runoff in times of abnormally heavy flows that generate significant surface flow. The catchment area excluding such abnormal rainfall periods is probably closer to generally poorly defined, with the catchment approximately half this size. The outlines of both variations of the catchment are shown in Figure 5.1.

In addition to the surface water catchment there is an extensive system of paleovalleys and paleochannels that has been defined by Geoscience Australia (Woodgate et. Al., 2012). These originate in the Northern Territory and extend west to the valley between the ranges to Lake Mackay, which is interpreted to be the discharge point for water in the paleochannels. The contribution of paleochannel water to the lake hydrogeology may be important, although this is currently not well understood.

5.2 Lake Mackay seasonal inundation

Observations from satellite imagery show that Lake Mackay undergoes some degree of inundation during the wet season from December to March annually, with surface water entering the lake along a series of channels, progressively inundate the lake. The images suggest that the northwestern margin of the lake has a higher elevation, as this does not undergo inundation. In contrast the most significant volume of water appears to enter the lake in the southeastern corner, spreading into the lake along drainage channels. These observations have relevance for recharge and concentration of groundwater within the lake basin and also for the potential location of future infrastructure. Observations on the lake surface from traverses with the Argo tracked vehicle show that there is noticeable topography across these channels, which are softer and have distinctive surface textures from areas outside the channels. A full season of inundation and drying images is provided in Appendix A, with an example image from March 2015 shown as Figure 5.2.

The seasonal inundation has implications for potential exploitation of the potash resource at Lake Mackay and the construction of infrastructure.

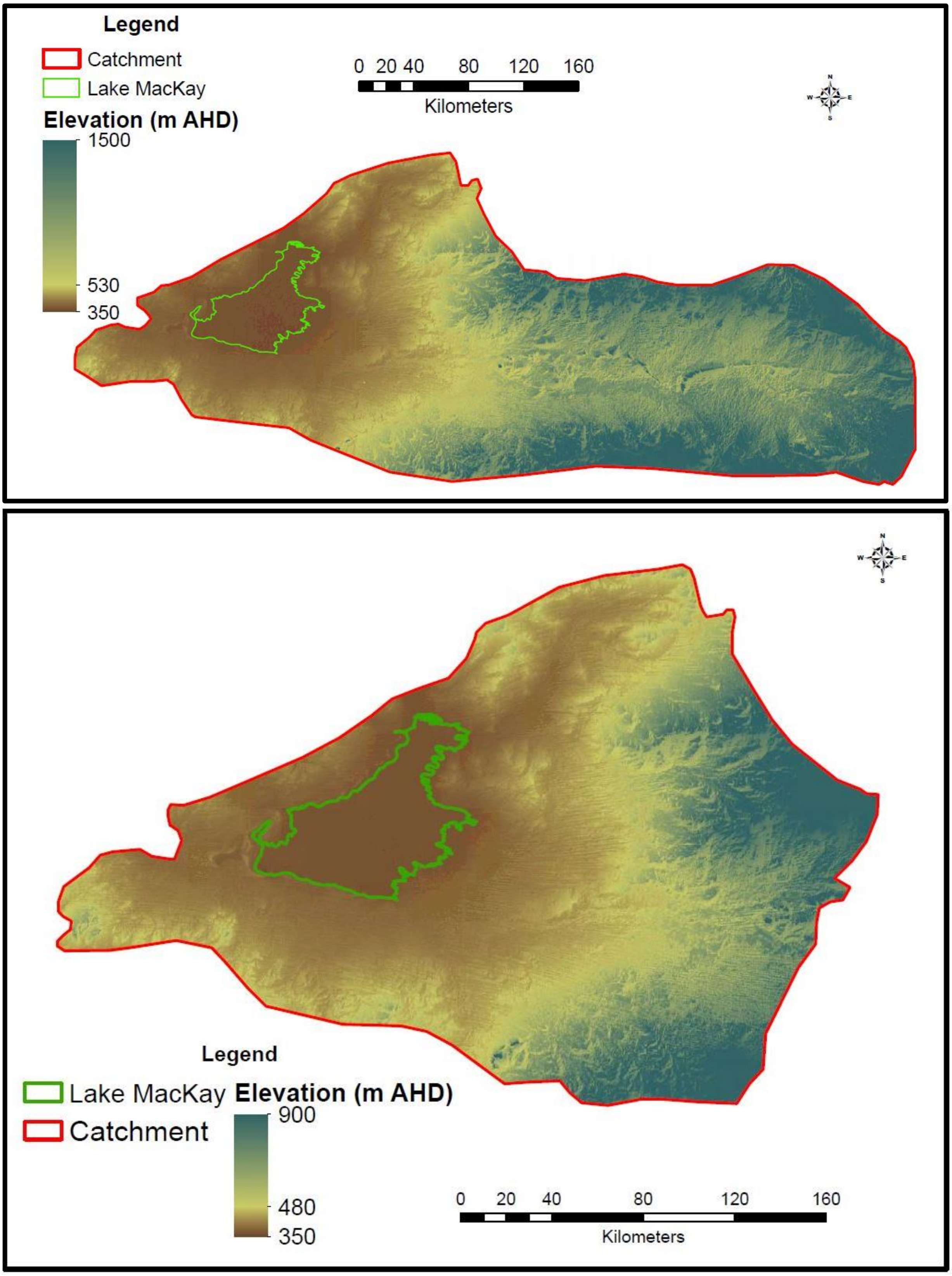


Figure 5.1: Lake Mackay catchment map and lake limit

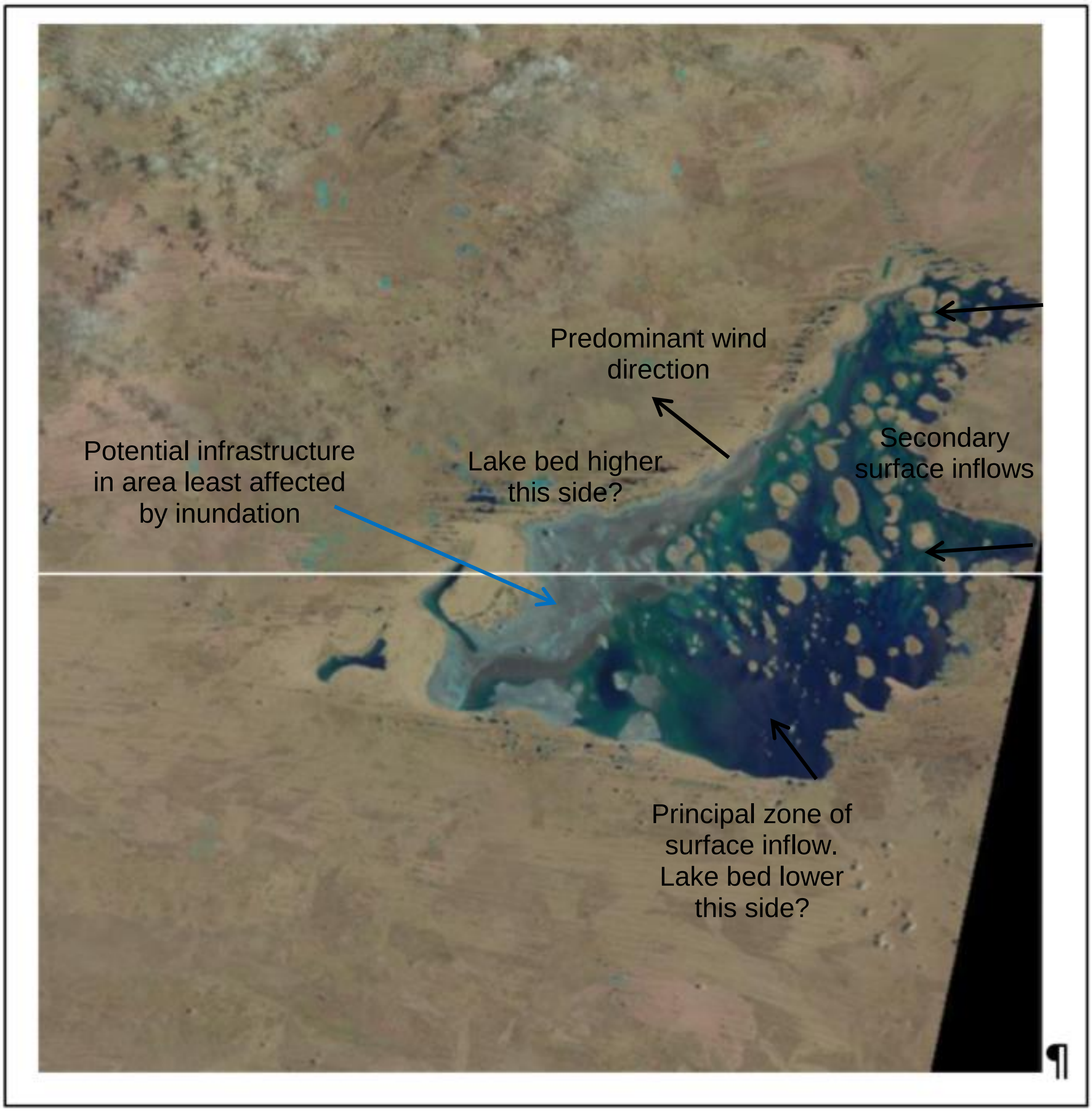


Figure 5.2: Landsat image from 1901/2015 showing maximum extent of inundation in 2015 wet season

5.3 Lake Mackay water balance

Lake Mackay is a very large salt lake, and is interpreted to form the low point of a large surface water catchment that in extreme rainfall events could be as large as 87,000 km^2. The catchment received periodic annual rains, as well as interpreted groundwater inflows as part of the Wilkinkarra paleovalley. These are balanced by evaporation from the surface of the salt lake, and on vegetation islands there is transpiration of fresher water interpreted to form lenses that overlie the salt lake brine.

Investigations by Jacobson (1988) at Lake Amadeus considered a water balance methodology of:

G + R = E +deltaS where

G= groundwater inflow to the playa lake (50 mm/year)
R = rainfall on the playa (which they considered as 250 mm/year)

E = evaporitic discharge from the playa (300 mm/year), and
deltaS = change in groundwater storage

Over an extended time frame brine is interpreted to sink beneath the playa and there may be Aeolian loss of salts from the playa surface.

Jacobsen estimates groundwater recharge at about 0.4% of incident rainfall over the catchment, very low compared to other arid parts of the world.

5.4 Central Australian paleodrainage (From Woodgate et. Al., 2012)

In a series of papers, Beard (1998; 1999; 2000; 2002 and 2003) refined palaeodrainage patterns in Western Australia using published 1:100,000 and 1:250,000 contoured topographic maps and 1:250,000 geological maps. In these papers, Beard examined the evolution and patterns of individual paleovalley systems and regional drainage divisions, mapped the position of major watersheds and elucidated the long-term post rifting geomorphic evolution of Western Australia. These later clarifications of paleodrainage patterns extended well beyond the Yilgarn and included paleovalleys related to the Eucla, Officer and Canning basins.

Therefore it is highly likely that many of the paleovalleys, or their precursors, have been in existence since Mesozoic or even Paleozoic times. In the central Australian ranges near Alice Springs, Mabbut (1967) also reported rivers which cut across the ranges and follow patterns established during the Late Paleozoic. English (2002) related the geomorphic structure in central Australia to the Alice Springs Orogeny, including the prevalent north and south trending drainage lines that orthogonally cut across the bedrock strike. Pervasive north-directed joint patterns are related to the east–west minimum stress direction of the Alice Springs Orogeny; these joints occur in many different rock types, including hard quartzite units which are mostly resistant to erosion.

The main period of erosion probably occurred from the Paleocene to Early Eocene, and may have been associated with transition from seasonal to wetter year-round rainfall patterns (Langford et al., 1995).

The second phase of Cenozoic paleovalley sedimentation probably extended from the Late Oligocene to Mid Miocene and was characterised by relatively lower energy, generally exorheic drainage systems. Fine-grained, lacustrine and dolomitic sediments dominate in the Lake Eyre Basin and in the paleovalleys of the eastern Eucla Basin margin, whereas fine-grained sediments and valley calcrete deposits are abundant in the western Eucla Basin, Yilgarn Craton and northern Australian paleovalleys. In central Australia it is likely that most paleovalley aquifer horizons are post-Eocene in age.

Post-depositional ferricrete and silcrete can occur in both the older and younger Cenozoic sedimentary phases described above, however calcrete is only known in the younger phase. The Early Oligocene to Late Miocene and perhaps the Pliocene are likely times of silcrete formation (Langford et al., 1995; Drexel and Preiss, 1995). Coarser-grained Eocene fluvial sediments function as important paleovalley aquifers in many parts of arid Australia, and are commonly overlain and confined by the later-formed deposits of fine-grained sediments.

During the Quaternary, aeolian sand sheets and dune fields covered portions of the palaeovalleys at a time when connected exorheic drainage and significant fluvial or lacustrine deposition had ceased. Playas with evaporites developed in many palaeovalleys in response to the evolution of saline groundwaters; these are active landscape elements, which can migrate, and are also sites of significant groundwater discharge characterised by little net sediment accumulation. Ephemeral channels connect some playas, but although these can flow in extreme rainfall events in the modern environment they are also characterised by minimal sediment accumulation.

5.4.1 Sedimentary facies

The basal Eocene paleovalley sediments are fluvial fine- to coarse-grained sands and gravels, generally in the range of 20–40 metres thick. These sandy deposits commonly fine-upwards from basal gravels and may contain carbonaceous material that can grade vertically and laterally into fine grained lignitic facies. Lignite horizons can be 10–20 metres thick and grade laterally to fine grained clastic material. These sediments represent deposition in an aggrading fluvial valley plain with braided river deposits indicated in some areas, such as the Lake Eyre Basin (Callen et al., 1986). Lignites and carbonaceous deposits formed in swamps and valley lakes associated with the fluvial systems.

The finer-grained Late Oligocene to Miocene paleovalley sediments unconformably overlie the Eocene sequence and adjacent deeply weathered bedrock of the valley sides. These sediments include some coarse- and fine-grained fluvial channel clastics but are dominantly very fine-grained vertical accretion valley deposits or lacustrine deposits indicative of less effective discharge than the Eocene river systems. Dolomite and dolomitic clay lacustrine deposits are widespread in the Lake Eyre Basin (including the paleovalleys), and in the paleovalley systems of central Australia and the eastern Eucla Basin margins. These alkaline lake deposits are clastic-poor and dominated by chemical sediments, indicating ineffective discharge – a probable consequence of a more arid climate and reduced gradient due to increased valley-fill thickness.

5.4.2 Secondary deposits and duricrusts

Discussion of deep weathering and associated deposition of chemical sediments formed by secondary weathering, herein generally termed duricrusts, is a major research topic by itself and is only briefly outlined in this review. The secondary duricrust deposits, which are typical of palaeovalleys and the landscape in which they are incised, chiefly consist of ferricrete, silcrete and calcrete. Although there is a good understanding of the nature and expression of these duricrust deposits, widespread uncertainty and disagreement exists about their depositional processes, ages and genetic connotations, particularly for ferricrete and silcrete.

It is likely that the onset of ferricrete formation is pre-Cenozoic and precedes silcrete formation, which probably dominantly occurred in two distinct Cenozoic episodes. In most areas calcrete formation likely represents the final phase of secondary duricrust deposition, and is thought to be related to the onset of arid conditions in the Neogene. However, iron and silica mobilisation has continued, at variable rates, throughout much of the Cenozoic. The stratigraphic relationship between ferricrete, silcrete and calcrete is a complex combination of precipitation, overprinting and replacement processes and events.

Calcrete deposits occur widely in palaeovalleys across the arid zone, particularly in the upper near surface sediments. They are deposited from laterally migrating shallow groundwater, and form as replacements of a variety of sedimentary and regolith materials. They have variable magnesium contents, ranging from calcite to dolomite. Calcrete deposits are typically up to 10 metres thick, although thicker deposits may exist,

Deposition of secondary duricrust deposits can have significant implications for groundwater storage, mobility and composition. Certainly where duricrusts are massive and form interstitial cement in primary materials they may reduce the storage capacity and transmissivity of aquifers and increase the confining capacity of fine-grained sediments in the overlying upper paleovalley sediments. Solution processes result in enhanced porosity and permeability of paleovalley calcrete; such deposits can, accordingly, function as significant paleovalley aquifers, often with much better water quality than occurs in the underlying alluvial facies of the paleovalley aquifers. The latter seems particularly the case where cavities and vughs in karstic calcrete have been silicified (English, 2002).

Paleovalleys in the arid zone are mostly covered by Quaternary aeolian sand deposits, in the form of sand sheets or dune fields. In most regions the sand cover is not sufficiently thick to infill the topographic expression of the palaeodrainage pattern or to mask the trace of individual palaeovalleys. In fact, selective development of dunes in palaeovalley tracts can enhance their visibility as distinct landform features.

This assumption erroneously regarded the playas as relict or defunct landscape elements of the paleovalley fill. The playas are a dynamic and active part of the modern landscape and a product of a new hydrologic regime involving saline palaeovalley groundwater interaction with the landscape surface. Playas are also an important component of the groundwater flow system, being a major site of groundwater discharge from palaeovalley aquifers. This aspect of the playas was evident to some early researchers who recognised that the playas were dynamic landscape elements and that they migrated upwind due to a combination of salt weathering and deflation (Jutson, 1914, 1917, 1918; Blatchford, 1917; Honman, 1914, 1917; Talbot, 1920).

The relationship between playa size and morphology and evaporite formation can be used to explain different patterns of palaeovalley playas. These characteristics and associations can also provide a useful first-pass predictive tool for understanding salinity and groundwater flow characteristics from the pattern of playas in a given palaeovalley. For example, where palaeovalley groundwater flow is relatively effective and extends long distances down-valley, salinity will be relatively low and playas will be few and small. However, there are many mechanisms which can occlude the hydraulic conductivity of paleovalley aquifers such as:

- Aquifer facies changes;
- Deposition of secondary cementing deposits, such as ferricrete, silcrete, and calcrete; and
- Tectonic displacement.

Given the Middle Eocene age for the dominant fluvial sand aquifers in arid zone paleovalleys, there has been ample opportunity for these major processes to occur (either singularly or in combination).

Very large irregular playas occupying paleovalleys imply a significant brine pool salt reservoir due to prolonged evaporative concentration. These are indicative of major long-term occlusion of groundwater throughflow, which implies the long-term influence of a significant tectonic disruption. Lake MacKay and Lake Disappointment are extremely large and irregular paleovalley playas and Beard (2002) has suggested tectonic disruption in the vicinity of Lake Disappointment (but not provided details). Lake MacKay is probably also a closed and internally draining system due to tectonic disruption, but it remains poorly studied or understood.

Groundwater bevelling, whereby the horizontal water table acts as a base level to deflation and salt weathering, commonly forms almost perfectly flat basin-floors in many groundwater playas. This process was first recognised from paleovalley playas in the Yilgarn Craton by Jutson (1917; 1918; 1934). Aeolian deflation from the exposed playa floor can also occur in basins subject to seasonal, or drought-cycle oscillations of groundwater level, where the evolution of groundwater reaches saturation of the controlling salts, mostly halite and some sulfates. Lake-floor clayey sediments are disrupted by efflorescence of salts and deflated by saltation as sand-sized aggregates to the down-wind margin, with construction of characteristic transverse dunes (lunettes). Sub sand sized sediment and salts are also removed from the basin by the same process and transported downwind as dust.

Groundwater playas generally have minimal sediment input and only minor oscillations of groundwater level, resulting in deflation being irregular and of relatively small magnitude. Thus, lunettes tend to be irregular and small but the combination of downwind lunette deposition and upwind groundwater bevelling can cause enlargement or upwind migration of playas.

Paleovalley groundwater characteristics are a result of Quaternary landscape processes and will vary according to Quaternary climatic controls as well as aquifer characteristics, which reflect stratigraphic architecture and post-depositional modification. Thus it is likely that the nature and characteristics of paleovalley groundwater systems will be more regionally variable than the infilling sediment sequences, particularly as calcrete deposits (the most widely variable stratigraphic element) are commonly significant paleovalley aquifers.

5.4.3 Groundwater recharge

The main paleovalley aquifers are the predominantly confined paleochannel sand and gravel facies, which lie in the deepest parts of the infill sequence, and the generally more surficial and unconfined calcrete deposits. However, other locally important aquifers exist, such as post-Eocene unconfined or semi-confined fluvial sediments in central Australian paleovalleys and Cenozoic basins. Direct recharge is generally regarded as minor in the arid zone (Lerner et al., 1990). The Eocene paleochannel aquifers are generally confined laterally and below by weathered bedrock and above by Oligo-Miocene fine-grained and dominantly lacustrine sediments of the paleovalley infill sequence (upper unit). The upper lacustrine unit is generally ubiquitous and covers a wider portion of the paleovalley than the underlying paleochannel facies, thereby preventing direct rainfall recharge of the paleochannel aquifer.

Recharge is likely to be dominated by slow vertical and lateral leakage from surrounding saturated weathered bedrock and the overlying fine-grained upper unit. These, in turn, are recharged directly from rainfall but at very low rates in the modern climate regime. Commander et al. (1992) argued that a number of factors combined to cause generally low recharge rates in the Roe Paleovalley, including:

Low magnitude and intensity of rainfall;
- High E/P (evaporation/precipitation) ratio;
- Relatively thick vegetation cover;
- Clayey soils; and
- Low permeability of both the weathered/fractured bedrock and the upper fine-grained paleovalley unit.

Commander et al. (1994) analysed 36Cl and 14C isotopes from groundwater in the Roe and Rebecca Paleovalley systems and determined chloride residence times >100,000 years and a hydraulic regime of low recharge, continual concentration of salts by playa evaporation, groundwater mixing and circulation between playas and underlying paleochannel sand aquifers.

5.4.4 Groundwater storage

The Eocene paleochannel facies were generally deposited in braided river environments with multiple channels. There were numerous cut and fill episodes and widespread deposition of lignite bearing facies and clay beds in valley lakes and swamps. De Broekert (2002) provided the most complete descriptions of the stratigraphic architecture and facies complexity of these paleovalley sediments. The most deeply incised paleovalley section (which contains the paleochannel facies) is sinuous and its width can vary significantly along-strike. Additionally, paleochannel sediments have been variably modified by post-depositional weathering processes and duricrust formation.

These paleochannel aquifer characteristics reflect the stratigraphic architecture dominated by generally small and irregular individual bedforms, though down-valley connectivity and groundwater transmission between bedforms is generally good. The paleovalley calcrete aquifers have been precipitated from shallow migrating groundwater, and may commonly replace the upper fine-grained paleovalley infill unit. Calcrete characteristics such as mineralogy, thickness, lateral extent, degree of cementation, original porosity and secondary porosity (solution weathering) can be highly variable as they depend on complex chemical reactions between shallow groundwater and the host sediments.

The major source of recharge to the paleochannel aquifer is believed to be derived from lateral slow leakage from less effective aquifers of the underlying and adjacent bedrock and overlying, more widespread upper paleovalley unit.

Very large and irregular paleovalley playas, such as Lake MacKay and Lake Disappointment, clearly indicate a long-term absence of down-valley throughflow and consequent development of a large, hypersaline reflux brine pool. This implies major prolonged tectonic disruption to the down-valley gradient which has been documented for Lake Disappointment (Beard, 2005) but is unresolved for Lake MacKay (Beard, 1973, 2003; Sandiford et al., 2007). In such cases there is no possibility of groundwater throughflow along the former paleovalley without effective reversal of the mechanism of tectonic occlusion. Paleovalleys with common large or elongate playas along their tracts, such as those of the eastern Yilgarn, indicate severely but not completely occluded throughflow. Aquifer blockage is likely to be due to multiple causes, with lithological barriers and structural features particularly important in the Yilgarn.

5.4.5 Groundwater region - Central Australia

The central Australian region here refers to drainage systems both north and south of the upland Central Ranges in the vicinity of Alice Springs. The Central Ranges broadly consist of two distinct geological provinces, based on diverse structural characteristics (Mabbut, 1967). The northern central Ranges are rugged uplands of well-exposed crystalline rocks, mostly gneiss and schist, which represent the southern fringe of the Warumpi Province of the Proterozoic Arunta Block. The region includes the northern MacDonnell Range and the Harts Range. To the south the Central Ranges consist of parallel strike ridges of folded sedimentary rocks within the 170,000 kilometre Proterozoic to Palaeozoic Amadeus Basin.

Prominent ridges are dominated by sandstone and quartzite in the west, and also include limestone in the east. A broader belt of ridges to the south and east forms the Krichauff, James and East MacDonnell Ranges and a narrower, more strongly folded belt forms the West MacDonnell Ranges in the north-west. The two belts enclose the synclinal Missionary Plain. Also included in the study region, are parts of the southern Georgina Basin and the Ngalia Basin, an east-trending intracratonic basin some 80 kilometres north of the Amadeus Basin. Both the southern Georgina Basin and Ngalia Basin mainly contain Neoproterozoic to Palaeozoic sedimentary rocks.

English (2002) provided a detailed description of the Cenozoic evolution and sedimentation history of the contiguous basin-and-range province of the Burt–Lake Lewis–Mount Wedge region of central Australia. In this area a sequence of up to 100 metres of Palaeogene sediments overlies the crystalline basement. These are pyrite-bearing, *grey-green lacustrine clays of probable Eocene age, known as the Mount Wedge Clay*, which infill east-striking depositional troughs north of the West MacDonnell Ranges. Contemporaneous sedimentation occurred north of the Stuart Bluff Range, in Witchetty Basin, in a separate depocentre which was not connected with the evolving Cenozoic basins to the south.

A second major phase of deposition in the Burt–Lake Lewis–Mount Wedge Basins occurred in the Neogene, with the depocentre migrating northwards and becoming more isolated from each other due to intervening basement highs influencing drainage patterns and fluvial–lacustrine sedimentation. Up to 100 metres of sediments deposited in alluvial fan, paleochannel and overbank conditions accumulated in the piedmont zone immediately north of the MacDonnell Ranges during the Miocene and Pleistocene. These sediments were derived from very large, mountainous headwater catchments, with sedimentation enhanced by uplift of the ranges and/or subsidence of the basins to the north (English, 2002). *The reddish Neogene sediments are highly oxidised and heterogeneous and sharply overlie the basal Palaeogene clay. Deposition of the alluvial fan facies was probably coeval (temporally) with down-gradient deposition of lacustrine clay deposits. For example, the Anmatyerre Clay at Lake Lewis*, which is up to 80 metres thick and extends over 3000 kilometres2, commonly infills depressions in the highly irregular basement.

Witchetty Basin to the north also accumulated significant fluvial deposits during the Neogene; drainage systems eventually flowed through gaps in Stuart Bluff Range to feed Lake Lewis to the south (English, 2002). At least nine vertical metres of uniform Anmatyerre Clay was deposited in Lake Lewis over the last 780,000 years, since the Brunhes–Matuyama magnetic polarity reversal. Optically Luminescence (OSL) dating reveals that dune fields formed on the basin >95,000 years ago, and that gypsum-rich aeolian deposits accumulated between 80,000–17,000 ka (English, 2002, English et al., 2001; Chen et al., 1995). Wetter conditions ensued, characterised by floodplain deposition and episodic shallow inundation of the lake during the past 20,000 years (English et al., 2001).

However Bunting et al. (1974) and Van der Graaff et al. (1977) suggested that the Lake Disappointment Paleovalley had captured extensive paleodrainage systems to the south including the Lake Burnside to Lake Wells and Lake Keane paleovalleys, which formerly flowed south to join the Throssel Paleovalley (Figure 4.21). Beard (2002) revisited this question in some detail and determined that the Lake Disappointment Paleovalley includes Lake Burnside and the Lake Keane paleovalley tributary and that the Carnegie system, south of Lake Burnside, has always flowed south and never connected to the Lake Disappointment Paleovalley.

5.5 Wilkinkarra and Kintore Paleovalley investigation (Geoscience Australia)

Geoscience Australia (GA) investigated the Wilkinkarra paleovalley system which has been identified to the east of Lake Mackay and is an incised 10-20 km wide undulating river system created during previous wetter climates of the Early to Mid Cenozoic. The modern valley is defined at surface by extensive calcrete deposits.

Activities included gravity and electromagnetic geophysics drilling and bore installation. They concluded that the paleovalley system terminates in Lake Mackay and is shallowing towards the lake. However, there may be deeper sections within the paleovalleys that are not identified if drilling is not close spaced. GA identified several deep (some >100 m) and narrow parts to the valley separated by bedrock highs. A similar situation is suggested by Toro Energy intersections of 100 m of sands and other sediments 7 km south of the lake. The location of the geophysical and drilling transects is shown in Figure 5.3.

Drilling in the Wilkinkarra paleovalley study involved installation of 13 bores (950 m) intersecting valley sediments between 9 and 127 m thick. Drilling confirmed the presence of a major paleovalley with 20 km wide morphology and multiple channels within the wider primary valley.

Figure 5.4 below shows the interpreted Wilkinkarra paleovalley cross section, with an upper layer of calcrete, underlying units of sandy sediments with internal clay units all overlying weathered basement of the Arunta Region and Ngalia Basin. Calcrete can be an important aquifer, and can be unconfined in places, allowing recharge. A comparison of the different paleovalley segments is presented in Figure 5.5.

The Wilkinkarra and Kintore Paleovalleys aquifer receives modern recharge, mostly from diffuse infiltration – as indicated by GA stable isotope analyses. Karstic characteristics of near surface calcrete may provide preferential infiltration to groundwater. The groundwater flow in the channel is towards Lake Mackay, although the valley floor is higher towards the west (Figure 5.6 - based on the two areas of drilling), decreasing from >100 m to 40 m thickness. Geoscience Australia suggests that Lake Mackay may not always have been the major depocentre of the regional drainage network. Doming of the MacDonnell Ranges in the Late Pliocene may have reversed the drainage direction towards Lake Mackay. Details of the geology around the two drilling traverses are presented in Figure 5.7.

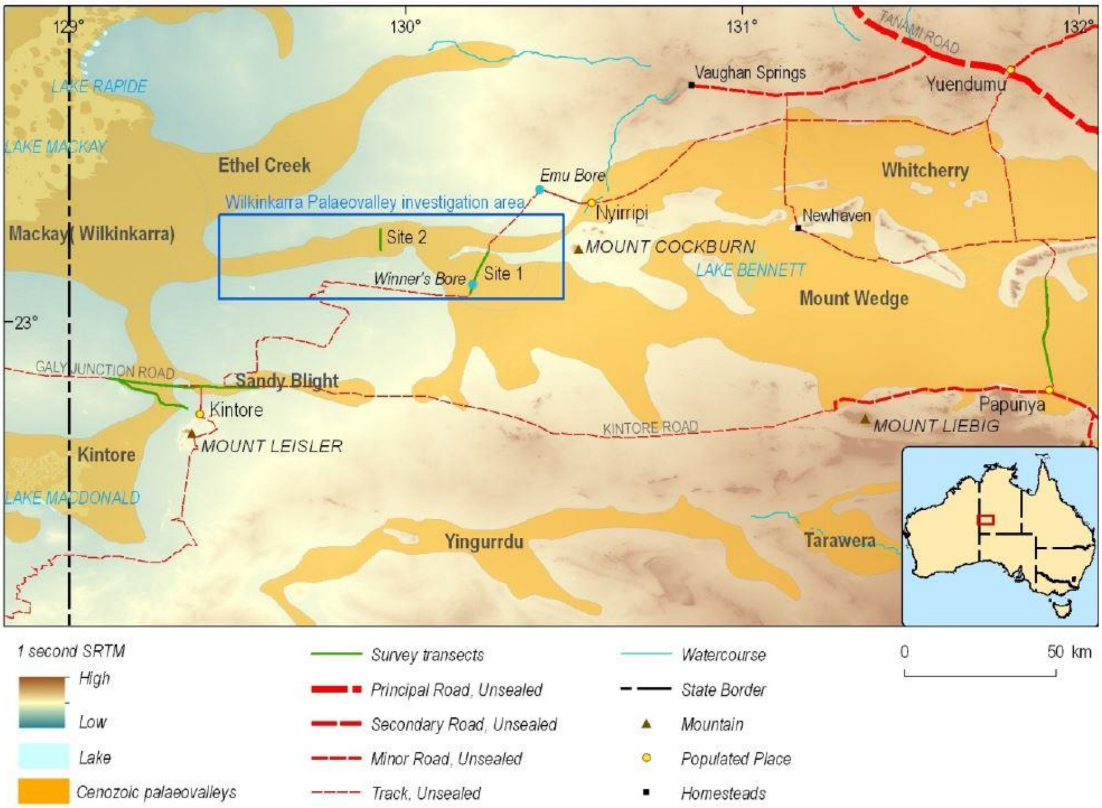
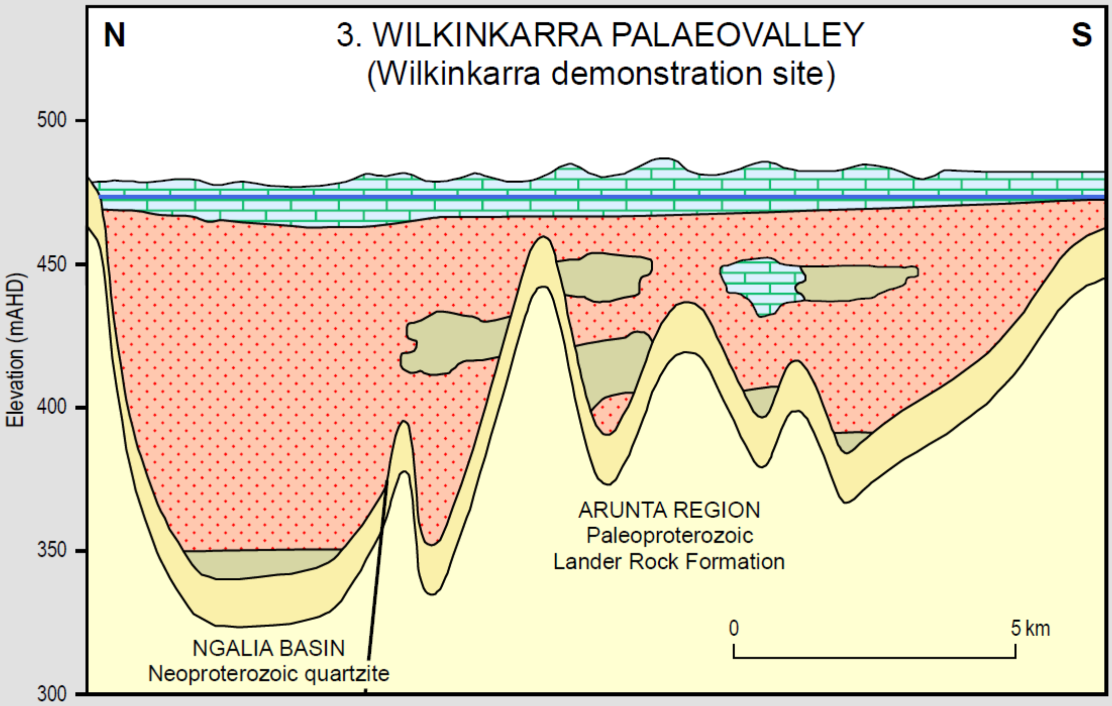


Figure 5.3: Wilkinkarra paleovalley on 1 second elevation data, showing geophysical and drilling east of the lake



The Wilkinkarra Palaeovalley in the central Australian Wilkinkarra demonstration site, Northern Territory. Multiple irregular channels are incised into the underlying bedrock units. The sediment infill sequence is sand-dominated, typical of moderately to highly energetic fluvial deposition. A thin calcrete horizon is extensively developed at the surface. Lithology and structure based on detailed drilling and ground geophysics. Previously unknown fresh groundwater supplies were encountered in palaeovalleys beneath dunefields in the area.

Figure 5.4: Wilkinkarra paleochannel schematic diagram

Additional geophysics and drilling was conducted on the southern interpreted branch of the paleochannel system, west of Kintore. This involved installation of three transects of bores and 5 geophysical transects. The location of bores is shown in Figure 5.8 and cross section 5.9.

The paleochannel sediments are reported to be dominated by quartz sand with variable sorting, interbedded with lesser layers of clay or silt. GA report the sands are partially lithified in places and form sandstone). The sandy sediments are micaceous, reflecting granitic and gneissic provenance. Stratigraphy can be broadly summarized as:

- Thin to negligible red Quaternary Aeolian sand (<0.1 m thick)
- Extensive calcrete 6-12 m thick in the shallow subsurface
- Poorly cemented fine to coarse grained sands which are moderately sorted and mostly consist of subrounded to subangular quartz veins. There is also minor quartz gravel

The entire Wilkinkarra paleovalley sedimentary sequence forms a moderate to good aquifer, with no obvious aquitard layers. Bore yields averaged 5-10 l/s. Drilling of the paleovalley system east of Kintore encountered significant groundwater in the sediments and a water table that was typically 4-7 m below surface. GA report that in the thickest part of the sequence pumping bore yields were commonly in the range 8-20 l/s, so the paleochannel sediments produce significant flows. The sequence is not reported to contain significant confining layers. Recharge is interpreted to occur in the southern part of the Site 1 transect.

The paleovalley aquifer near Kintore contains abundant fresh water, with TDS of 360-720 mg/l near the Kintore range and increase in TDS to the north (reaching ~5500 mg/l). The groundwater discovered in drilling west of Kintore is potable but contains elevated nitrate concentrations.

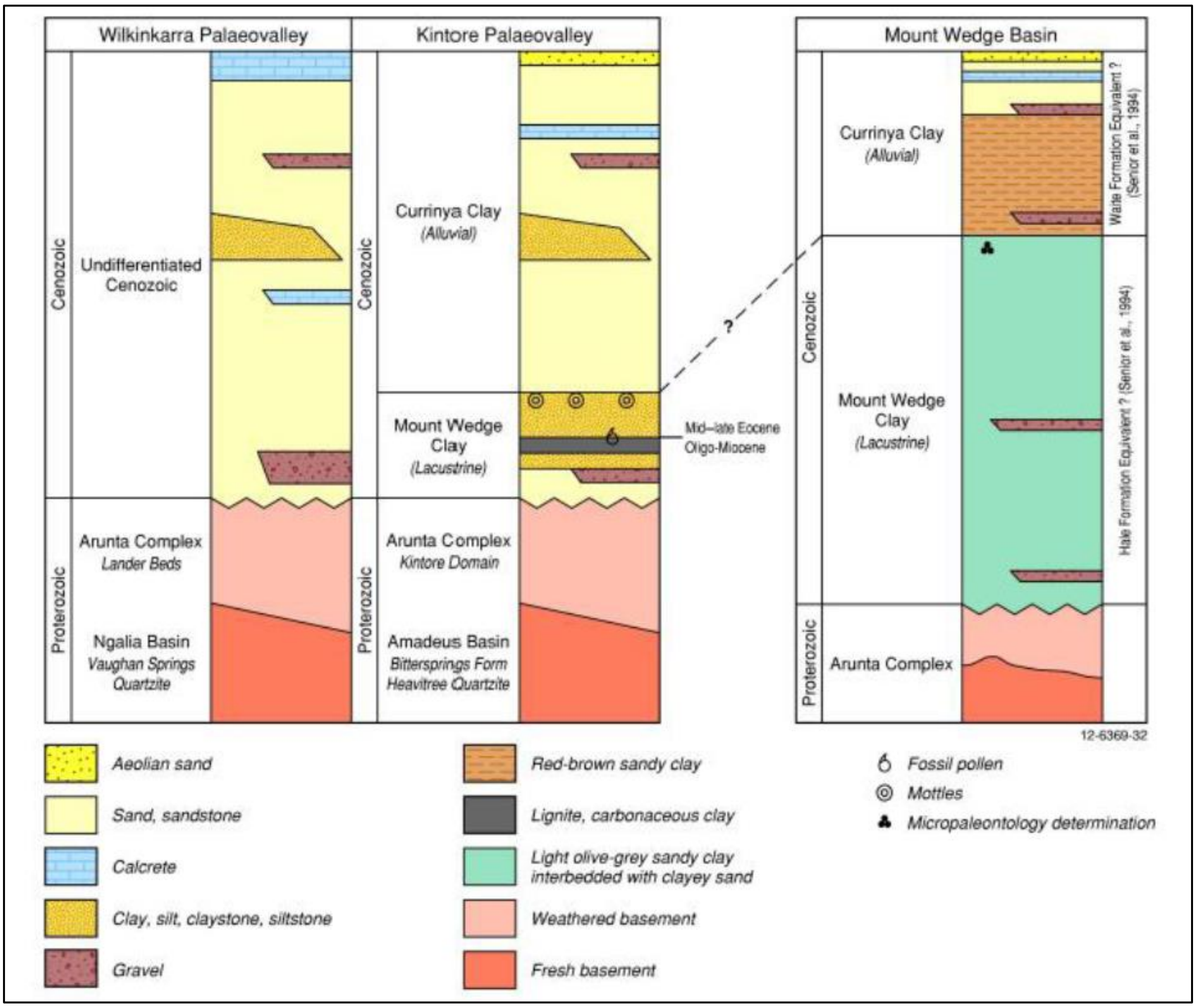


Figure 5.5: Stratagraphic correlation chart between different paleovalleys

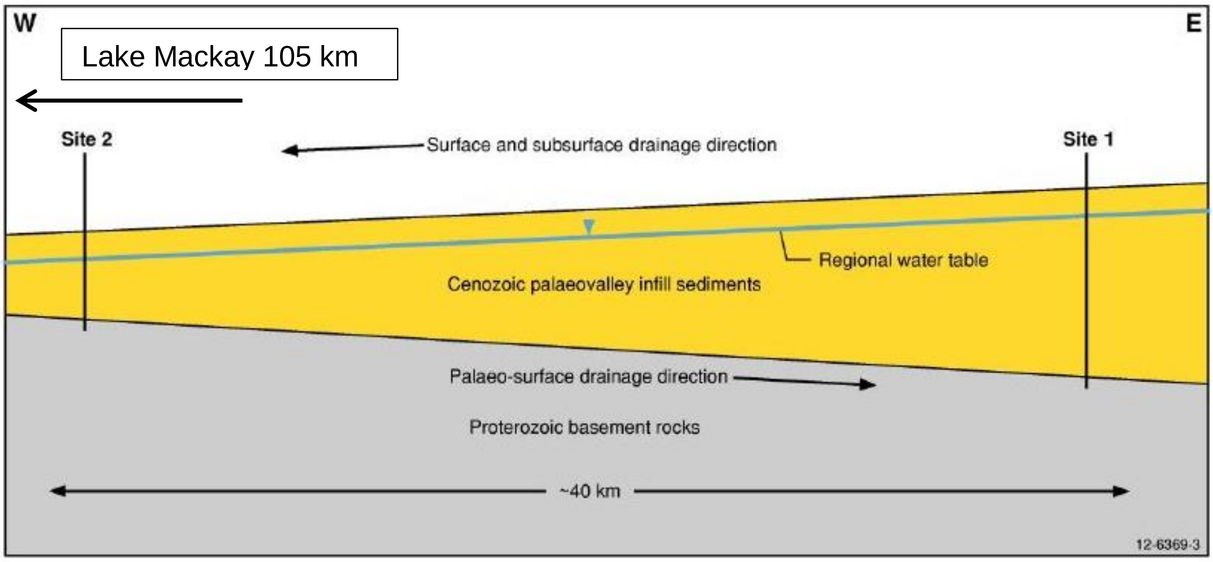


Figure 5.6: Schematic cross section looking north through the Wilkinkarra paleovalley

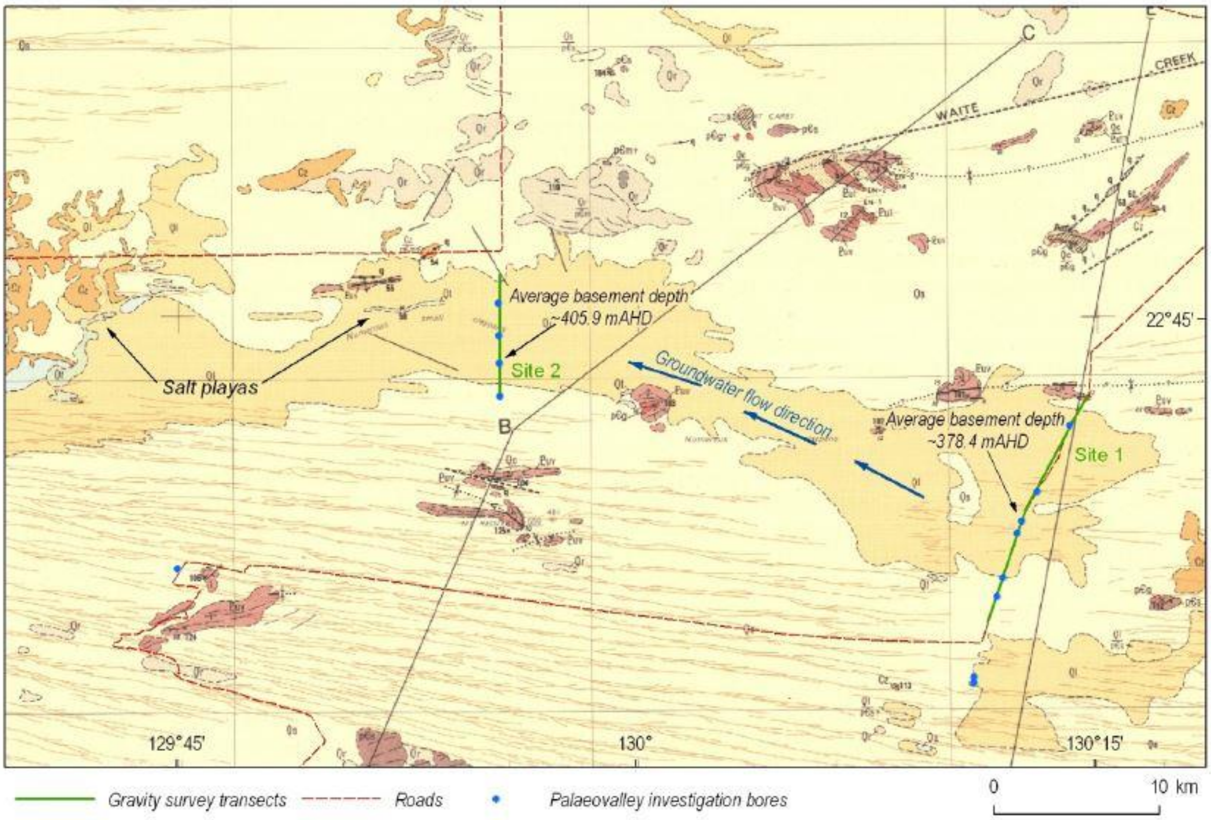


Figure 5.7: Basement geology of the Wilkinkarra paleovalley, with saline playas interpreted to become more common towards the west

GA (2012) note that Domahindy (1990) noted in the Wiluna area of WA that rainfall of >50 mm in 48 hours is required to induce general runoff. Domahindy (1990) calculated a recharge rate of 4.5 mm/year over the Tanami study area. Cresswell et al., (1999) derived more conservative recharge estimates based on C14 and Cl36 isotope ages for groundwater in a paleodrainage tributary of Lake Mackay. They estimated <<1mm/year, with the Cl36 results showing a bimodal pattern with modern recharge around the margins of the basin and most groundwater 80-100,000 years old – implying the last major recharge period was during the previous interglacial period. On this basis there are substantial periods (i.e. 80-100,000 years) where no recharge has occurred, demonstrating that extraction of groundwater exploits a non-renewable resource.

Paleovalley development in WA in the Yilgarn is interpreted to be primarily related to epeirogenic uplift in the mid Eocene. There was also contributions via a fall in the eustatic sea level and a change in climate around the Early/Middle Eocene boundary. Climate indirectly assisted paleovalley development by promoting deep weathering of the Precambrian bedrock within the primary valleys (De Broekert and Sandiford, 2005; Buried Inset Valleys in the Eastern Yilgarn Craton).

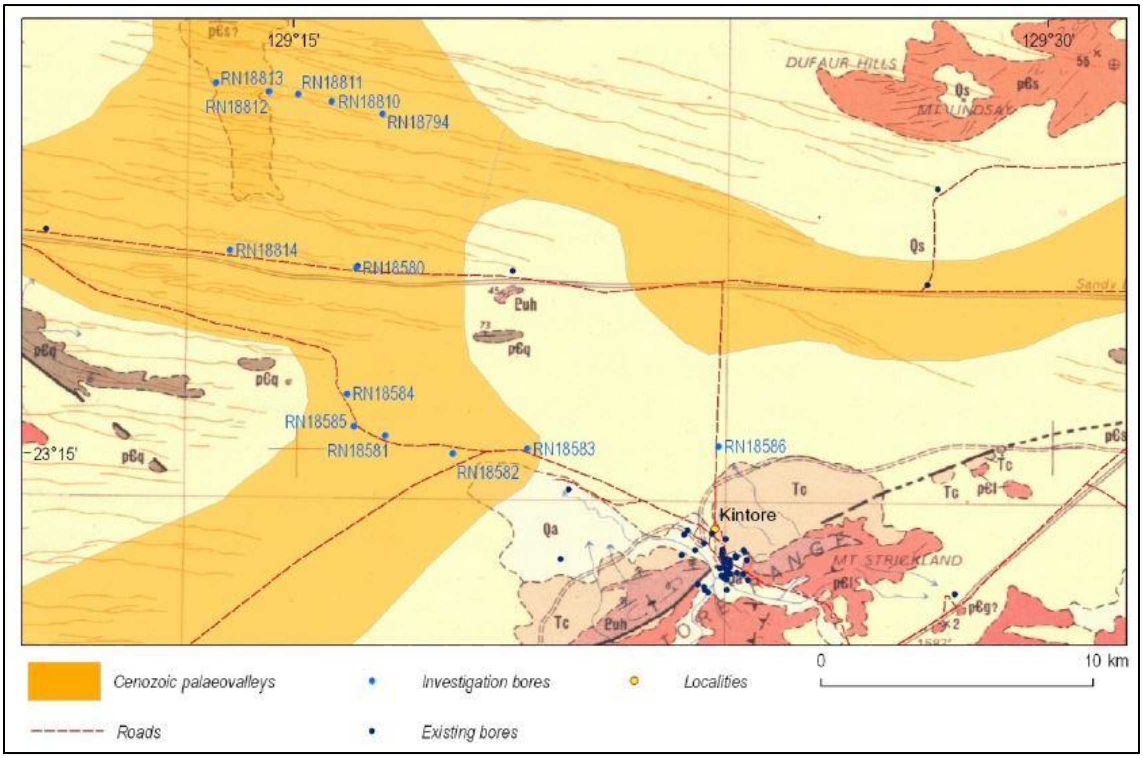


Figure 5.8: Location of bores drilled in the Kintore branch of the paleovalley on the Mount Rennie 1:250,000 map

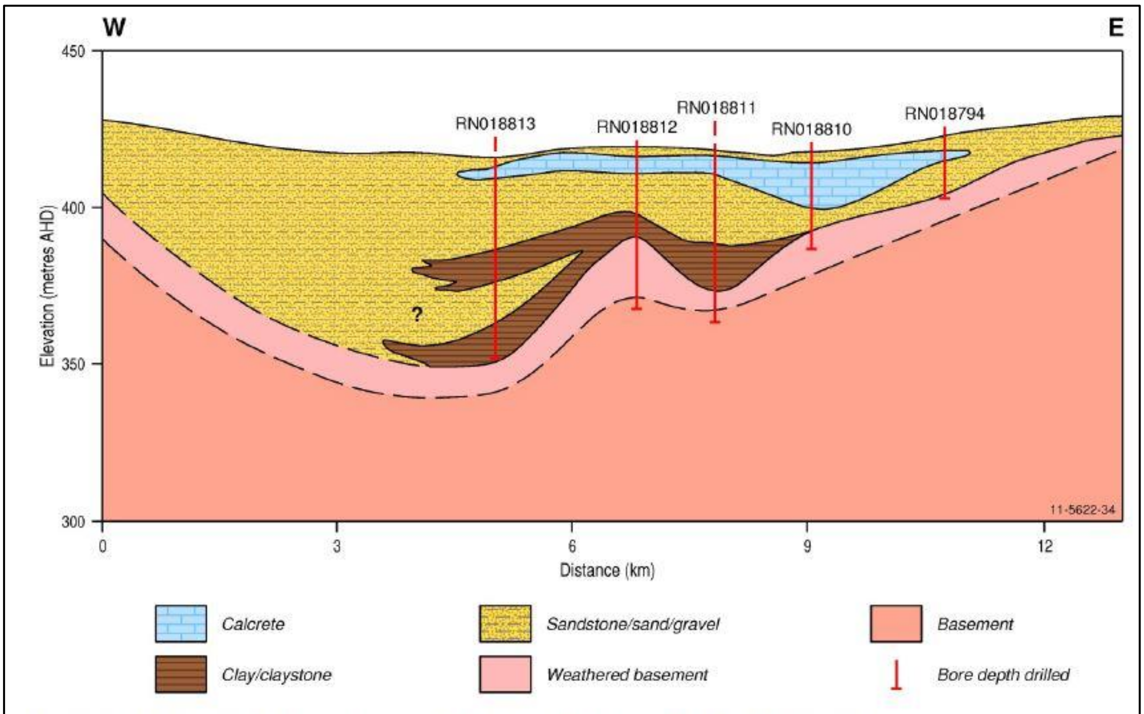


Figure 4.24: Geological cross-section of the Kintore Palaeovalley for Transect 3.

Figure 5.9: Cross section through the northern Kintore transect, showing the generalised distribution of units in the paleochannel

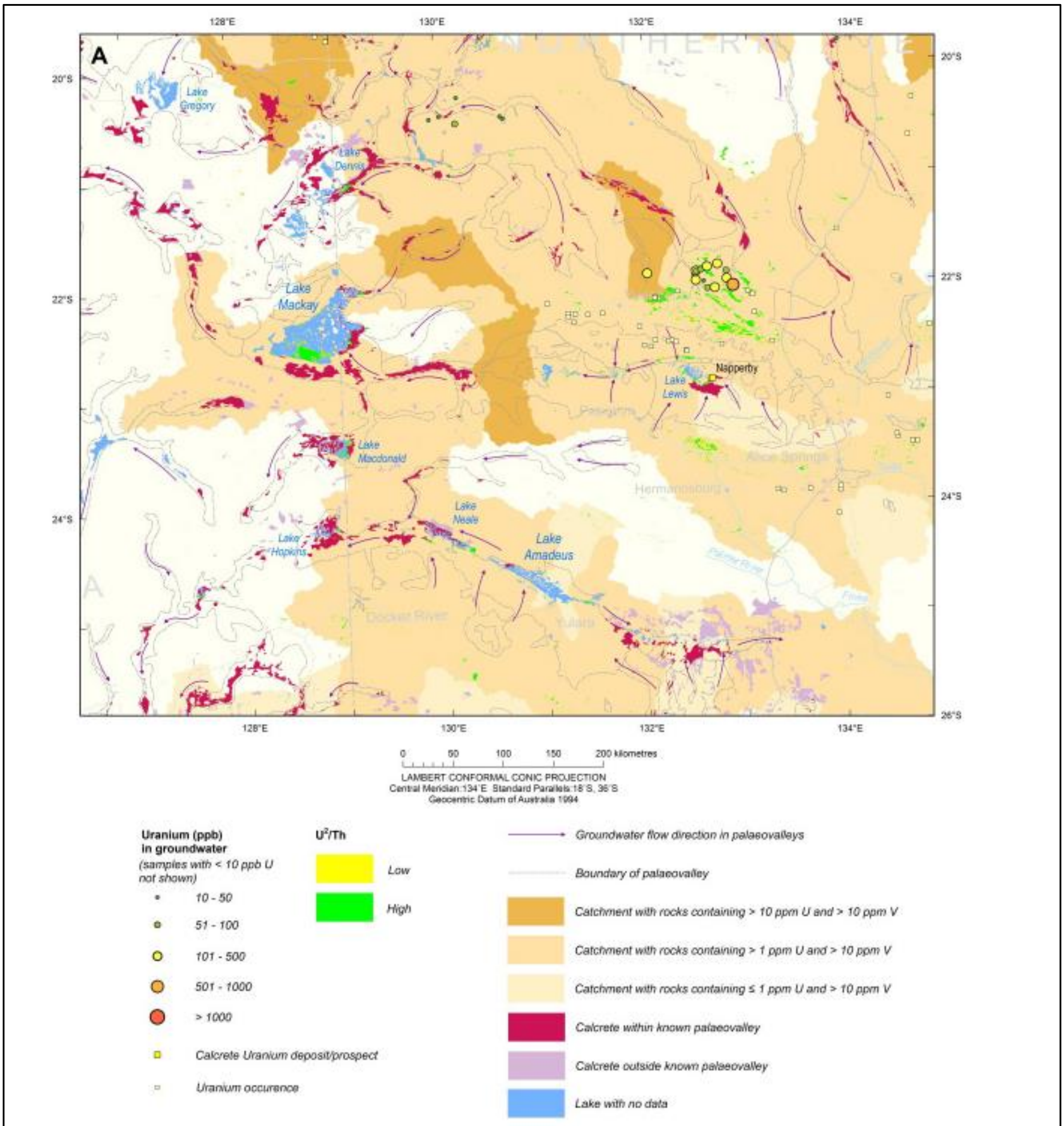


Figure 5.39 (Inset A, Map 4, Appendix B). Map of lake systems in Arunta region. The lake systems host a few valley- and playa-type calcrete-hosted uranium deposits and prospects. Note the spatial correlation between high U^2/Th values and palaeovalleys hosting uranium deposits and prospects.

Figure 5.10: Distribution of calcretes in the vicinity of Lake Mackay

6 GEOLOGY AND GEOMORPHOLOGY

6.1 Regional geology – Lake Mackay area

A suite of Paleoproterozoic intrusives and metamorphic rocks is identified to the southeast of Lake Mackay in mapping presented in the Wilkinkarra Paleovalley Aquifer Report (Woodgate et. al, 2012/09). In the area in general there is very little outcrop (Figure 6.1), with a predominance of dunes, alluvium and lesser areas of ferruginous duricrust and calcrete recorded in regional mapping.

Geoscience Australia (2012 Salt lake review) note that Lake Mackay, lies in the western parts of the Paleoproterozoic Arunta complex and Neoproterozoic Amadeus and Ngalia basins. The Proterozoic Bitter Springs Formation of the Amadeus Basin basal sequence crops out to the immediate south west of Lake Mackay (Webb 1:250,000 geology map sheet), and may occur at shallow depth elsewhere beneath dunes of the Great Sandy Desert.

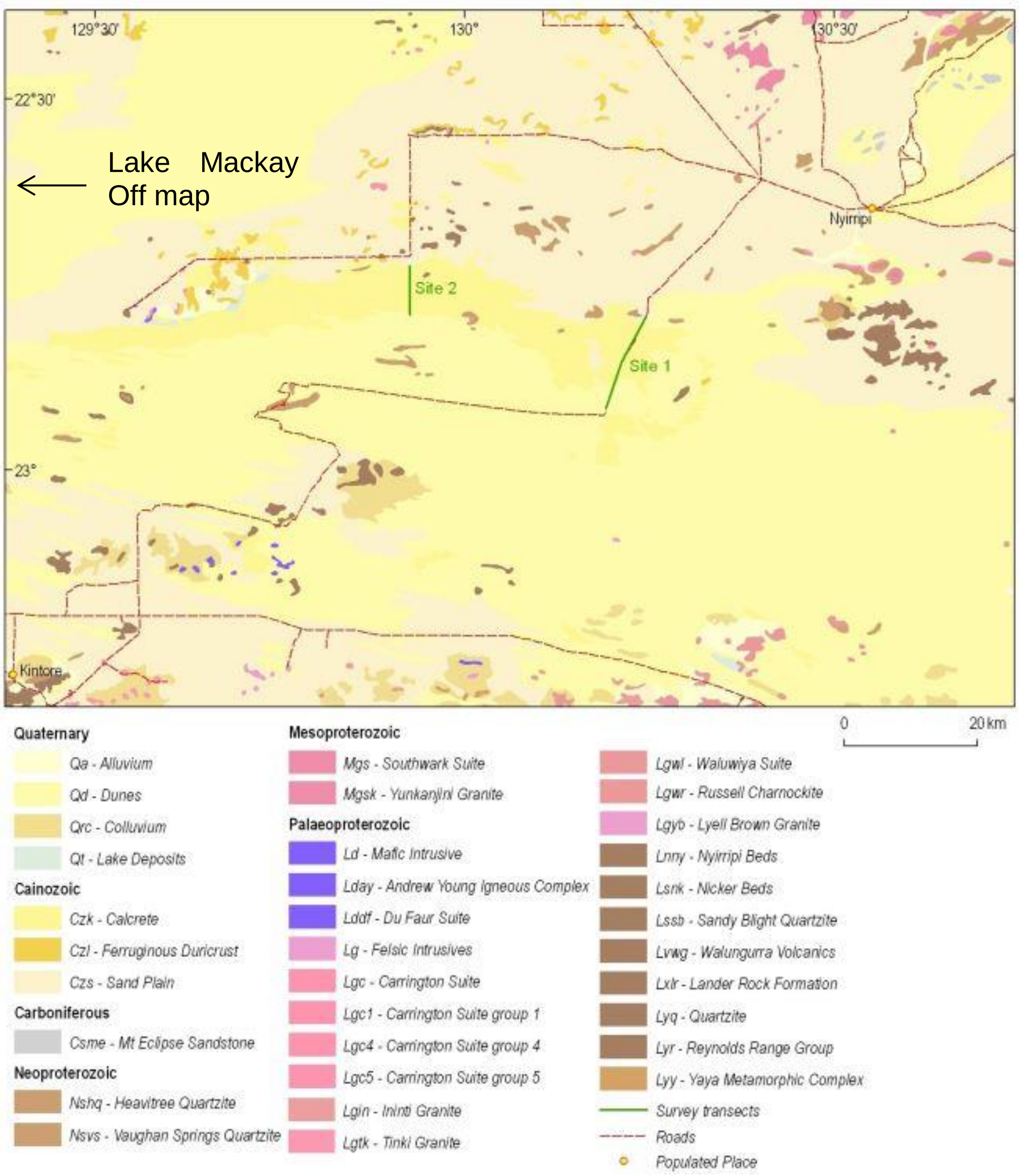


Figure 6.1: The 1:250,000 geology around the Wilkinkarra paleovalley east of Lake Mackay

6.2 Central Australia – origin of salts

There has been a suggestion of salt recycling from the Proterozoic Bitter Springs Formation in the Amadeus Basin to contribute the salts accumulated in Lake Mackay and other Central Australian salt lakes. Paleovalley reconstruction by Bell et al. (2012) and described in English et al. (2012) suggests Lake Mackay, (Figure 2.1 and Figure 2.14) may represent an ancient salt lake basin composed of Bitter Springs Formation evaporites (Gillen Member in particular). These authors proposed that a former diapir rose to the landscape surface where it dissolved and created a hydrologically-closed depression in which a large Cenozoic salt lake developed. A diaper origin for the lake basins at Lake Mackay, Disappointment and Wells is suggested by GA in the 2012 Review of Salt Lakes.

The GA Salt Lake Review (2012) suggests a salt lake was not present at Lake Mackay during the last glacial maximum of 12-20 ka. The basis for this suggestion is unclear and might correspond to the surficial gypsum island building phase – but the underlying slow accumulating lacustrine clays suggests to this author that there has been lake sedimentation here for at least 1Ma, comparing information from drilling with other Central Australian salt lakes.

Drilling by Agrimin and Rum Jungle at Lake Mackay and by Reward Minerals at Lake Disappointment has not intersected any remnants of salt diapirs. Further, it is observed that there is a similar range of potassium and other major elements noted in a number of Central and Western Australian salt lakes (concentrations of 3000 to 5500 mg/l potassium) under investigation. This suggests that a contribution from ancient evaporites is not necessary, and these Central Australian salt lakes evolve to have similar major ion concentrations from a variety of bedrock salt sources.

6.3 Salt lake geomorphology

In the classification of Houston et al., 2011 Lake Mackay would be classified as an immature salar, dominated by clastic sediments, with limited thicknesses of halite. Lake Mackay and the surrounding area contains a diverse range of different landform types that may display a relationship to the subsurface geology. The porosity and permeability is highly variable, due to differences between sand and clay units.

Lake Mackay does not appear to contain a basal coarse sediment layer, but instead has a coarse grained upper gypsum sand unit (which also appears to be present in other Central Australian lakes). The lake does also not have an internal halite nucleus, surrounded by marginal deposits of carbonate and sulphate, instead sulphate is the dominant facies. Carbonate is however reported in extensive calcretes mapped by satellite imagery in are area surrounding the lake and in paleochannels flowing towards the lake.

Australian salt lakes rarely show the classic bullseye pattern of evaporite deposits, with concentric distribution of increasingly soluble salts towards the centre of the lake (e.g. Rosen et al., 1991). These tend to occur in small coastal salt lakes such as those described by Warren (1982). Instead, Australian inland salt lakes are floored by sulfate-rich muds, a central zone with an ephemeral surface halite crust may be present in some lakes, but this often dissolves when the lakes are fully inundated (e.g. Clarke, 1994b; Macumber, 1992; Jacobson et al., 1989; Draper and Jensen, 1976). Lake Eyre is the only Australian salt lake known to have a permanent buried halite layer (Johns and Ludbrook, 1963; Magee et al., 1995). Evaporitic minerals deposited in these lakes are predominantly gypsum and halite, with alunite [$KAl_3(SO_4)_2(OH)_6$] and jarosite [$KFe_3(SO_4)_2(OH)_6$] in the more acidic lakes (Section 2.5.4) and minor carbonate in those that are more alkaline (Macumber, 1992; Bowler, 1986a; De Deckker, 1983).

Investigation of Australian salt lakes by Bowler (i.e. Bowler, 1981) considered the relationship betweek the catchment and lake areas and climatic parameters that influence what sort of salt lake develops. This presented the concept of surface water and groundwater dominated lakes (Figure 6.2). Salt lakes at the groundwater-dominant end of Bowler's classification are characterised by irregular shorelines, common residual islands and low irregular lunettes on the downwind margin. These plays lack smooth constructional shoreline deposits and are dominated by groundwater discharge and outcrop. The water table is considered to act as a base level for deflation of sediments and salt weathering. Lake floor sediments are disrupted by efflorescence of salts and deflated by saltation of sand-sized agregates in the downwind direction. This constructs traverse dunes (lunettes). Both Lake Mackay and Lake Disappointment have these characteristics, with archepelagos of islands formed in the east of each lake, with a more homogeneous western surface.

Geoscience Australia (GA) note in their review of Australian Salt Lakes that thick Cenozoic palaeolacustrine clays commonly underlie Australian Quaternary salt lakes that have a lacustrine, rather than a fluvial, origin. These extensive Australian salt lake systems have evolved from full, commonly overflowing, lakes to terminal lakes with no outlets, to dry terminal lakes, to groundwater lakes in which surface water is rare. These salt lakes fundamentally function as hydrologically closed entities that are dominated by groundwater discharge, regardless of where or whether there is a regional groundwater flow component within the basin.

GA (2012) note that lunette dunes on downwind shorelines are characteristic of all four geomorphic lake categories, and Australian arid-zone lakes are very commonly referred to as lunette lakes because of the almost universal occurrence of lunettes. The lunette facies and lithology depends on the sedimentary conditions in the lake. Quartz-rich lunettes containing abundant biogenic carbonates occur when surface water dominates as lunettes are derived from beach foredunes. As hydrological budgets become more negative and saline groundwater dominates, lunettes become clay- and gypsum-rich (Bowler, 1973, 1983; Magee, 1991).

GA note that salt lake deltas have been described for Lake Buchanan, Queensland, by Wakelin-King (1984), and at Lake Lewis, Northern Territory, by English (2002). Lake deltas are distinctive sedimentary and hydrological environments, not only in perennial lakes, where a mix of fluvial and lacustrine processes prevail, but especially when lakes become ephemeral and contract during arid periods when new deltas form on the surface of exposed former lake beds. Delta morphologies change in response to differing regimes.

Geomorphological features that may include strandlines from former high-lake stands, terraces, spits, lagoons, islands of gypsiferous aeolian landforms, playa-fringing dunes and encroaching linear sand dunes may be indicative of such changes. These features may be combined with the impact of sporadic high magnitude run-off events that typify desert hydrological processes and the influence of the build-up of calcrete bodies around a playa. The complexity is exacerbated when contracted lakes become saline and incoming fresh fluvial waters intermix with shallow brines in the delta setting, promoting intense physical and chemical responses and reactions.

At Lake Tyrrell in South Australia deposits are up to five metres thick and consist of clay, silt and sand and are covered by an ephemeral halite-gypsum crust (30–60 centimetres thick). The sediments show a cyclic pattern that reflects alternating periods of wet and dry conditions. Radiocarbon analyses (Bray et al., 2012) indicate that the sediments are about 7500 years old. Decaying algal mats occur locally on the lake floor causing reducing conditions and creating a build-up of sulfide minerals (Long et al., 2009).

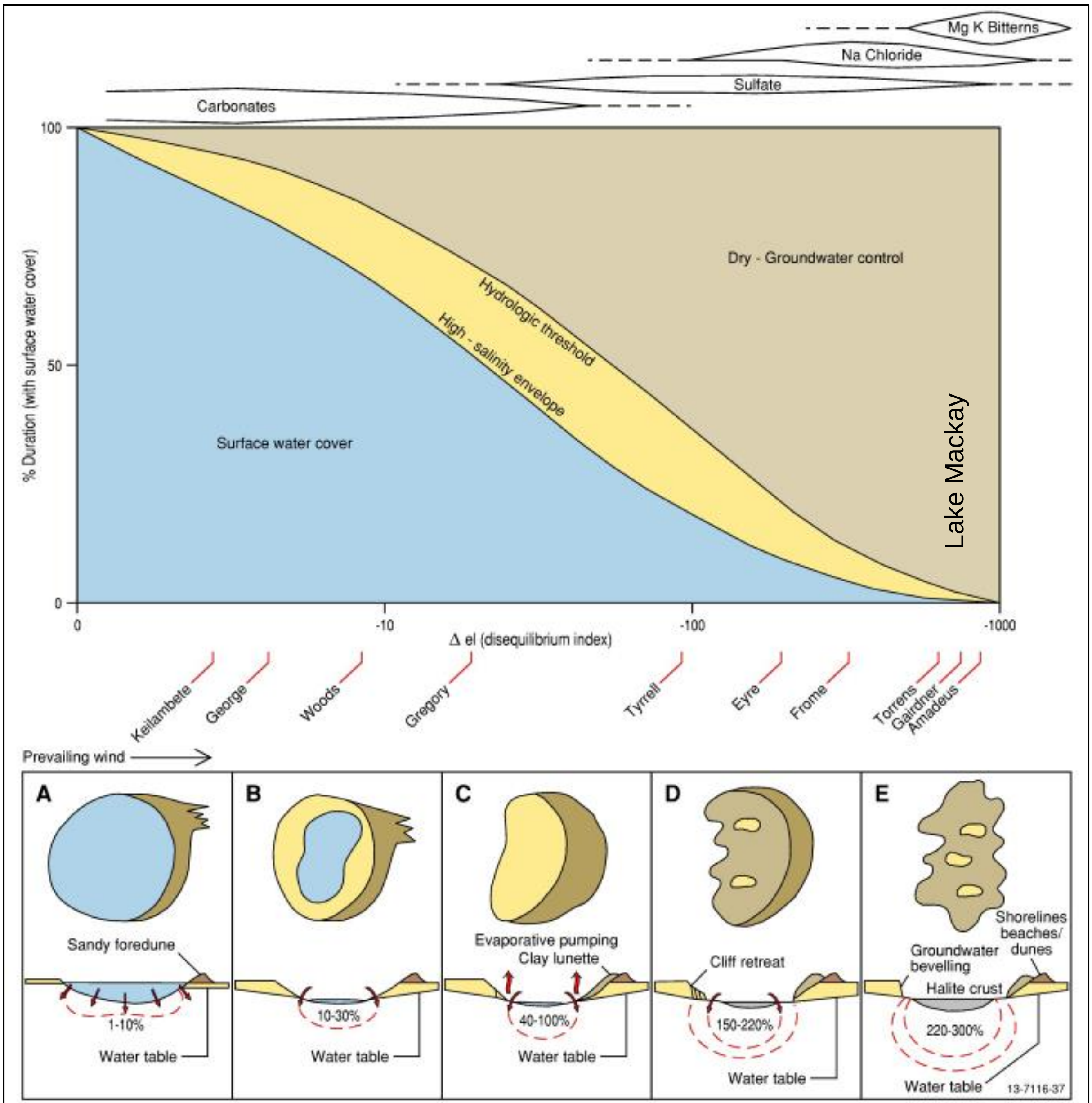


Figure 2.5 Classification of Australian lake/playa basins across a climatic gradient which extends from humid to arid conditions. Five lake/playa basin types, A to E, are differentiated by morphological and sedimentological features, which reflect successive stages in a hydrological series from surface-water to groundwater dominated systems including the evolution of a sub-playa brine pool. Figure is modified from Figures 2 and 5 of Bowler (1986a). Lake George, NSW, near Canberra, ACT, and Lake Kielembete, western Victoria, both located in the humid climate zone, are endorheic lakes, i.e., closd basins with no outflow.

Figure 6.2: Classification of Australian playa lakes after Bowler (1986)

6.4 Lake Amadeus geomorphic map and observations

Lake Amadeus is probably the most well studied of the Central Australian playa lakes, having been investigated by a number of workers including Jacobson et. al., (1988); Jankowski and Jacobson (1989), Chen and Barton, 1991, and Chen et. al., (1991a and b). This lake is located in the Central Australian Discharge Zone, between the McDonnell Ranges and the range to the south – where Ayers Rock is located. These authors note that the Central Australian playa lakes are dominated by groundwater discharge and have distinct morphology and facies development.

Distinct features of the lake (some referred to in Figure 6.3) are:

- Gypsum islands with dunes up to 10 m high. Dunes are mostly gypsiferous, covered by quartz sand mantles. Dunes are parallel to the island margins.
- Along much of the playa margin a terrace several to several hundred metres long exists between the gypsum dunes and the playa. This is flat and 20-100 cm above the playa floor. It is often colonized by salt resistant shrubs and grasses.
- Salt flat covers the majority of the playa, with about 1 cm of efflorescent halite crust
- Gypsum ground – composed of friable to compact gypsum in central areas of the playa.
- Sulphidic lowlands are characterized by lower relief and a black sulphide stained layer up to 3 cm thick at surface.

These features are observed at Lake Mackay, suggesting the same processes have generated these features in both lakes. They are discussed in the following sections.

Gypsum Ground

Gypsum Ground (Figure 6.3, 6.4) is described as a broad region within the centre of the playa, with a 2-5 cm thick brittle crust and irregular surface with broader crests and troughs up to 10 m across, with relief of 15-20 cm (Figure 6.5). This pattern of relief has a distinct pattern of parallel ridges. Chen et. al. (1991b) note the texture resembles gilgai microrelief (Figure 6.4), a characteristic of expanding soils in Northern Australia associated with reactive clays. Chen et al suggest that evidence of surface water is restricted to the salt flat and sulphidic lowlands, with the higher elevation of the gypsum ground limiting seasonal inundation to its margins only.

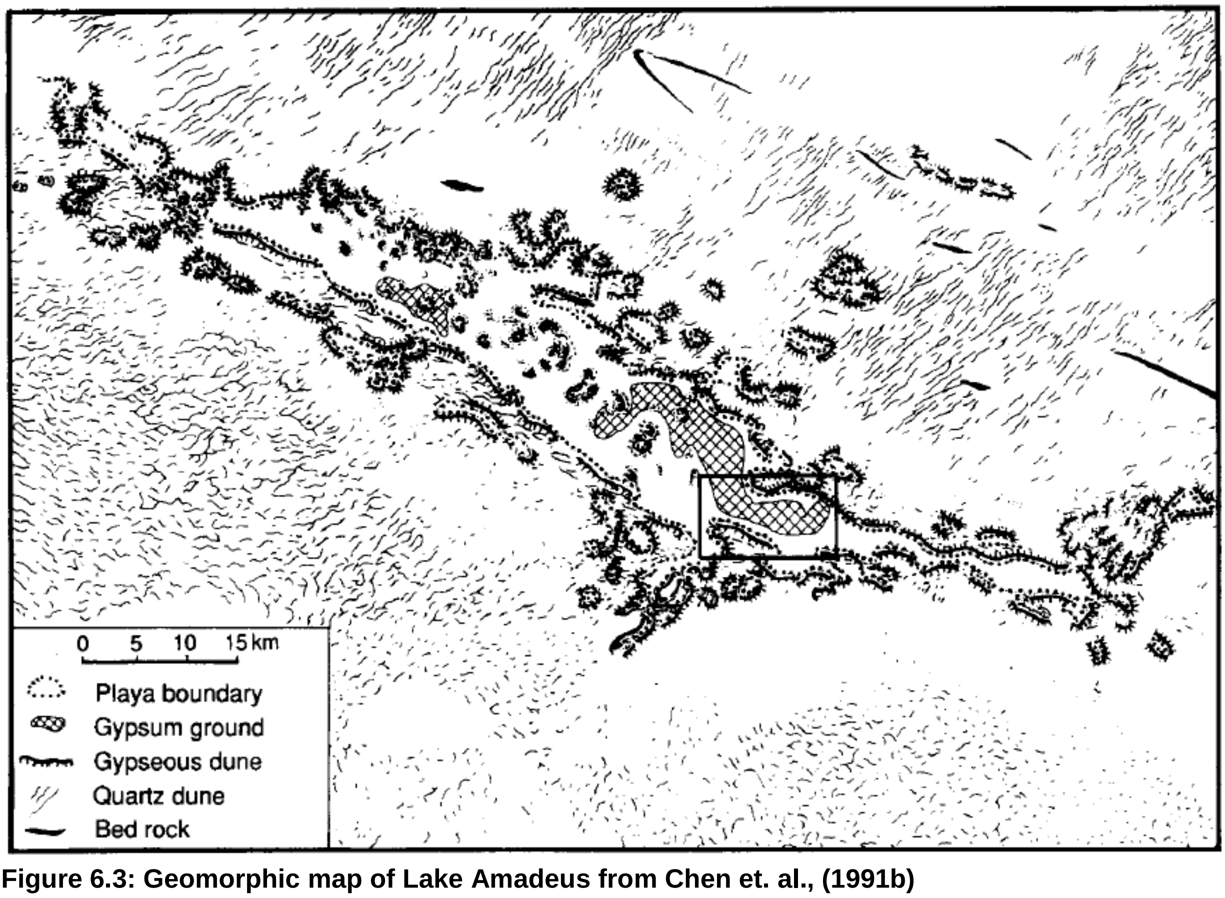


Figure 6.3: Geomorphic map of Lake Amadeus from Chen et. al., (1991b)

The Gypsum Ground is described as having a rough consistency and being hard and brown when dry and 50-70 cm thick. Some NaCl is present in voids. The contact with the underlying sediments is often flat. Analysis by Chen et., al., determined the ground is 38-56% gypsum and 40-50% halite and Epsomite ($MgSO_4.7H_2O$). Clastic content was recorded to be 6-20%, consisting of quartz, kaolinite, illite and minor magnetite.

Fig. 6. Gypsum ground, gilgai-like surface features with undulating micro-relief, and a preferential concentration of efflorescent white salts appearing in the troughs. The trench is shown in more detail in Fig. 10.

Figure 6.4: Gypsum Ground gilgai-like surface features with undulations and minor efflorescent salt

Oblique aerial photograph showing the marginal terrace (*T*), the terrace islands (*TI*), and the patterns of micro-ridges and troughs in the gypsum ground. (The approximate scale is along the transect.)

Figure 6.5: Photograph showing Gypsum Ground with channels through Lake Amadeus

These authors note an indistinct boundary between an upper (A) and lower (B) part of ths unit (Figure 6.6). The upper part has sublayers several cm thick of relatively pure sand-sized gypsum crystals, intercalated with <1 cm thick bands of red-brown clayey sand. The bands are approximately horizontal and laterally dicontinuous such that they sometimes merge. The lower part is grey-brown gypsum and sandy clay around 20 cm thick and often below the water table.

The moisture content increases to around 20% around the water table, with the dry bulk density increasing from 0.91 g/cc to 1.2 g/cc near the water table, as the sediment becomes more compact. This compares to a density for solid gypsum of 2.3 g/cc. The low densities of the granular gypsum reflect the very high porosity of this material.

Underlying the Gypsum Ground is a 1-3 cm fine grey quartz sand, extending throughout the playa. Underlying this there is a red sand layer with bioturbation that represents partial soil development throughout the playa and is texturally similar to a regional dune sand. The authors interpret this as an aeolian sand sheet deposited during a very low watertable in the last glacial maximum (25-15k). This suggests that 0.5-0.7 m of gypsum sand has accumulated following this period.

Grain size analysis showed that the gypsum crystals became coarser with depth, to ~2 mm near the water table. The clastic material in the gypsum ground was predominantly sand, with a lesser amount of clay.

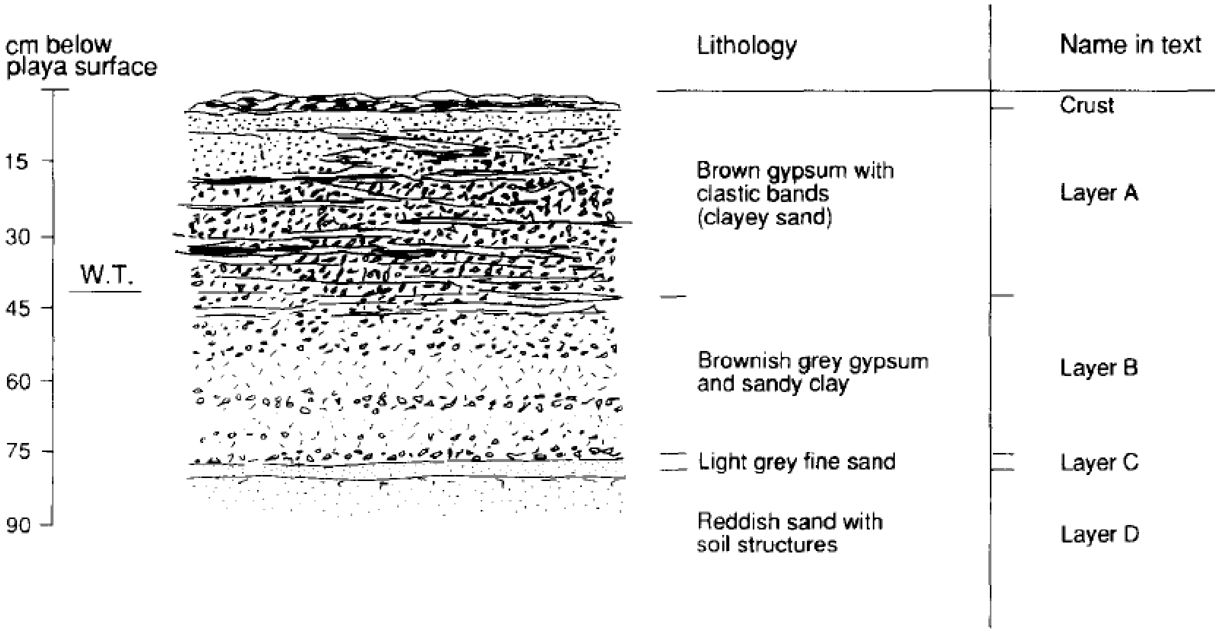


Fig. 9. Near-surface stratigraphy of the gypsum ground, showing division of upper and lower parts.

Figure 6.6: Stratigraphy of the Gypsum Ground described by Chen et. al., (1991b)

A cross section from the study by Jacobson in 1988 shows the stratigraphy in different parts of Lake Amadeus from shallow drill holes (Figure 6.7). Jacobson notes that groundwater modelling of the area suggests grooundwater flows towards Lake Amadeus through the sediments, with a small amount of flow from fractures in the underlying Proterozoic basement which discharge as springs in the lake bed. A similar situation could be expected at Lake Mackay, although the catchment lacks the topography of the Petermann and George Gill ranges.

Recharge study and groundwater density

During field evaluation by Chen et. al., there were a number of rain events and the results of this recharge were observed. The water table was noted to responde immediately to the

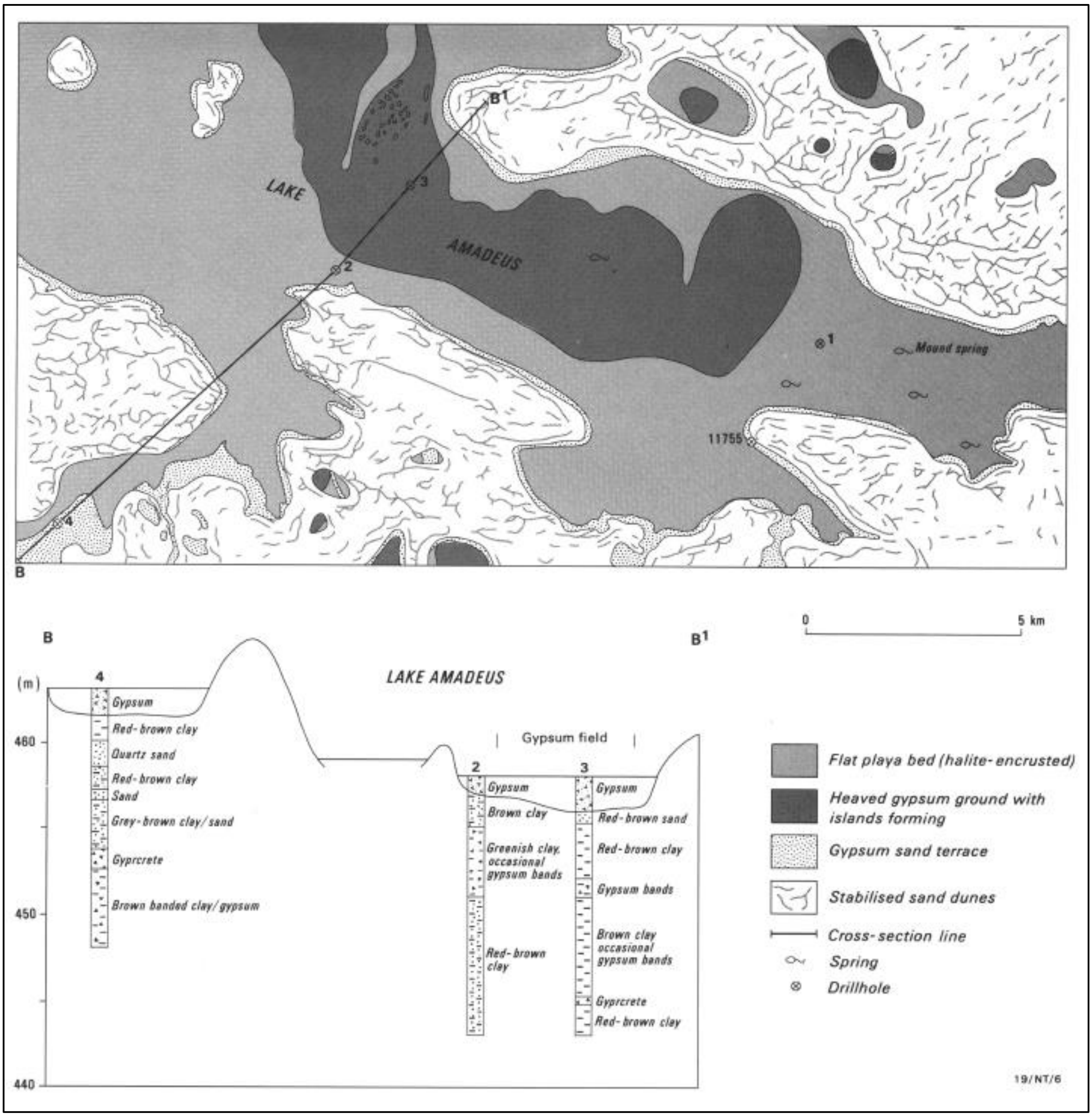


Figure 6.7: Cross section through central Lake Amadeus

rainfall, with a rapid decline that slowed over time. These authors show that the water table under the gypsum ground was less responsive to change than under the playa or sulphidic zone (Figures 6.8 to 6.9). This may reflect the lower moisture content and high porosity of this material above the water table, absorbing the rainfall withough significant rise of the water table. The clayey sediments have much higher moisture content and lower porosity (compared to the super-porous gypsum), so this may explain the different response.

Chen et. al., note that the brine density in the gypsum ground is lower than measured in the salt flat and sulphidic lowlands (Figure 6.10), a comparable figure by Jacobson (1988) is shown in Figure 6.11.

- Gypsum ground 1.13-1.16 g/cc (with the isodensity line of 1.16 corresponding with that of the Gypsum Ground). Jacobsen (1988) noted densities of 1.12-1.13 g/cc.
- Salt flat and sulphidic lowland 1.18 to 1.23 g/cc. Jacobson (1988) noted densities of 1.18-1.19 in these areas.

These authors installed six sets of nested piezometers to different depths below the playa surface. In the Gypsum Ground density increased down hole from 1.136 to 1.155 g/cc over a depth of 10 m. They suggest that because the material is very porous capillary action is less effective in driving evaporation in this material compared to finer grained lithologies. This results in lower net evaporation (total evaporation minus rainfall and input surface water) in the gypsum ground.

A total of 83 samples wer analysed from across the playa. Calcium concentration decreases with > TDS

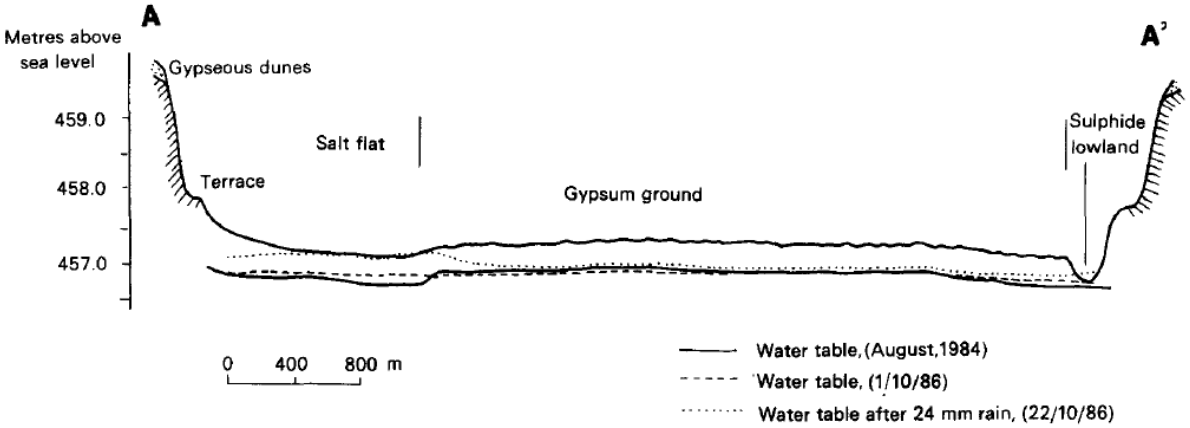


Figure 6.8: Profile corresponding to photograph in Figure 6.5, with water table changing after rain events

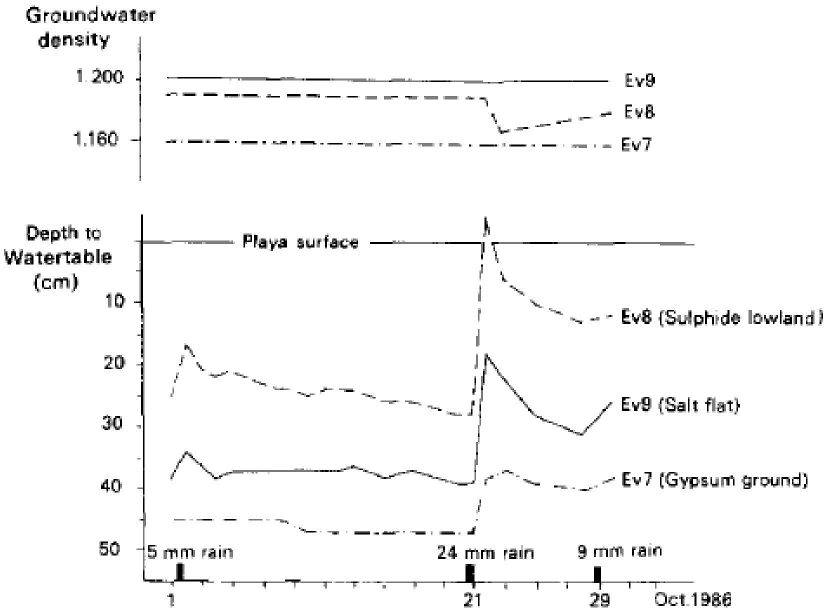


Figure 6.9: Variation in the water table and groundwater density at three measurement sites with different surface morphologies

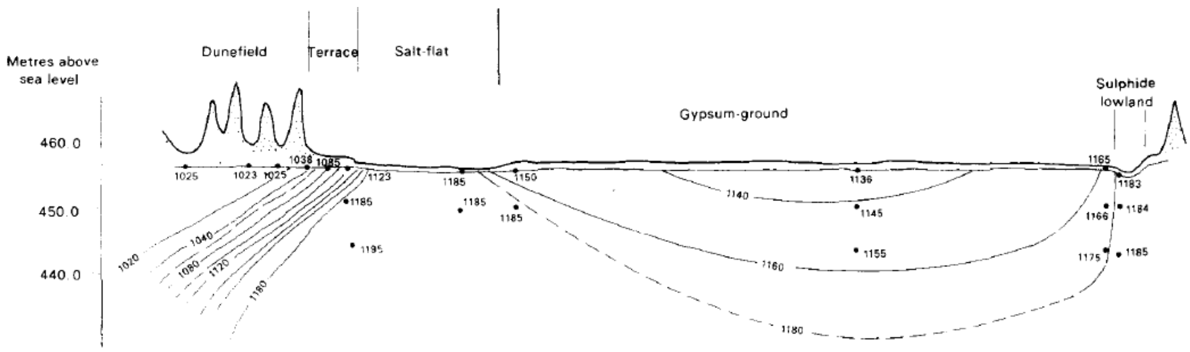


Figure 6.10: Cross-section A-A' from Figure 6.5, showing interpreted groundwater density structure, with significant vertical exaggeration

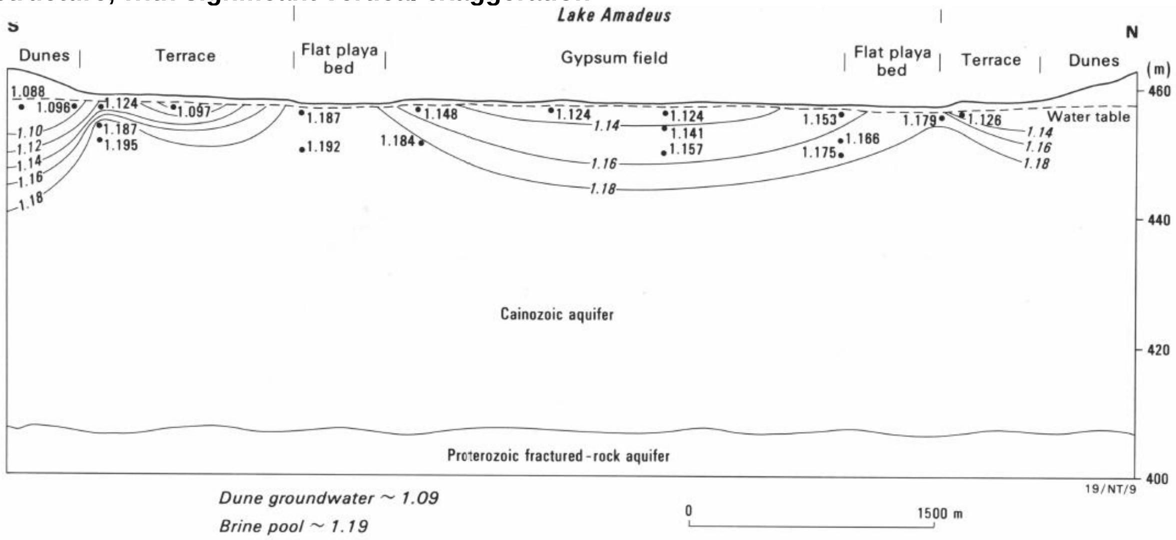


Figure 6.11: Cross section from Jacobson, 1988 showing brine densities on a Lake Amadeus transect

Jacobsen (1988) notes that generally 1-2 m of gypsum underlies the lake bed, overlying red clays. 20 piezometers were installed in the lake bed to 10 m deep. These showed the water level below the lake is generally 0.4 m below surface, and 0.6 m below surface in the gypsum ground. Groundwater showed daily diurnal fluctuations of several cm. As noted by Chen et. al., (1991) rainfall events typically cause a rise in water level then a fall over the dry period.

Terrace island formation

The islands consist of a weakly developed gypcrete surface (described as cemented micro-crystalline gypsum) over a pale sand-size pure gypsum layer. This contrasts with the brown gypsum layer of the surrounding gypsum ground.

The gypsum crystals show overgrowth and dissolution features that indicate the crystals are in a state of degradation. They are probably an alteration fo a pre-existing pure gypsum, such as on the terrace islands. Stratigraphic continuity implies the islands were more widely distributed than today as part of an extensive terrace, extending through the modern gypsum to the marginal terrace. This was deposited in a period of high water table this might have resulted in active groundwater seepage amd more frequent shallow surface brine. This may reflect a wetter period.

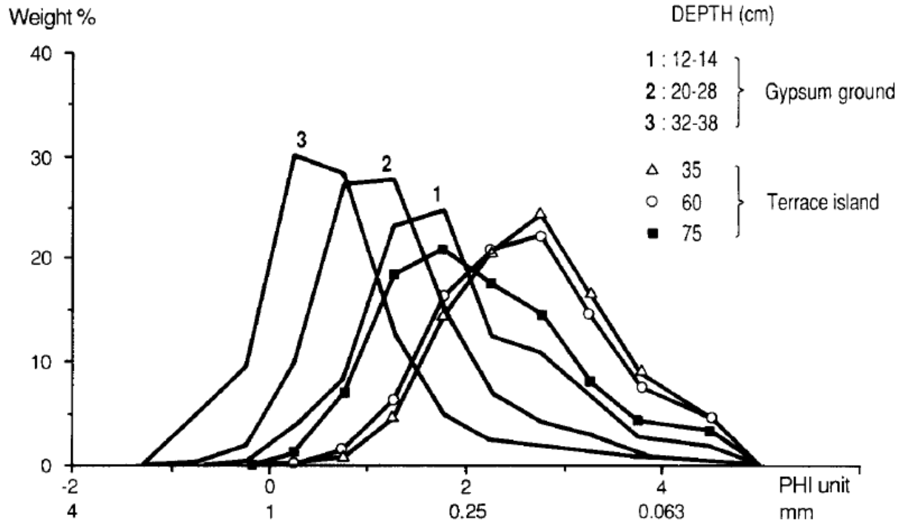


Fig. 16. Size distribution of pale gypsum in the terrace island sequence (line and symbol), compared to those of the brown gypsum layer of the gypsum ground (line and number 1–3).

Figure 6.12: Grain size comparison of Gypsum Ground and island gypsum

After a lowering of the regional water table the surficial pure gypsum was above the influence of groundwater capillary rise and gypcrete developed. Dissolution and collapse then became dominant, leaving the marginal terrace and terrace islands as relics. Gypcrete on the upper surface of the island is necessary to prevent underlying gypsum crystals from being eroded. A low cliff on the margins of the island where the gypcrete is better developed is evidence of the retreat of the island surface. This may reflect a climate similar to today.

6.5 Comparison to non-australian salt lakes

A comparison of surface textures in other salt lakes from the USA and South America shows that a similar surface texture to the gypsum ground can be seen in sands and silts at Saline Valley, California – a playa lake system (Figure 6.13). This texture is also reported to have ripples/crests and troughs developed. However, in this setting gypsum is not discussed.

6.6 Lake Mackay geomorphic map

A geomorphic map of Lake Mackay was compiled based on GoogleEarth and Landsat satellite imagery and observations made at drill sites and when crossing the lake in the Argo track-mounted vehicle. The different geomorphic zones are shown in Figure 6.15, with photographs of different morphologies around the lake shown in Figure 6.14. The area of gypsum ground is interpreted to cover 758 km^2 in the east of the salt lake.

In Lake Disappointment, the area that appears to correspond to gypsum ground is entirely in the east of the salt lake, as at Lake Mackay. However, this appears to correspond principally with the area that is embargoed and which Reward Minerals are not working in.

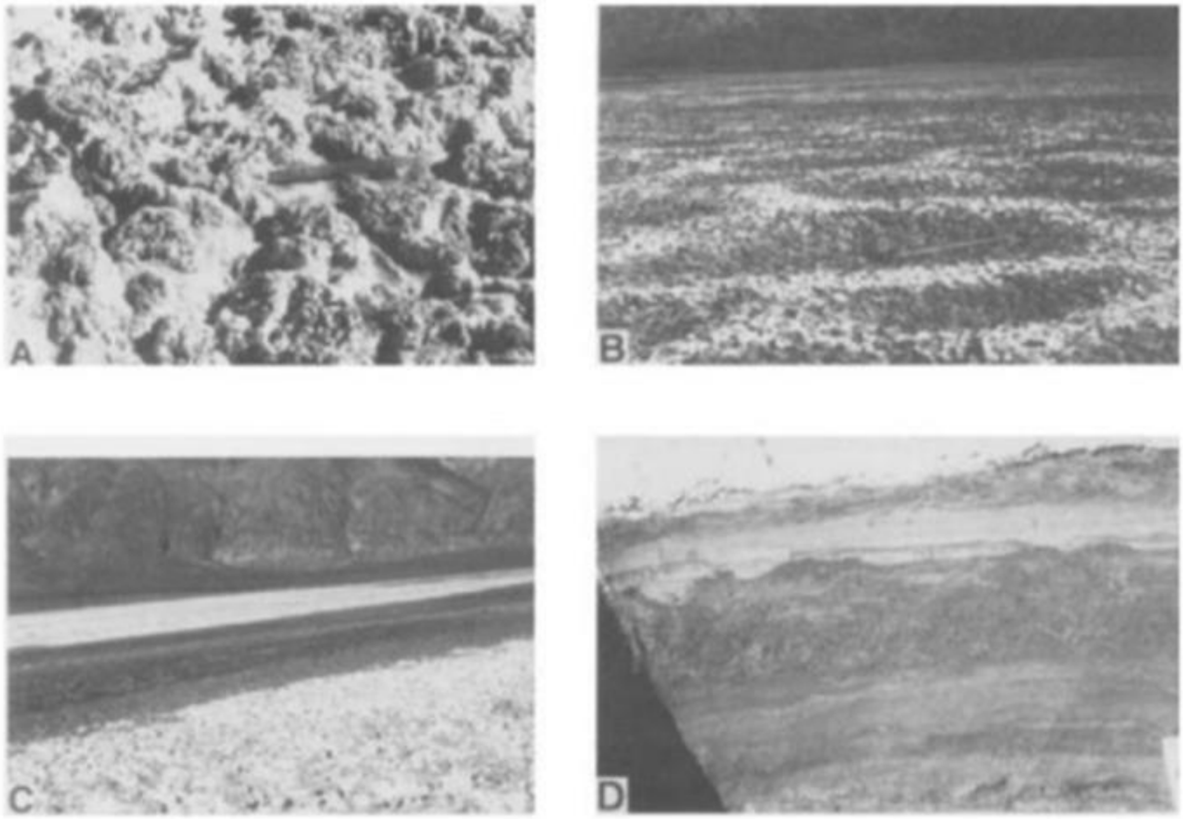


*Fig. 3.15. **A).** Efflorescent salt crust at Saline Valley, California, showing flat-topped sand and silt patches partially filling depressions between humps of efflorescent crust with "popcorn" surfaces. Scale = 35 cm long. **B).** Surface view of a sandy saline mudflat adjacent to an eolian sand sheet, Saline Valley, California. The efflorescent crust forms a polygonal pattern of broad troughs and narrow crests (light). Shovel = 1.4 m long. **C).** Channel in the efflorescent salt crust of the saline mudflat at Saline Valley, California. The channel floor (darkest area) is covered by salt encrusted linguoid and straight-crested ripples, lighter areas are salt-encrusted silt-mud levees. Channel and levee area = 10 m wide. **D).** Trench in channel similar to fig 3.15C parallel to flow (to the left). There are two fining upward sequences of flat lamination grading to ripple cross-lamination with efflorescent crust deformation at the top, then muddy sand with sand patches and layers of deformed ripples. Thickness = 50 cm.*

Figure 6.13: Gypsum ground equivalent from Saline Valley in California

6.7 Probable gypsum ground areas in other Central Australian salt lakes

As the estimation of the brine resource at Lake Mackay considers the gypsum ground to be a very important brine host it was considered important to compare the area it covers at Lake Mackay to other Central Australian salt lakes held by competitor companies. The comparison of the different salt lakes is presented in Figure 6.12, with all areas picked from Google satellite imagery.

- Lake Disappointment – the potential area of gypsum ground (and hence high near-surface porosity and permeability) covers ~ 401 km^2 in the south and 174 km^2 in the north for a total of 575 km^2.

- Lake Amadeus – the potential area of gypsum ground covers three areas of ~112, 22 and 14 km^2 for a total of 146 km^2.

By comparison Lake Mackay covers approximately 758 km2 of gypsum ground, which is not all in the Agrimin properties, some extends into third party properties to the east.

Lake Wells contains an area of islands in the south held by Wildhorse Energy. This reflects the observation at Lake Mackay/Lake Disappointment that islands develop in the east.

6.8 Lake Mackay geomorphic textures/zones

6.8.1 Gypsum islands

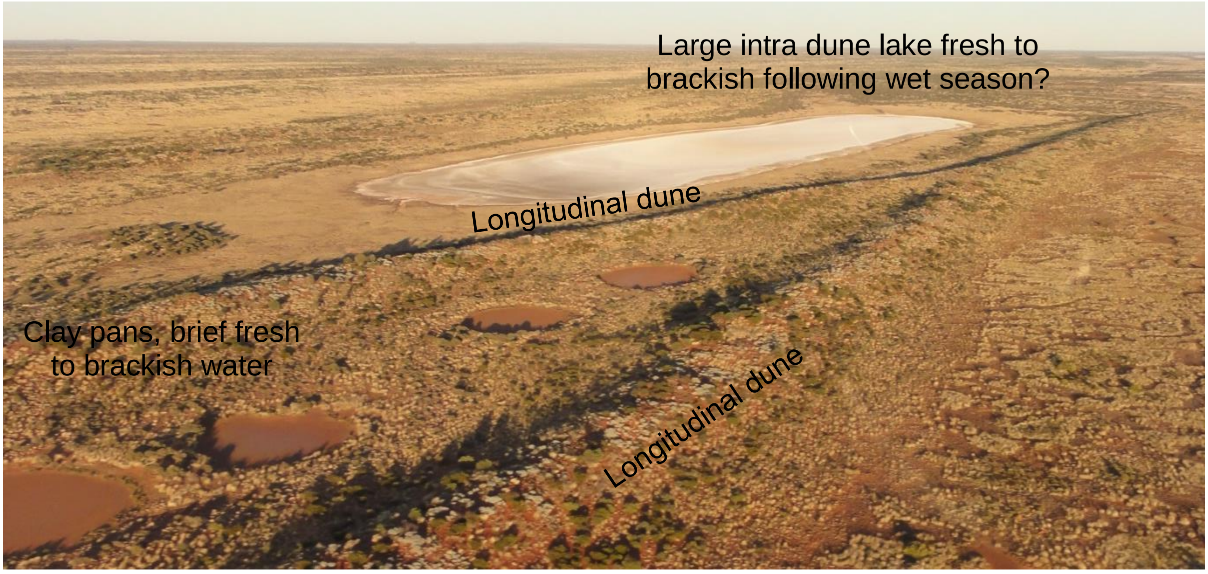
The gypsum islands in the east of the lake may show a distinct elongation east-west, or a barchan dune like geometry, with a broader loped eastern side and a compact shorter western side. This suggests the predominant wind has been important in forming these islands. The larger islands maybe eroded to form the smaller islands, according to observations by workers such as Chen et., al. (1991a and b). Figure 16.6 is a comparison to othe Central Australia Salt lakes and Figure 16.7 shows the island geometry.

6.8.2 Regional longitudinal dunes

These are aligned approximately east-west in the project area and are continuous over many kilometres, forming due to the Australia Anticlockwise Gyre, the wind system that blows out from the centre of Australia. The predominant wind system at Lake Mackay is interpreted to be from the southeast, contributing to development of the longitudinal dunes.

In the GoogleEarth imagery dunes can be observed extending from the western boundary into the lake as peninsulars, appearing to support the SE origin of the wind. Interestingly these longitudinal dunes are also observed on the gypsum islands, when they pass a certain area and the dunes appear to overprint the gypsum islands, extending off the western end of the islands, as observed in the peninsulars on the eastern margin of the lake. This suggests these dunes are the most recent active landform.

Developed between the dunes there are extensive clay pans which fill as lakes during wet seasons and progressively dry over time, so only the largest pans maintain water to late in the dry season (Figure 6.14 below).



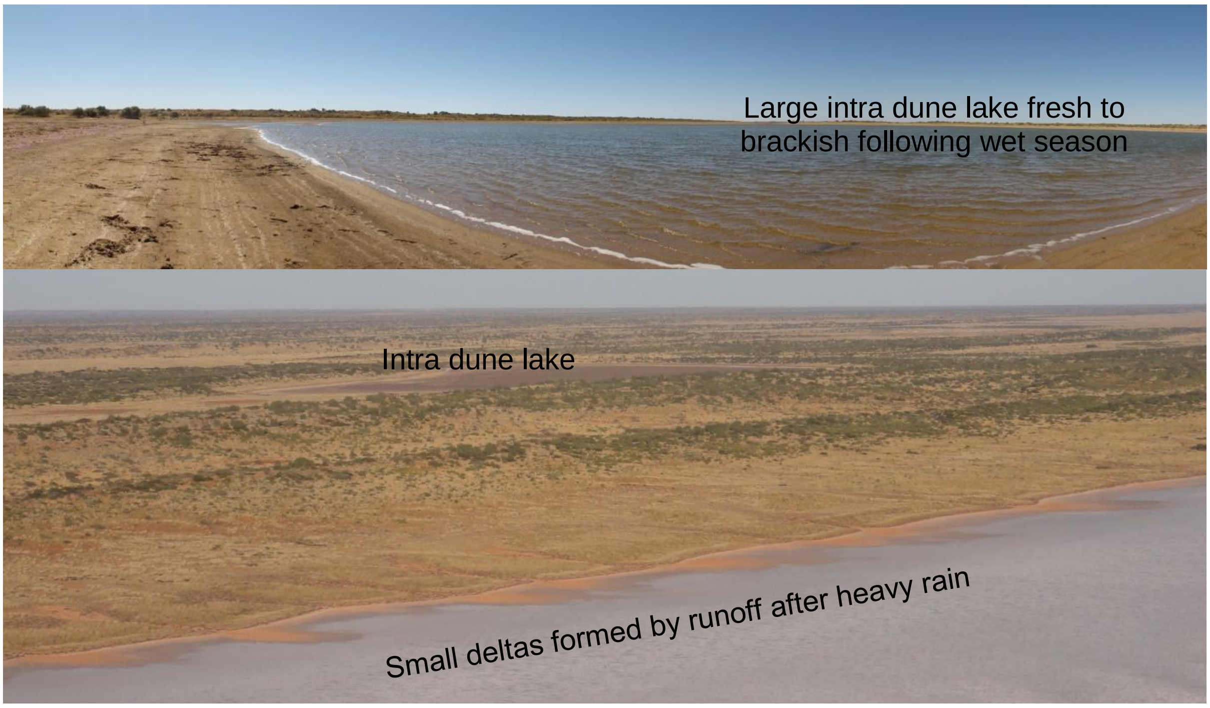


Figure 6.14: Longitudinal dunes, intra-dune lakes and the salt lake margin

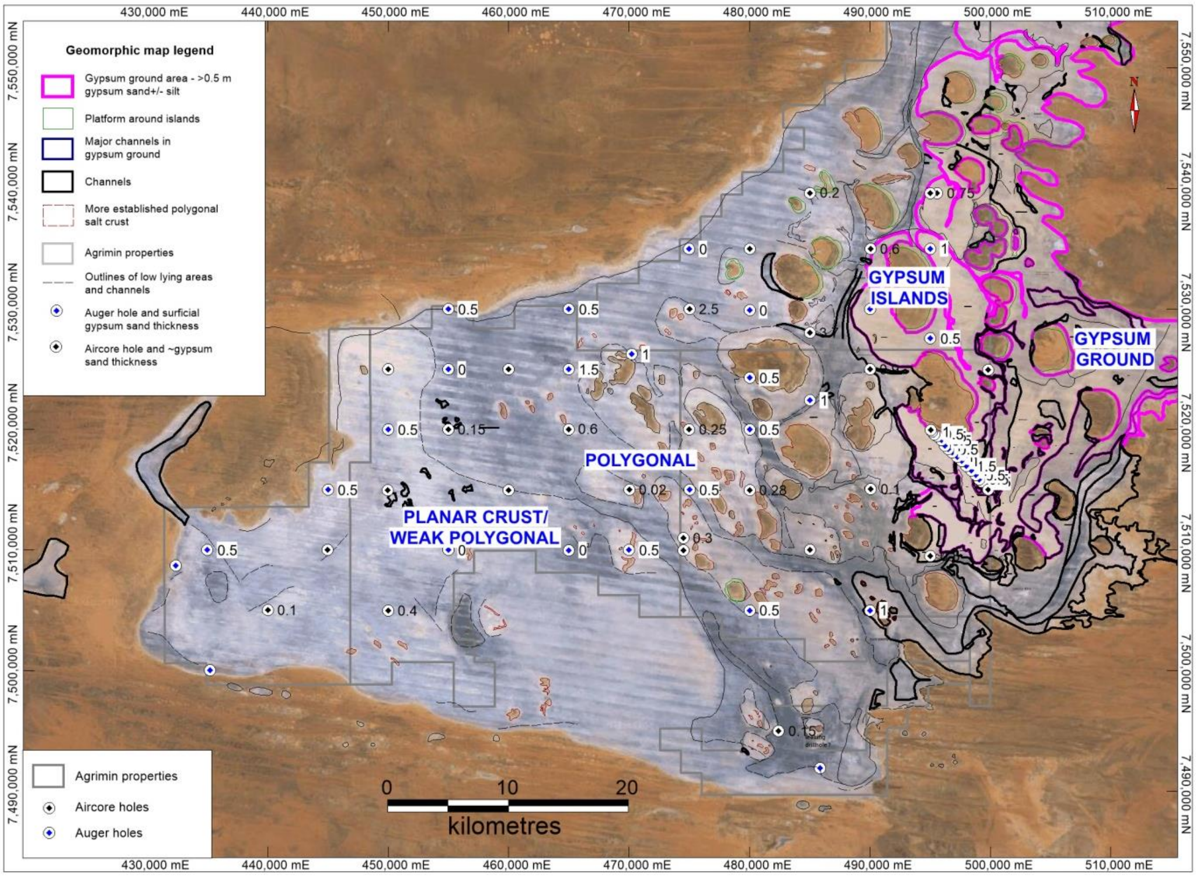


Figure 6.15: Lake Mackay geomorphic map

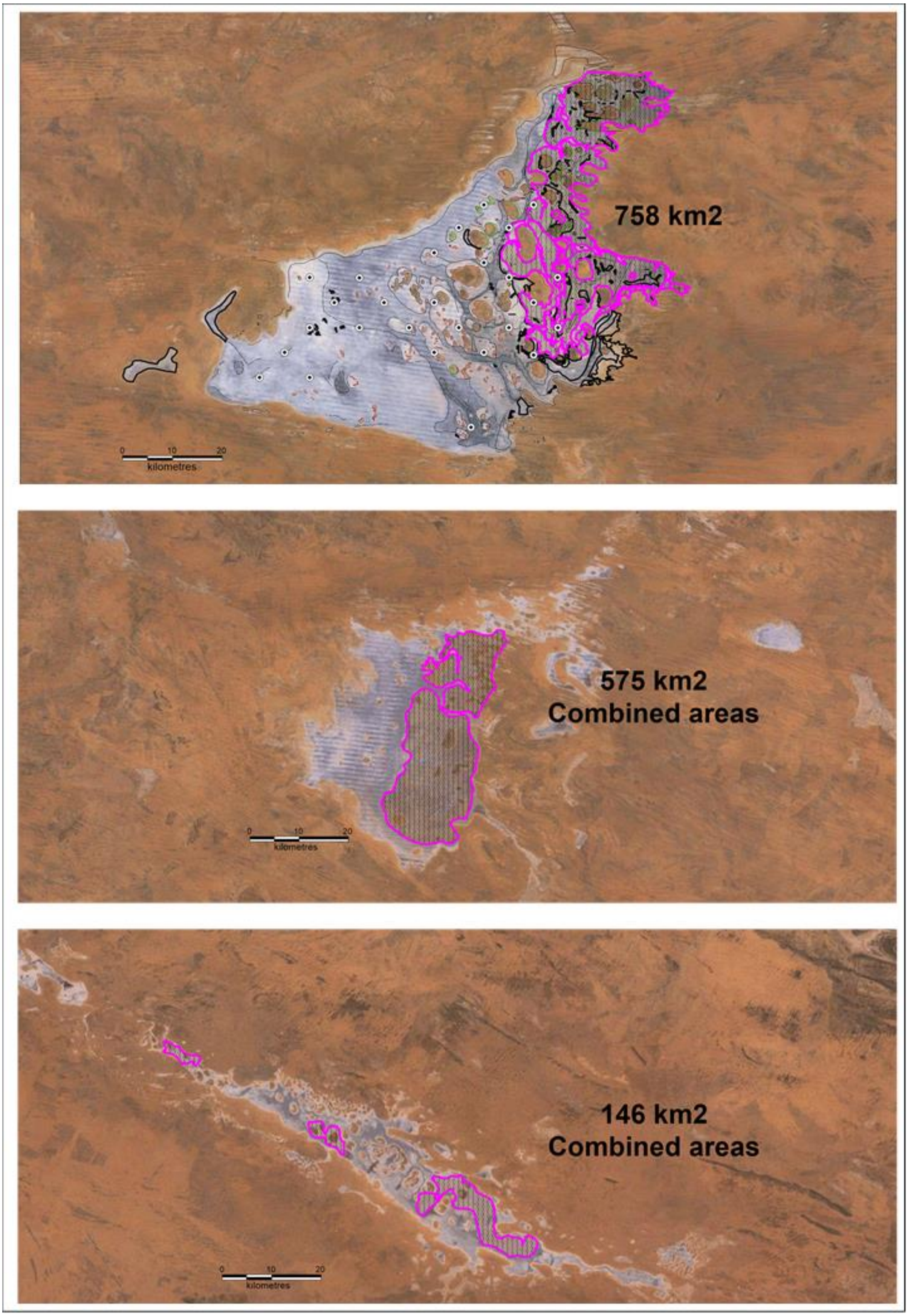


Figure 6.16: Comparison of Lake Mackay, Lake Disappointment and Lake Amadeus gypsum ground

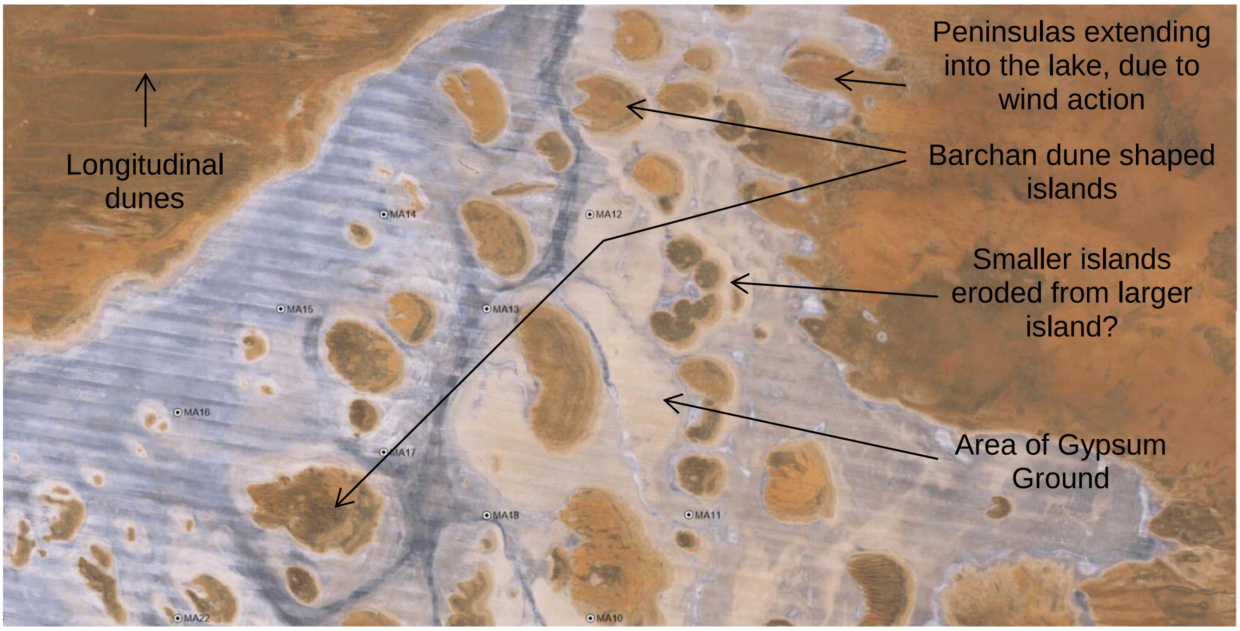


Figure 6.17: The geometry of islands in the east of Lake Mackay

6.8.3 Organic blotches

Organic blotches are ovoid patches up to 2 metres long in the lake surface (Figure 16.18) where the halite crust is thinner and where a thin (generally a maximum of 1 cm) organic layer is noted in the west of the lake. The organic material may generate acid conditions, that thin the salt crust, although this is not certain. These may bear some relation to what Chen et., al. (1995) have referred to as sulphidic lowlands in their study of Lake Amadeus. However, pH in groundwater samples does not suggest any major acid formation, with near-nuetral pH overall.

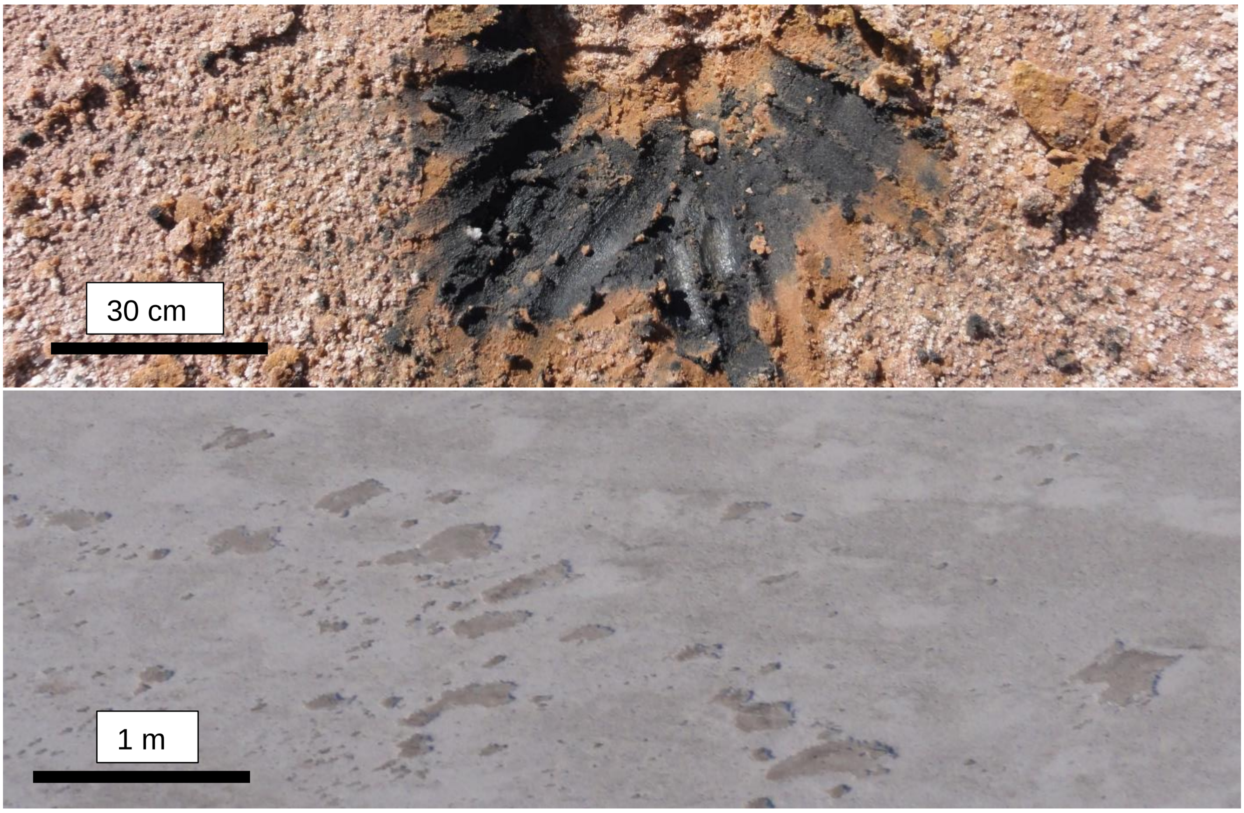


Figure 6.18: Blotchy surface texture and view of the thin organic layer below the halite

6.8.4 Polygonal crust

Extensive areas of polygonal crust are present across the lake (Figure 6.4 – Site of MA05 in the west of the lake). This is a typical salt crust texture, developed as the salt contracts. Houston (2011) notes that the Atacama and Hombre Muerto salt lakes this is between 2 and 5 years old – so if a similar relationship holds at Lake Mackay it will only be preserved in areas that are not inundated every year.

Figure 6.19: Polygonal salt crust – polygons are approximately 2 m across

6.8.5 Wind shaped crust

Wind textured crust are areas of more compact microsculptured halite crust with a fibrous texture that in places consists of “hair” of halite in a porous crust. This distribution and relevance of this crust type is uncertain.

Figure 6.20: Windblown "hair" texture

6.8.6 Puffy gypsum-halite crust “Gypsum Ground”

This surface texture type (Figure 6.21) is more common in the east of the lake, where a porous gypsum and halite texture resembling mounds/water release structures are present. This textural zone also appears to show ripple-like textures, particularly when observed in satellite images or from the helicopter. This texture was noted by Chen et. al. (1991) to be a significant texture in parts of Lake Amadeus and in Google imagery can be interpreted in most of the playa lakes in Central Australia. Chen et. Al., note that gypsum is the major evaporite precipitating at present and preserved in the gypsum ground. This texture is very similar to that observed in mudflat areas of the sea coast and in lakes such as Saline Valley, California, where it has been referred to as popcorn texture. These areas are likely to be covered with water only during seasonal inundation, when winds and wave action are probably important in generating the ripple textures observed.

6.8.7 Channels and low points

Within the lake there are well developed channels developed, which predominantly cross from the southern lake margin towards the north. These channels suggest the majority of inflow water originates from the southern side of the lake. These channels are darker coloured and this may reflect a thinner salt crust and higher surficial quantity of silt or organic material. These channels are clearly visible in Google imagery and have a dendritic drainage pattern (Figures 6.22-6.24).

Redissolution and precipitation of the halite crust occurs around the channels, with zones of ripples developed at a greater distanc efrom the channels. Areas of ?sheetwash are present on the margins of some channels.

6.8.8 Dissolution crust

Dissolution of polygonal or gypsum ground crusts is noted around channels, where there is a thin halite covering of the underlying sediments. These are interpreted as a crust left behind after the most recent inundation. Note dark sediment below thin halite (Figure 6.25).

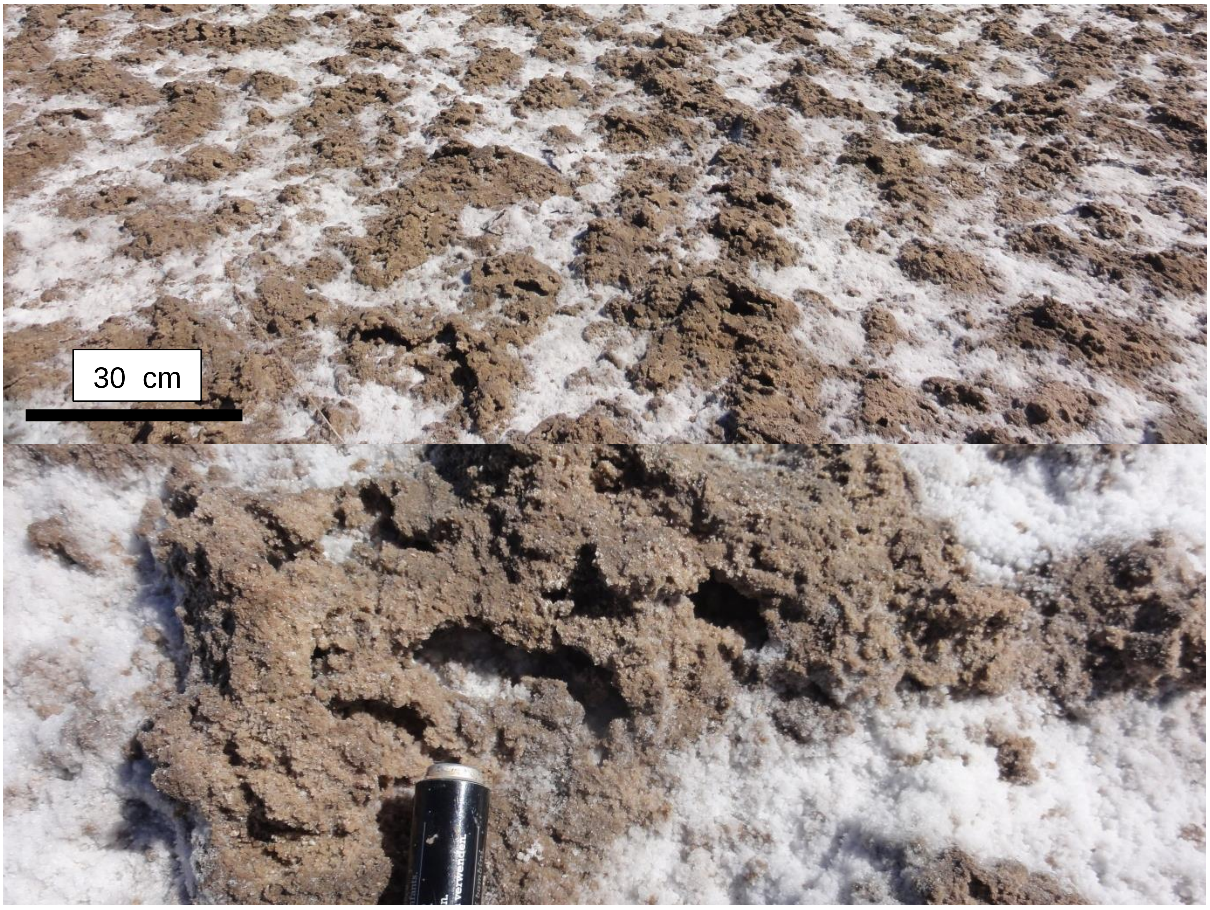


Figure 6.21: Puffy gypsum-halite crust. Distance between mounds approximately 20 cm

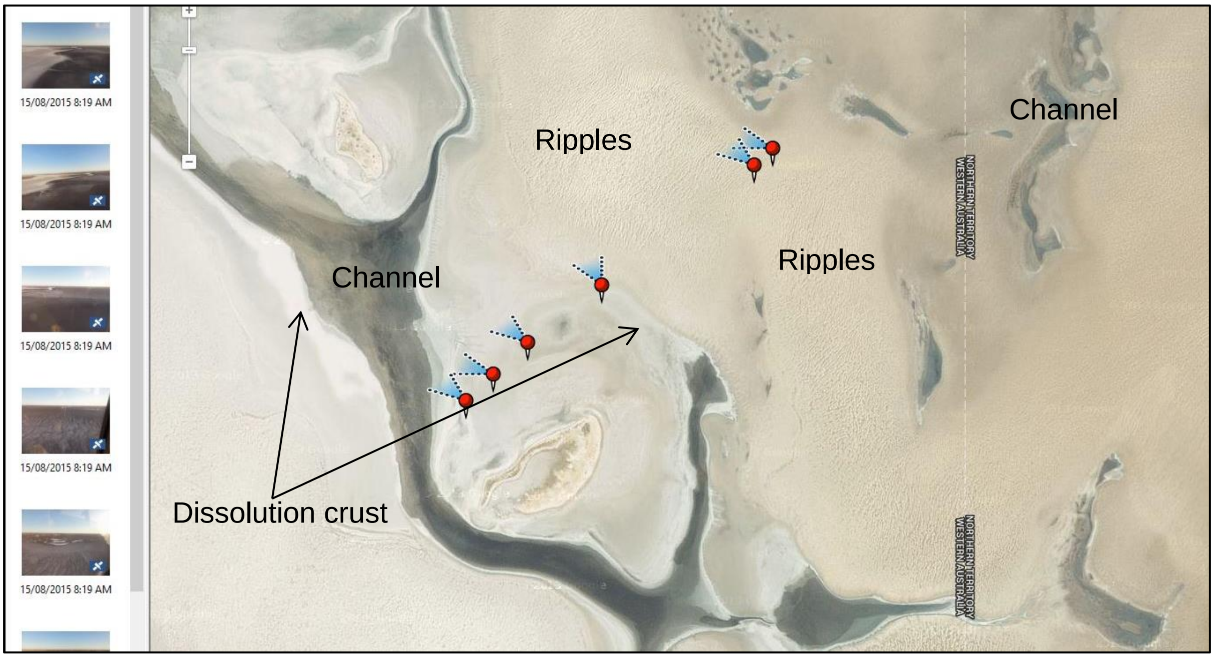


Figure 6.22: Channels and different surface texture zones (with photo locations)

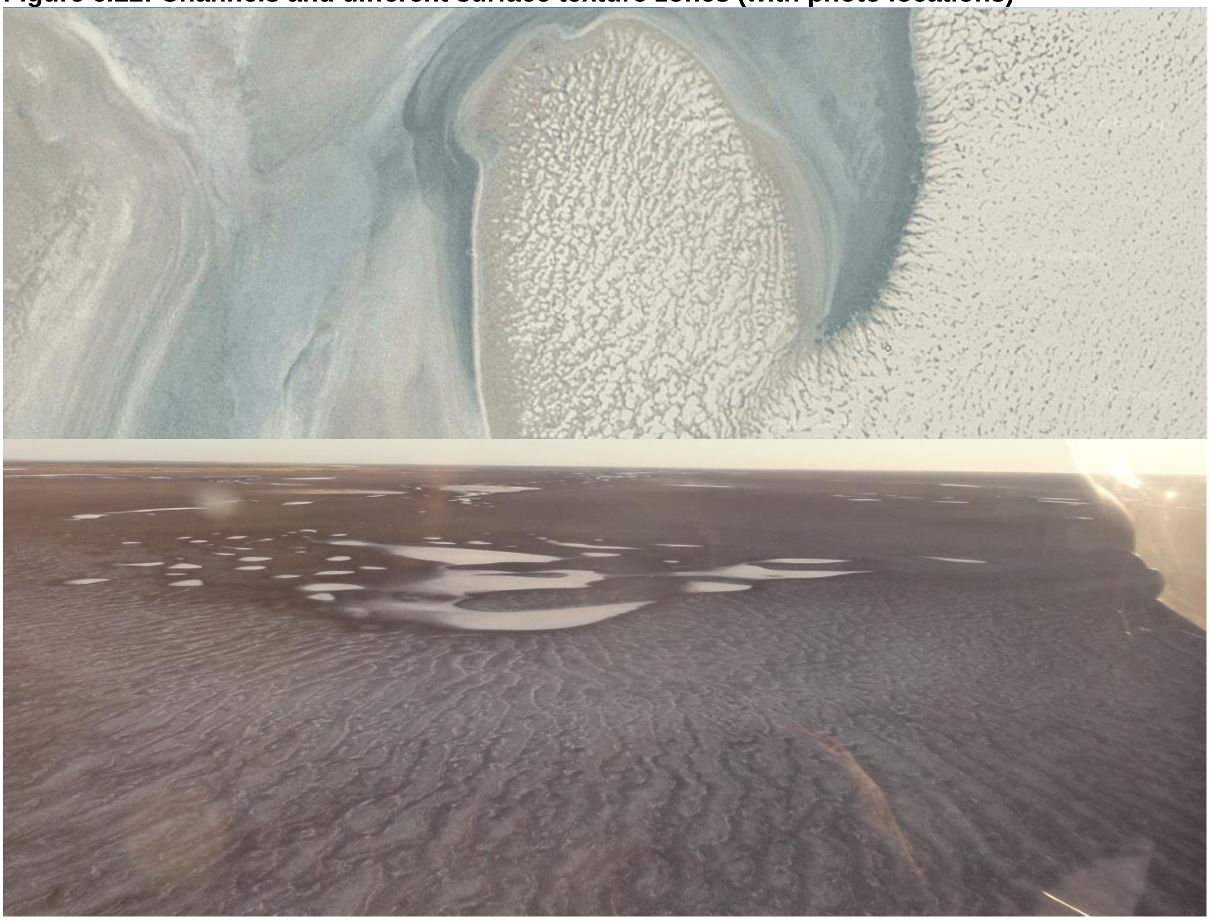


Figure 6.23: Ripple zones as seen in satellite imagery and from the helicopter

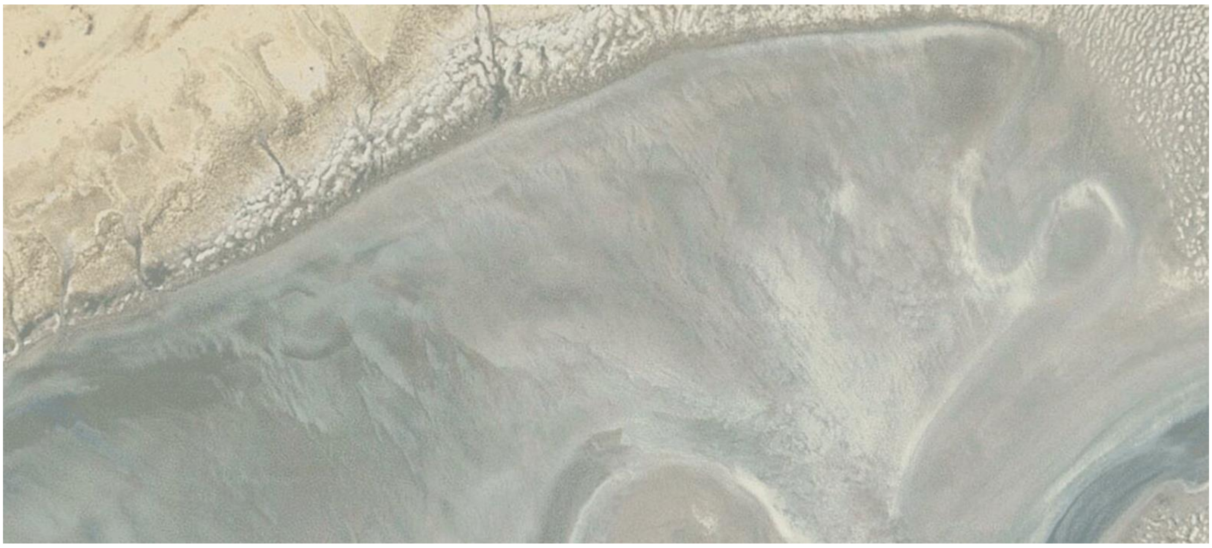


Figure 6.24: Sheetwash margins – affected by drainage

Figure 6.25: Dissolution crust and gypsum ground, dark channel in background from vehicle

6.9 Salt lake lithostratigraphy

The salt lake deposits have been evaluated by drilling aircore holes to a maximum of 30 metres deep, and by power hand auger holes to 1.5 m deep. Drilling has revealed a consistent picture of lithology across Lake Mackay. Key lithological units are noted below from top to bottom of the sequence. Drilling has showed the salar is between 16 and >30 metres deep.

6.9.1 Surficial halite

This is generally only 5 mm or a single salt crystal thick. In the west of the lake this crust takes on a different, less porous form than in the east of the lake, where it is intermixed with gypsum in small mounts with internal vugs/void spaces in what are interpreted as water escape structures (see 6.4.3). The halite is interpreted to dissolve each wet season and reprecipitate when waters evaporate. Chen et. al. (1991) note that in playas in Central Australia halite only occurs as a thin (several cm thick) white, ephemeral, efflorescent crust at surface.

6.9.2 Organic silt layer/s

The salt lake hosts an upper organic layer which is up to several cm thick and occurs at surface or within ~5 cm of surface (Figure 6.18, 6.26). This unit is exposed in patches within the salt lake where surficial halite is not present. It is unclear whether this represents a recent inundation that carried a significant volume into the lake sediments. It is also unclear whether this material is reworked to remain at the surface of the lake, similar to the halite crust. Typically a cm or several thick in the west of the salar, drilling suggests this unit thickens to the east and may be correlated with a silt unit 10's of cm thick in the upper metre of sediments.

At Lake Amadeus, SE of Lake Mackay a sulphide lowland, occupying less than 2% of the total playa area is characterized by an elevation10-40 cm lower than other playa areas. The black sulphide-rich layer (up to 3 cm thick) occurs at the surface, with gypsum and mud beneath, where the water-table is shallower than 30 cm. This is similar to the surficial organic layer at Lake Mackay.

6.9.3 Friable gypsum sand

Augering and drilling has intersected a unit of friable gypsum sand from surface, where it may be interbedded with the silt described above. This varies from a fine to coarse gypsum sand and grit, which has a maximum thickness of approximately 1.5-2 m in the east of the tenements. The grit-like gypsum changes below approximately 0.5 m to finer grained gyspum with interbedded layers of clay. The exact thickness of this unit is uncertain, as it was not well distinguished in the sampling of the first three metres, below the depth of surface brine pits or hand pushed transparent tubes. This unit is a very important host of brine and improved definition of the thickness of this unit is necessary in the future. A photograph of this material is presented in Figure 6.27. A map showing the distribution and thickness of the surficial sand layer is presented as Figure 6.35 below. This is interpreted as identical to the "Gypsum Ground" texture identified by Chen et., al. (1991 a and b) and other authors who have investigated Central Australian salt lakes.

Figure 6.26: Red-brown clay below upper grey sandy-silty interval

This unit is thought to be comparable to Gypsum Ground described at Lake Amadeus by Chen and Barton (1991a). This consists of a halite-gypsum-clastic material crust to 5 cm thick, over banded gypsum and sandy clay, where the water table is around 40 cm deep.

Figure 6.27: Friable fine to coarse gypsum sand

6.9.4 Red brown to brown clay layer

This is the dominant salt lake lithology, beginning within ~10 cm of surface in the west of the lake to as deep as 1.5-2 metres in the east and continuing to the contact with the underlying weathered bedrock. The clay shows some variation in colour from medium brown to red brown but is overall homogeneous, with minor gypsum sand grain content. There is an almost complete lack of internal structure or bedding. A photograph of this material is presented in Figure 6.28. There is an interval of upper clay that is generally paler coloured, passing into a more reddish clay beneath this in most locations. The red colour suggests an oxidized, sub-aerial to shallow subaqueous depositional environment for this unit, with periodic additions of sand, probably as wind-blown gyspum.

Drill holes in the eastern part of the lake terminated at 30 m in this unit, however it seems unlikely the lake sediments further east are much deeper than 30 m, and the depth to bedrock may shallow towards the eastern lake shore. The total sediment thickness (dominated by this clay unit from ~1.5 to the end of holes is presented in Figure 6.36.

In places the clay unit is paler and can be described more as olive green to grey, rather than red; reflecting a distinct period in the clay deposition. However, this change could not be correlated across the salt lake. In other salt lakes this type of interval represents more reducing conditions (deeper water) rather than oxidizing non-permanent water cover or surficial conditions. Green intervals occur between 5 and 24 m below surface.

Figure 6.28: MA18 push tubes to 7 m in clay

6.9.5 Compact gypsum sand layers

Within the dominant clay unit there are horizons of gypsum sand, with grains typically up to 1 mm or smaller, in compact horizons that when recovered as drill chips. They are texturally distinct from the triable gypsum sand but may represent similar surfaces where the gypsum has recrystallized as a compact mass. These layers may correlate between drill holes, although as there are multiple horizons it is uncertain what lateral continuity they have.

The gypsum grains are agglomerated and drill cuttings (Figure 6.29) and cores can be broken between one’s fingers to observe the internal texture. Units are pale green when fresh and reddish when oxidised. These units are more common below 9 metres depth in the centre and east of the lake. A summary of the depth occurrence of these units is provided in Figure 6.30. This shows that these units are common at all depths.

6.9.6 Crystalline gypsum layers

Crystalline transparent gypsum crystals were intersected in several drill holes and it appears there may be some correlation between these gypsum intersections, although they occur at different depths (Table 6.1, Figure 6.30). The individual crystals can exceed 4 cm long and in places this gypsum has produced significant flows of brine. A prominent crystalline gypsum layer is intersected in a number of drill holes in the east of the lake at approximately 3 m deep. An example is shown in Figure 6.31.

6.9.7 Saprolite

This saprolite material is recognizable as a cream/white colour (Figure 6.32 below), compared to the typical red-brown clay. The thickest intersect (8 m) of this was in MA01, with intersections typically <3 m. In other holes the drilling refused in the weathered rock, beneath saprolite.

6.9.8 Weathered basement layer

Aircore holes in the western part of the salar reached aircore refusal, generally on the basement rocks underlying saprolite, although in some holes the saprolite had no significant thickness. The thickness of weathered basement intersected was typically < 1 m. Evaluation of the lithologies with a hand lens suggests the basement is a fine grained unit, such as siltstone or metasediment in the west of the lake. In other intersections sandy texture is noted, with small pebbles in places, suggesting the material is a sandstone. Often the recovered material is deeply weathered or ferruginous. Photographs have been taken from chip trays for reference.

Figure 6.29: Compact gypsum sand in drill chips

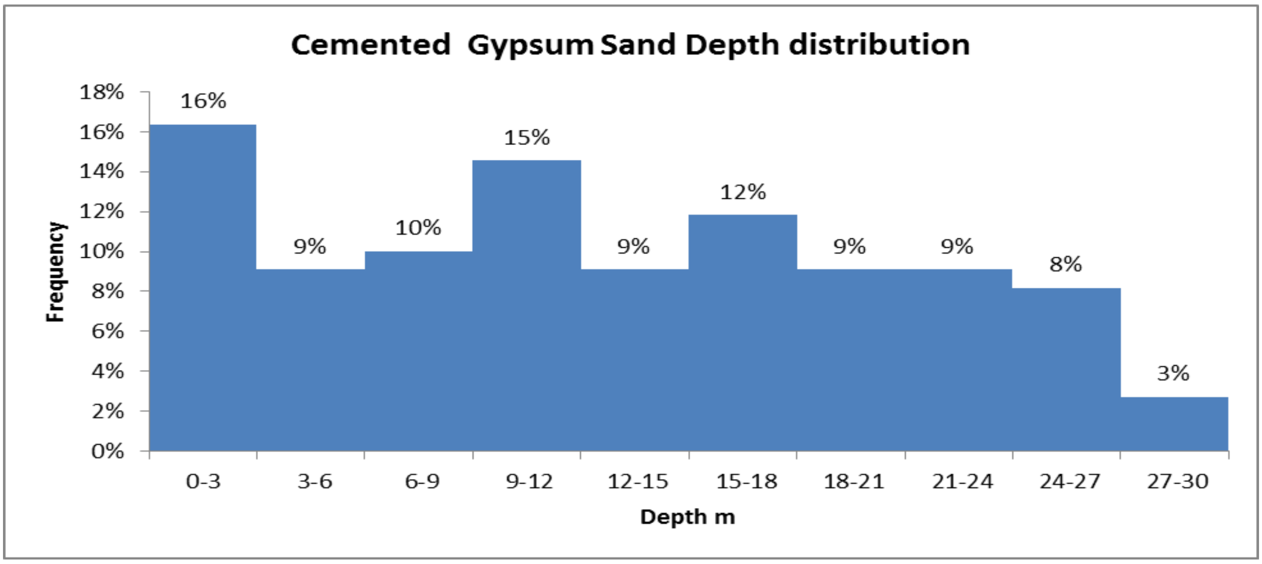


Figure 6.30: The distribution of cemented gypsum sand with depth (% of total)

Depth Interval m	Frequency
1-3	4
3-6	5
6-12	1
12-15	3
15-18	1
21-24	3
27-30	1

Table 6.1: Crystalline gypsum interval depths and frequencies

Figure 6.31: Coarse crystalline gypsum in clay

6.9.9 Gypsum islands

In the east of Lake Mackay there are a large number of islands ranging from tens of square metres to square kilometres across. These islands reach a height of several metres above the salt lake surface and appear to be entirely composed of gypsum grains. The gypsum is deposited in layers with different textures. These gypsum islands support significant communities of grasses, scrubs and trees which are interpreted to survive exploiting fresh to brackish groundwater that has infiltrated the gypsum layers from rainfall. A gypsum island is shown in Figures 6.33 and 6.34, with additional photographs in section 18 – Environmental Studies.

Figure 6.32: Saprolite cuttings from aircore drilling (MA01)


Figure 6.33: Compact gypsum cliff on island near MA08


Figure 6.34: Loose friable gypsum sand on the surface of a sand island

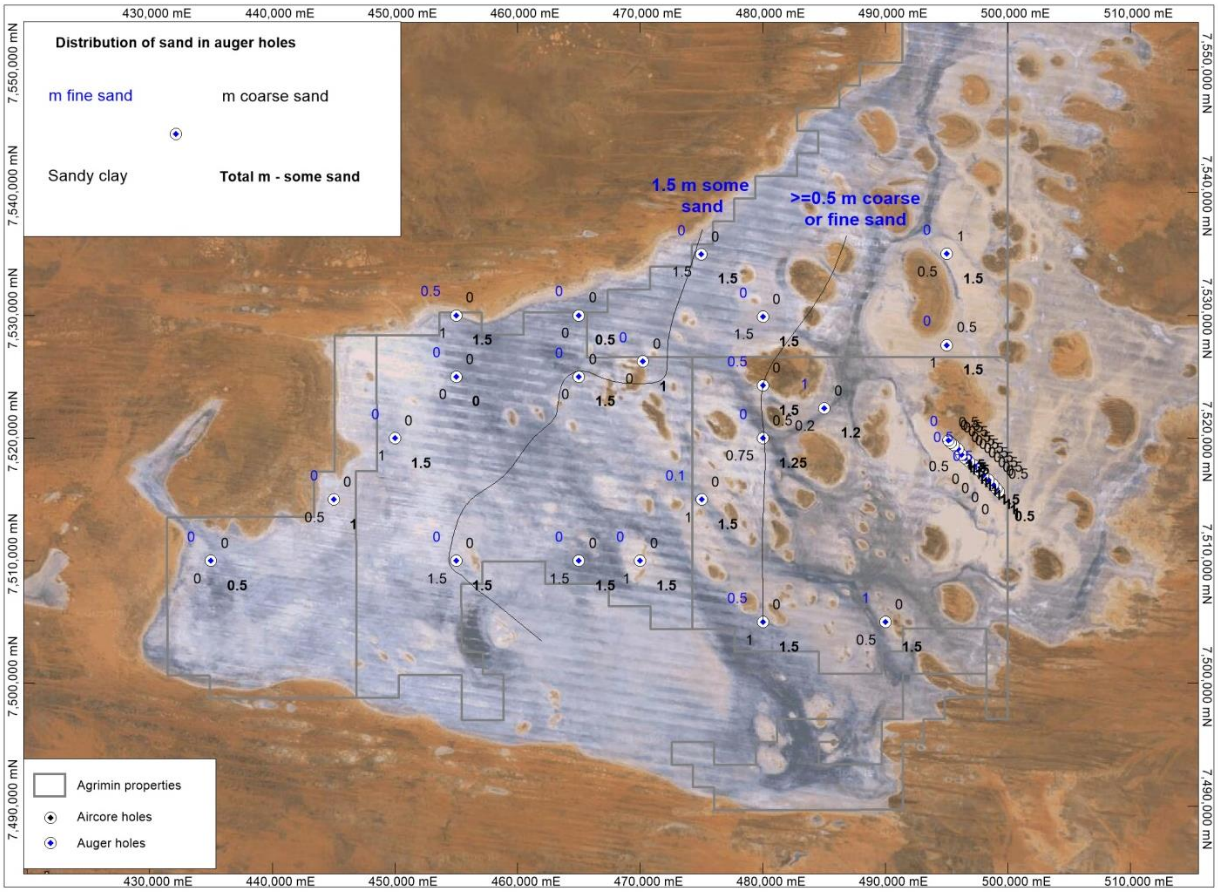


Figure 6.35: Distribution and thickness of the friable upper sand unit

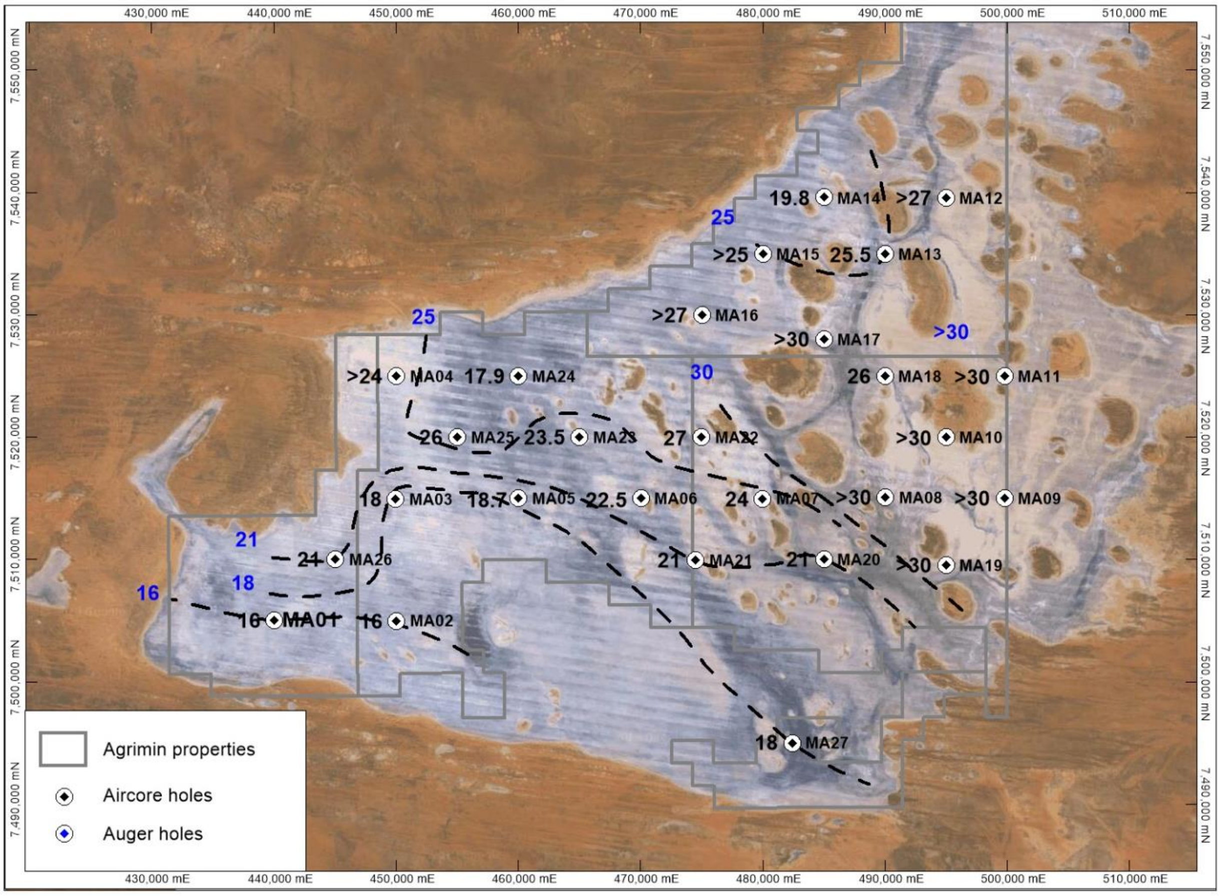


Figure 6.36: Thickness of the lake sediments and depth to bedrock

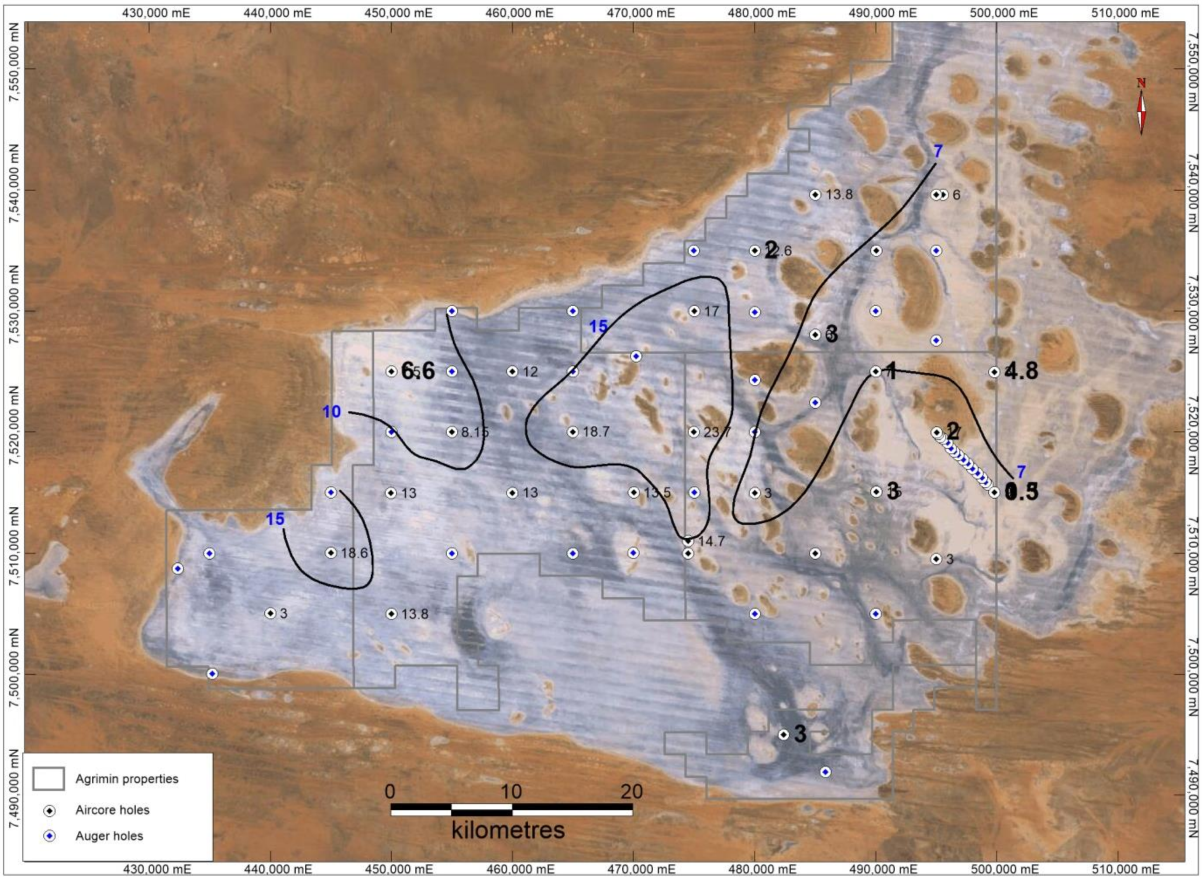


Figure 6.37: Distribution of the cemented gypsum sand layers

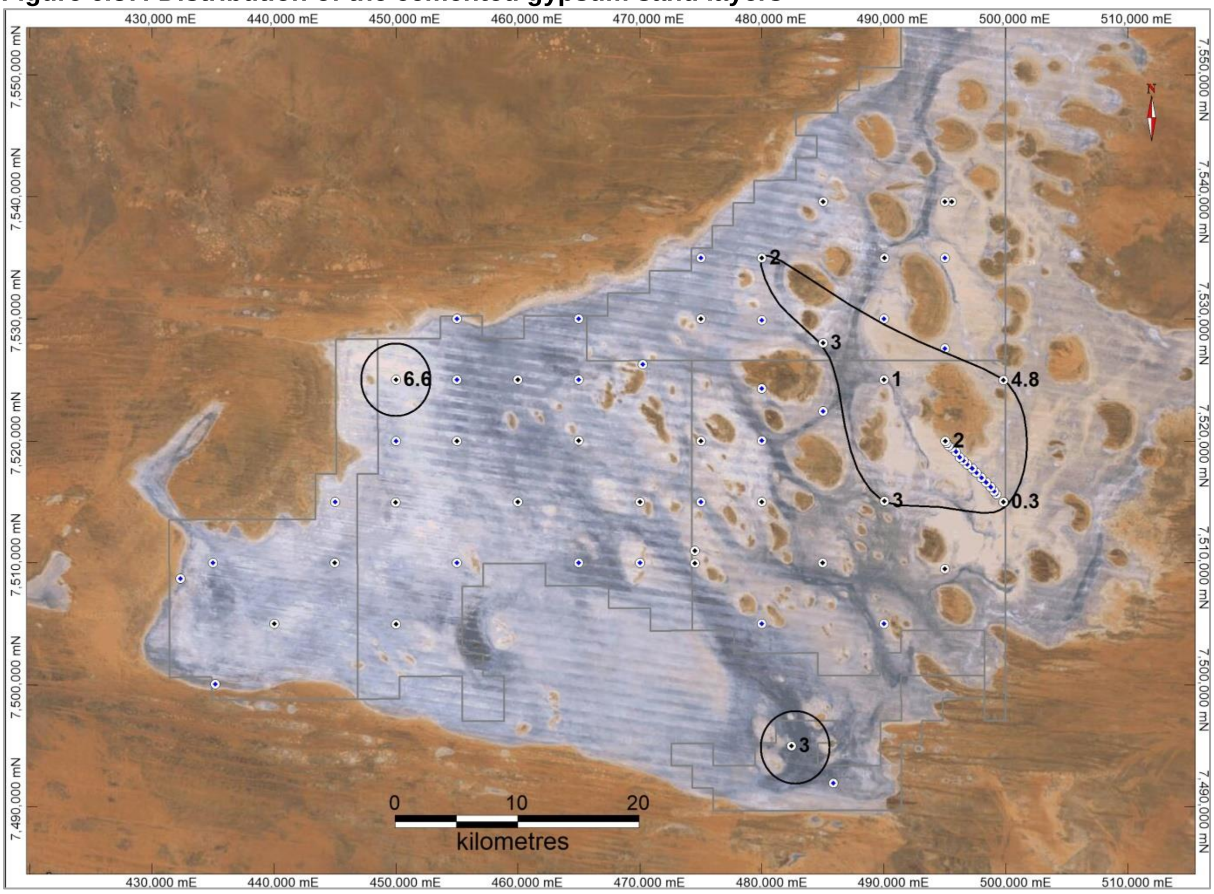


Figure 6.38: Distribution of the crystalline gypsum layer

6.9.10 Structural geology of the Lake Mackay basin

Publicly available magnetic (Figure 6.39) and gravity data has been interpreted over the Lake Mackay basin. This shows a series of prominent NE trending faults north of the lake and WNW trending probable stratigraphy and associated structures. It is not clear if any faults have controlled the development of Lake Mackay, however this is often the case in creating "drainage sinks" of this sort. Woodcock (GA 2012) suggest there is some tectonic control of the lake basin.

In the Review of Australian Salt Lakes GA note that active faults are widespread and seismic activity is significant. Tectonism during the Cenozoic has greatly contributed to the shaping of the landscape that now contains the present-day array of salt lakes. Many of the faults are ancient in origin, associated with major orogenies of the Precambrian and Phanerozoic, and have been reactivated during the Cenozoic. The Wilkinkarra paleovalley study suggests the regional hydraulic gradient was previously to the east, but is now towards the west, ending in Lake Mackay.

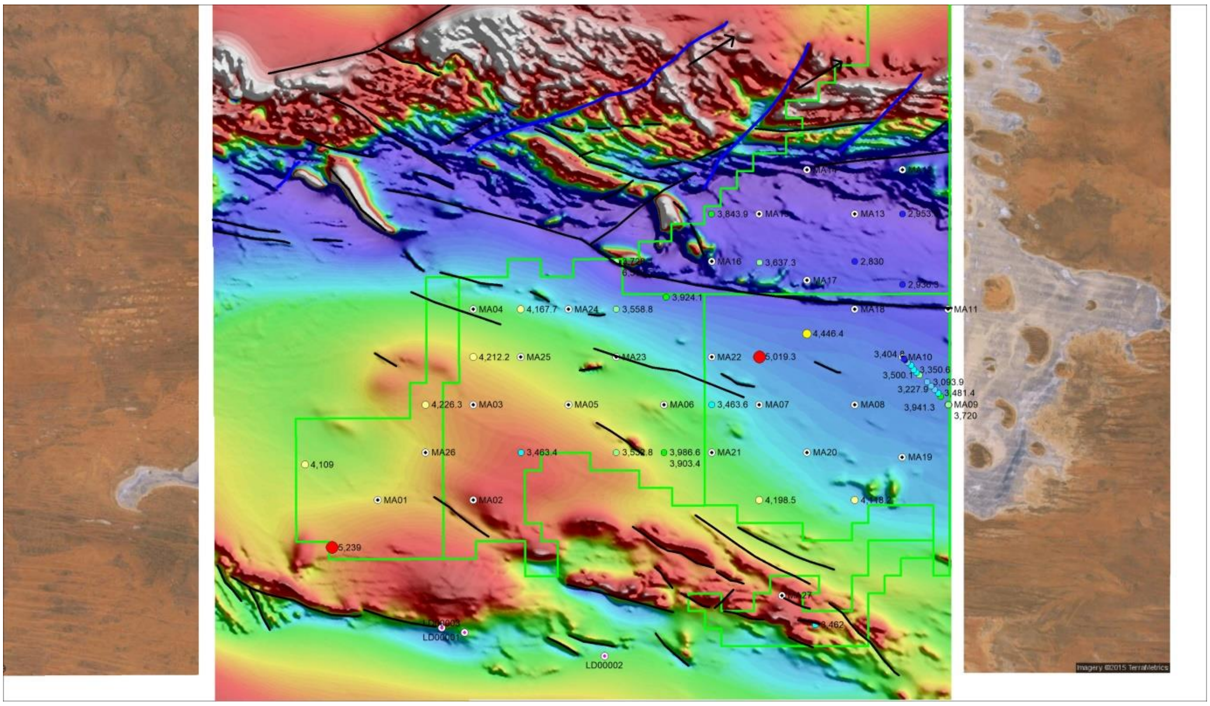


Figure 6.39: Interpretation of faults on magnetic data over Lake Mackay

6.10 Other Central Australian Playa Basins

As in more active tectonic environments like the Andes and China tectonics and climate are important controls on formation of brine deposits, influencing sedimentation patterns and brine development. In Australia the tectonic influence is likely to be lesser, although tectonic controls are thought to be important for changing drainage networks and generating internal drainages. Comparison of information from Central Australian projects suggests there is a significant climatic and sedimentological change around 1 Ma, with a change from lacustrine clays to increased gypsum accumulation. Gypsum islands and sands are noted in the upper levels of many of the Central Australian salt lakes. This has important implications for potash projects across inland Australia.

Lake Amadeus

Investigations carried out by Chen and Barton in the Lake Amadeus basin, to the south of the McDonnell ranges identified two major units in the lake. **The basal Uluru Clay** was defined to be at least 60 m thick, overlying the Proterozoic basement. It consists of uniform clay horizons with minor intercalated gypsum in shallow lacustrine and fluviatile environments, which were periodically saline and often dry. Paleomagnetic reversal stratigraphy suggests **deposition commenced prior to 5 Ma.**

The **overlying Winamatti Beds are 0.6-3 metres thick and consist of Aeolian sand, gypsum-clay laminae and gypsum sands**, which represent deposition in a saline groundwater discharge playa system. The basal Winamatti Beds were interpreted to coincide with the Jaramillo paleomagnetic subchron (0.91 Ma), but **may be as old as 1.6 Ma** (Chen and Barton, 1991). The boundary between the Uluru Clay and Winamatti Beds may correspond to a similar transition in Paleo-lake Bungunnia in the Murray Basin.

This gypsum deposition is interpreted to represent a change from wetter to drier conditions. These authors note that the lake is ringed by an older gypsum dune system that may have formed soon after the Uluru Clay. Chen and Barton also note a younger inner gypsum dune – based on thermoluminescence dating at 40-50 ka. These dunes are interpreted to have formed by deflation of near-shore gypsum deposited in the groundwater seepage zone during high regional water table and wetter climate.

Gypsum ground within the lake is described by Chen and Barton (1991) as consisting of a thick (to 5 cm) gypsum crust over banded gypsum and sandy clay, with the water table around 40 cm deep. This gypsum ground in photos by Chen (1991b) appears identical to that in the west of Lake Mackay.

The gypsum islands may have 2 or 3 rings of gypsiferous dunes (Figure 6.40) and there may be quartz sand coatings on underlying cemented gypsum. These are surficial white microcrystalline indurated gypcrete 0.5-1 m thick. They may be covered by layers of Aeolian silica sand. Beneath the surficial gypcrete layer there are coarse sand-size gypsum crystals, fine quartz sand, and minor clay. These authors conclude the most plausible source of the islands is simultaneous gypsum precipitation and deflation. Sand-size gypsum was precipitated in groundwater seepage zones around the playa margin under a seasonally high water table, with deflation onto islands and the surroundings of the lake. This process requires a high regional water table, strong climatic seasonality (wetting and drying cycle) and probably a windier and overall wetter climate. In Lake Amadeus the gypsum islands range from 3-4 m to 10 m high.

The dunes nucleate around and obstruction and grow through a series of deflation episodes, with stabilization of the dunes. A typical dune profile consists of Aeolian, gypsiferous sediments capped by gypcrete. The island gypsiferous dunes are underlain by playa sediments (Figure 6.41). The gypcrete is 0.5-1 m thick and forms a white indurated massive layer of microcrystalline gypsum. The surface often shows karstic dissolution features.

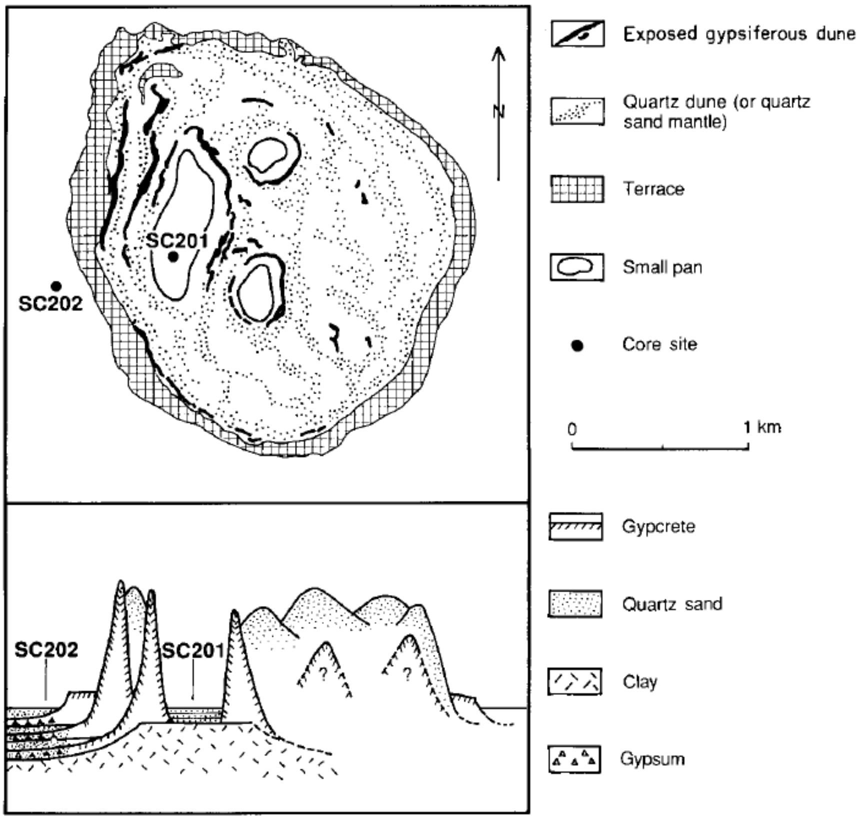


Fig. 20. Geomorphological map and section of Auger Island (for location see Fig. 5), illustrating the difference in sedimentary history between the small pan within the island and the main playa.

Figure 6.40: Lake Amadeus gypsum sand island profile

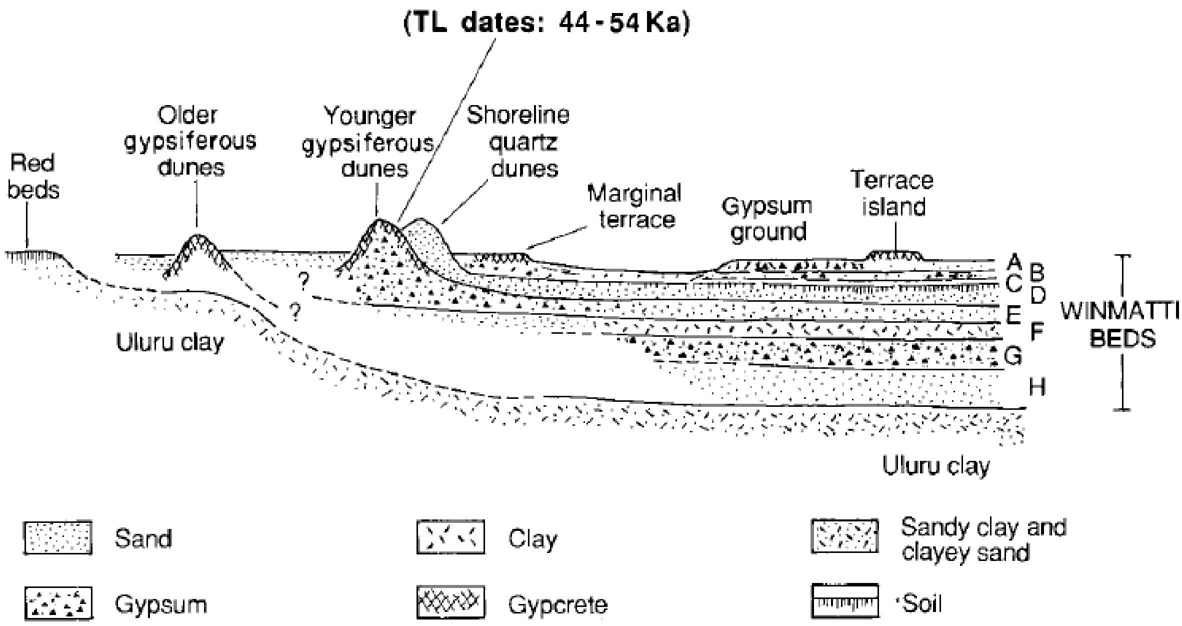


Fig. 21. Graphic summary of the stratigraphy of the Lake Amadeus system.

Figure 6.41: Lake Amadeus lake profile

These authors note that **regional quartz dune activity includes an Aeolian sand deposit on the playa floor and thick mantling of the gypsum dunes. They interpret this as a drier period following the gypsum dune building**. The latest feature is interpreted as another shallow-water gypsum layer representing a return to relative high groundwater levels, forming playa-margin terraces and low terrace islands.

Lake Lewis

Investigations by English (2003) at Lake Lewis identified the lacustrine plain consisting of a lower layer of red-brown homogeneous Anmatyerre Clay (Figure 6.42, 6.43) that was deposited in standing water during high lake water conditions during the Early and Mid Pleistocene. This clay is at least 28 m thick and may extend to 80 m deep beneath part of Lake Lewis. Detrital minerals include quartz, feldspar, illite and kaolinite+/-smectite, with carbonate absent. The upper layer consists of the Tilmouth beds of olive-grey clay and gypsum laminae, reflecting fluctuating lake conditions, high salinity and chemically reducing conditions in bottom muds. The detrital material is similar to the underlying Anmatyerre Clay. Abundant gypsum displaces surrounding clay material and calcite is present as microfossils. English interprets the Tilmouth Beds were deposited in a hydraulically closed lake, larger than the present-day playa. They are tentatively correlated to the last Interglacial period around 130-110 ka. The playa lake is related to subsidence north of the Redbank Thrust Zone.

The Tilmouth Beds and Anmatyerre Clay are exposed in playa islands and form the very flat landscape forming the lacustrine plain. Much of the near-surface lacustrine sediment has been calcretised and can be several metres thick, karstic and silicified.

Within the playa lake there are islands composed of Aeolian gypsum, traverse and linear sand dunes. These gypsum playa islands and playa fringing dunes have been described by Chen (1995). The gypsum sands are interspersed with gypcrete layers and carapaces. Up to a metre of sediments overlies lacustrine clay in the playa.

There is a broad, low gradient alluvial plain across the south of the basin, with sands, clays and minor gravel. Aeolian dunes trending WNW-ESE to E-W reflect the dominant wind direction. Dunes are typical “red desert sands” with hematitic patinas on grains. The dunes are now largely stabilized by vegetation.

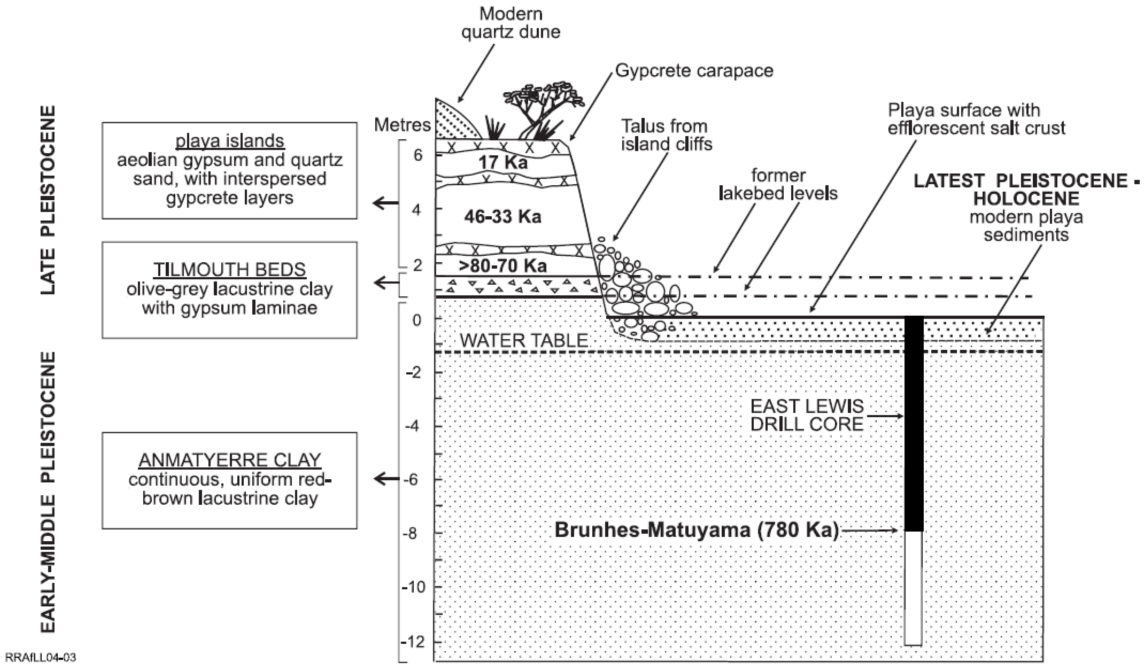


Figure 4. Generalised stratigraphic relationships of the main Lake Lewis playa units. Location of the East Lewis drill hole shown in Figure 3. Thermoluminescence ages for gypseous aeolian units from Chen *et al*. (1995); palaeomagnetic data from English (2001b).

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Figure 6.42: Lake Lewis (NT) stratigraphy

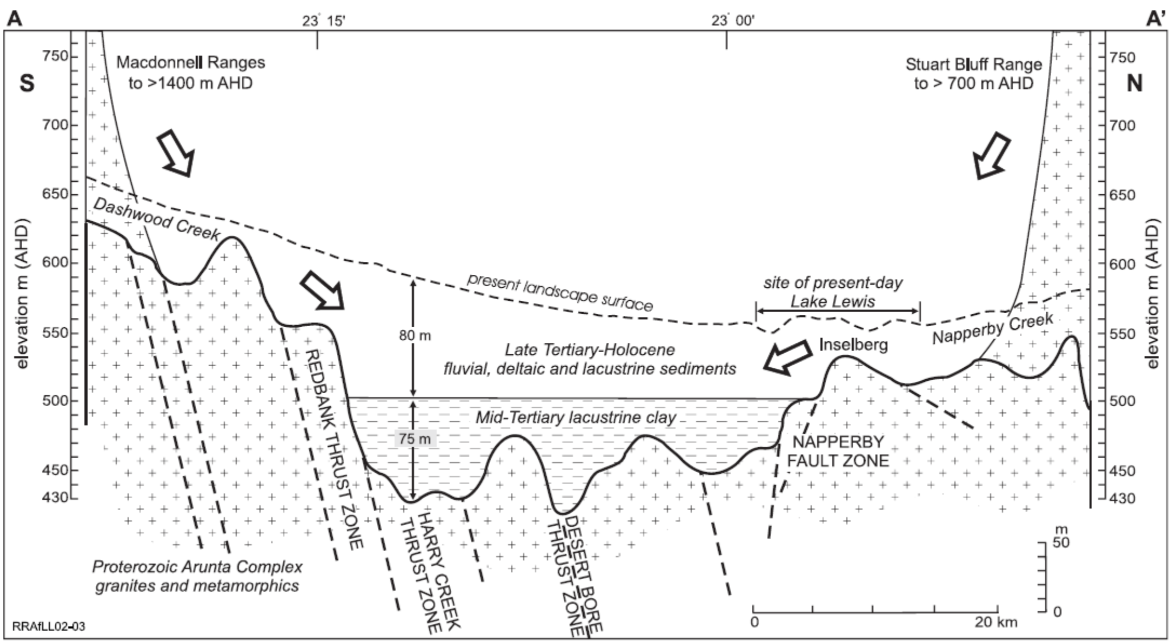

Figure 2. South–north section through the Lake Lewis basin along part of the BMR 1985 seismic line (A–A' in Figure 1), showing the subsurface relief of the Arunta Complex granitic and metamorphic basement, based on seismic reflection, airborne magnetic and drill-hole data. Cenozoic basin evolution was structurally controlled and resulted in initial infill of the depocentre with Palaeogene lacustrine clay (arrows denote surface water and sediment flow directions). Subsequent Neogene to Pleistocene sedimentation involved up to 100 m of piedmont alluvial fan, lacustrine and palaeochannel deposits.

Figure 6.43: Lake Lewis schematic cross section and tectonics

6.11 Lake Mackay Basin development over time

The Lake Mackay basin has been slowly accumulated fine sediments and has been subject to periods when chemical sedimentation has prevailed, leading to deposition of gypsum layers over extensive areas. The gypsum islands are interpreted to have formed by the precipitation of gypsum from brine and wind transport of the gypsum grains, with grains agglomerating on islands that themselves are constantly migrating with the wind.

GA has developed ASTER mineral maps that map gypsum distribution in surficial lake sediments (Figure 6.44). The marine influence and the amount of sulfur available to salt lake settings decreases inland, limiting the amount of gypsum that can be formed. Local zones of gypsum response in inland lakes are interpreted to be restricted mainly to where the water table intersects the land surface. Inland salt lakes displaying a high gypsum signal in the ASTER product could therefore provide a preliminary indication of a greater relative contribution of rock weathering constituents and down-gradient salts, particularly sulfate.

In Lake Amadeus, southeast of Lake Mackay, the geomorphology and major lithological units of the lake and its surroundings were sampled and mapped in detail by Chen et al., (1991a), who found that the lake surface has an extensive coverage of a distinctive gypsum-rich unit (~16 %), which they termed "gypsum ground" (Figure 5.2 and Chapter 2 of the GA review of Australian salt lakes). Additionally the margins of the playa were found to be outlined by predominantly gypsiferous dunes.

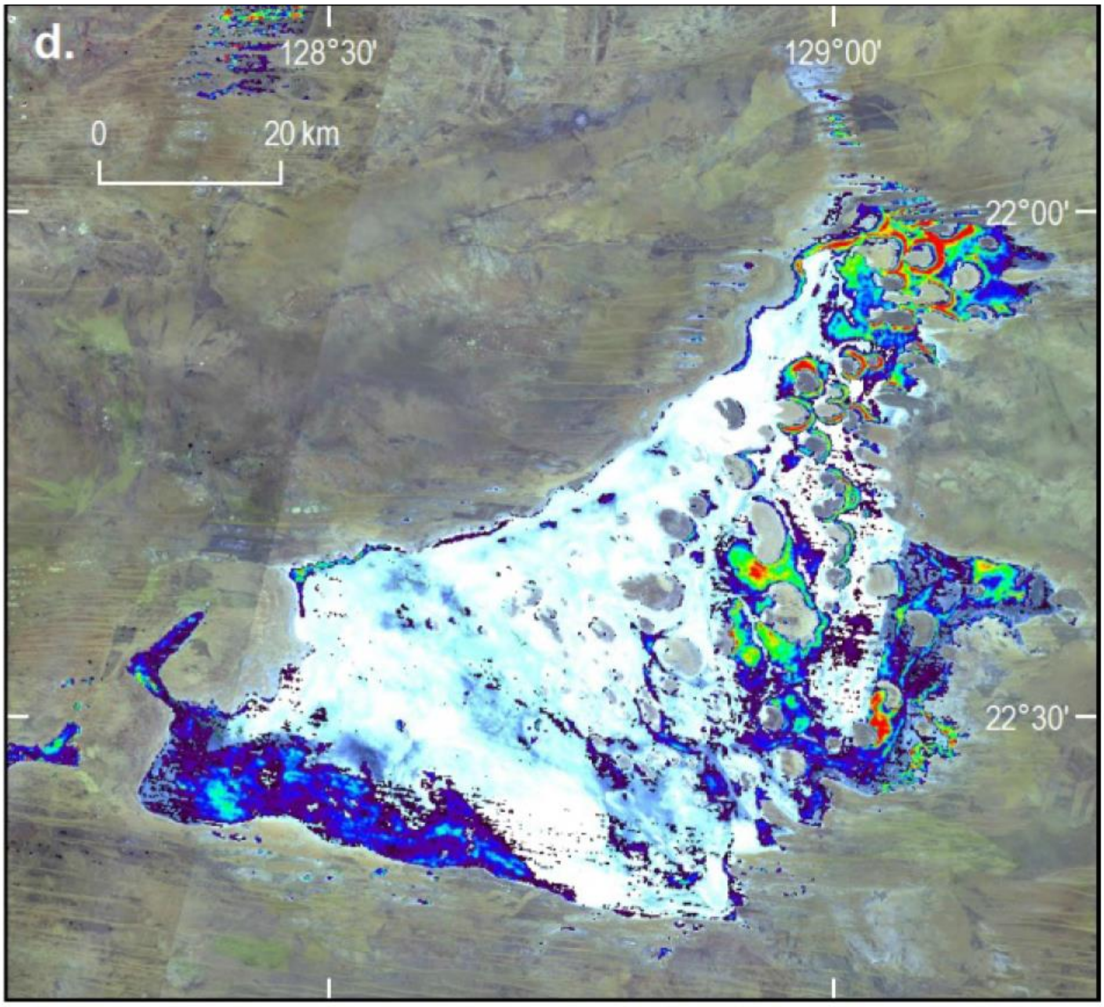

Figure 6.44: Aster gypsum index image of Lake Mackay, where red shows the highest levels of gypsum and blue shows low levels (from GA review of Australian Salt Lakes)

7 ADJACENT PROPERTIES

7.1 Observations from the Rum Jungle tenements

The Rum Jungle joint venture tenements in the south of Lake Mackay were drilled by RUM in 2014, with a resource defined to an average depth of 12.1 metres. RUM commented their aircore program, commenced following a period of strong rainfall, produced lower grade results than the shallow 2011 Toro vibracore program (Figures 7.1 and 7.2). The results from that vibracore program appear directly comparable to the assay results obtained by Agrimin in aircore and power auger holes.

The results from the RUM aircore drilling average 3243 mg/l K less than the vibracore results, which probably reflects rainfall dilution – as Agrimin aircore drilling suggested K results do not vary significantly between the upper gypsum sand layer and the underlying clays. This is an important observation, as it indicates there is significant dilution following periods of rain and this has important applications for solar concentration of brine.

Another important observation (recounted by the driller used by Agrimin and RUM) is that there were significant water flows from the gypsum sand unit during RUM drilling. This was confirmed by drilling of MA27, which is reported to have produced up to 10 l/s during airlifting during installation of the collar pipe. Artesian conditions were previously identified by RUM in their properties and these bores are most likely to have been LMAC001 and LMAC002, on the southern boundary of the lake (see Figure 7.1 below). It is uncertain what the geological/hydrogeological connection is with the paleochannel identified by Toro Energy south of the lake (see below).

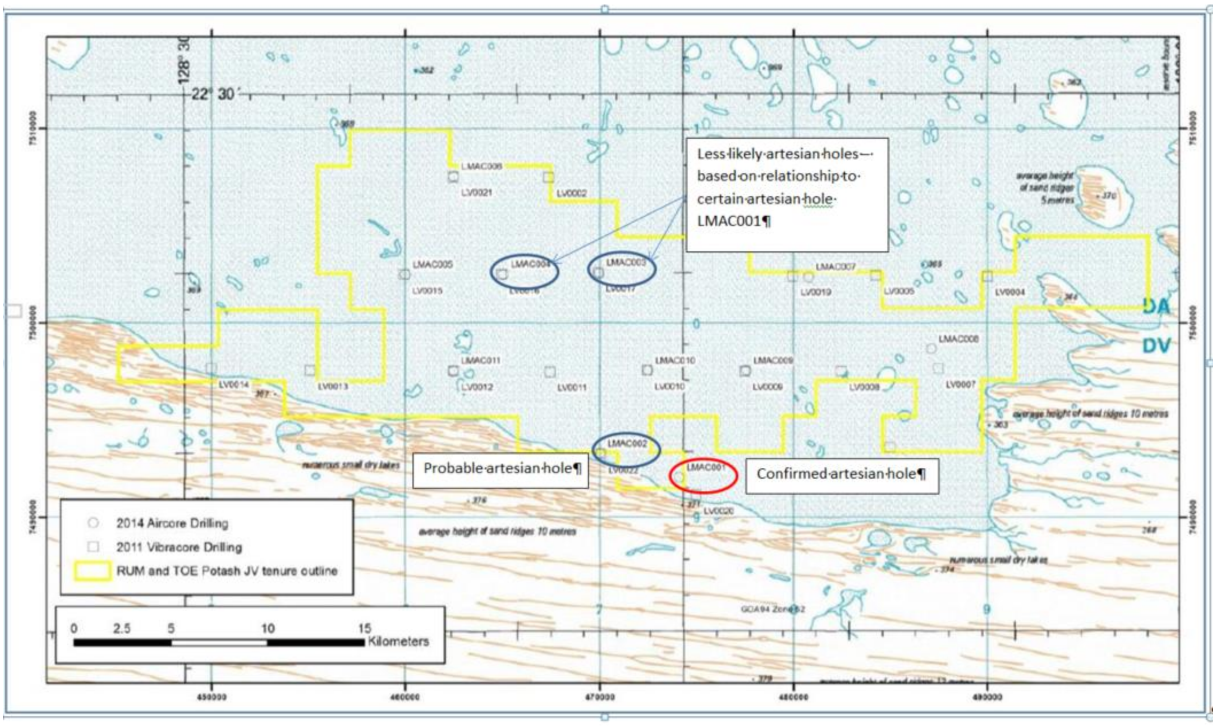

Figure 7.1: Location of Rum Jungle drilling and probably artesian holes

7.2 Observations from the Toro Energy exploration

Toro energy drilled three holes (1 diamond, 2 RC) on magnetic targets for IOCG style mineralisation at different locations approximately 7 km south of the lake boundary. These holes intersected sands to a depth of 105 to >112 metres with sands and clays. Significant sand dominated units are apparently present, as suggested by the terminology “running sands” in the Toro report (2009) on the drilling. This appears to be a paleochannel that may be part of the broader network interpreted in the Wilkinkarra study by Geoscience Australia, which identified the channel they drilled east of Lake Mackay to be shallowing toward the lake (depth of ~45 m in the closer holes 100 km east of the lake.

The channel reported by Toro Energy is significantly deeper (Figure 7.3). Unfortunately no information was provided on the salinity of the water in these three holes. An attempt should be made to obtain the geophysics conducted by Toro, as this may define the channel in this area and whether it projects into Agrimin tenements.

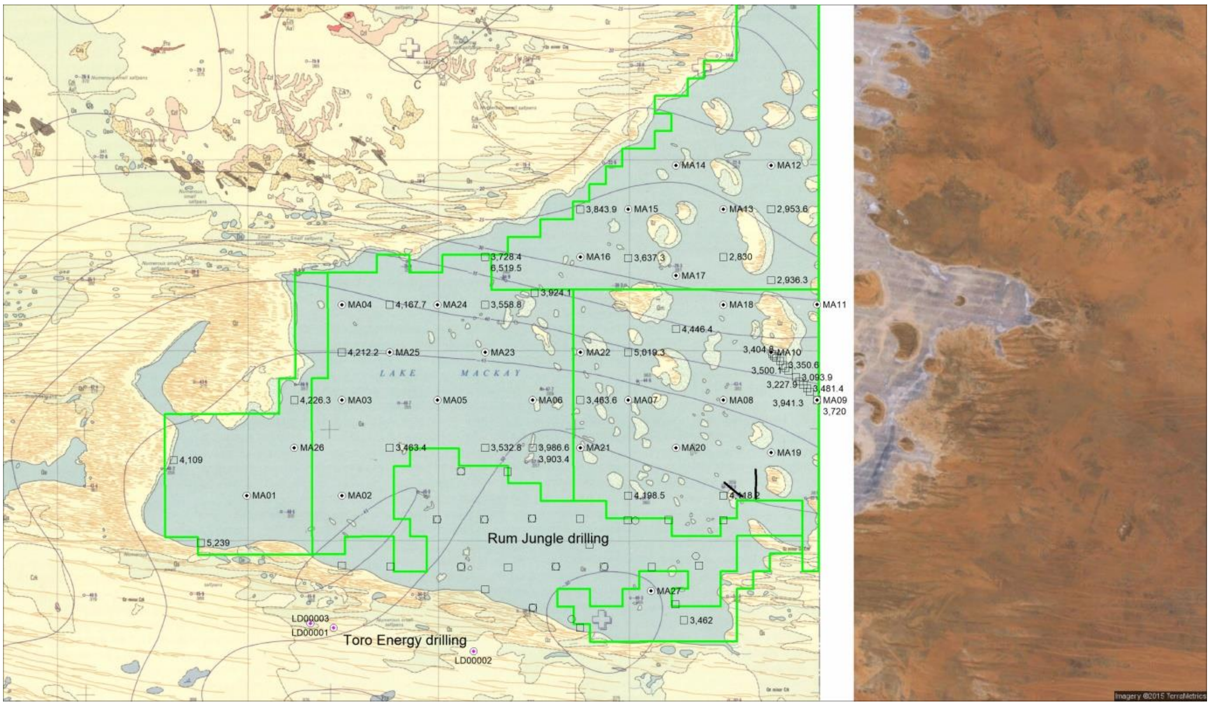

Figure 7.2: Location of Rum Jungle and Toro drilling

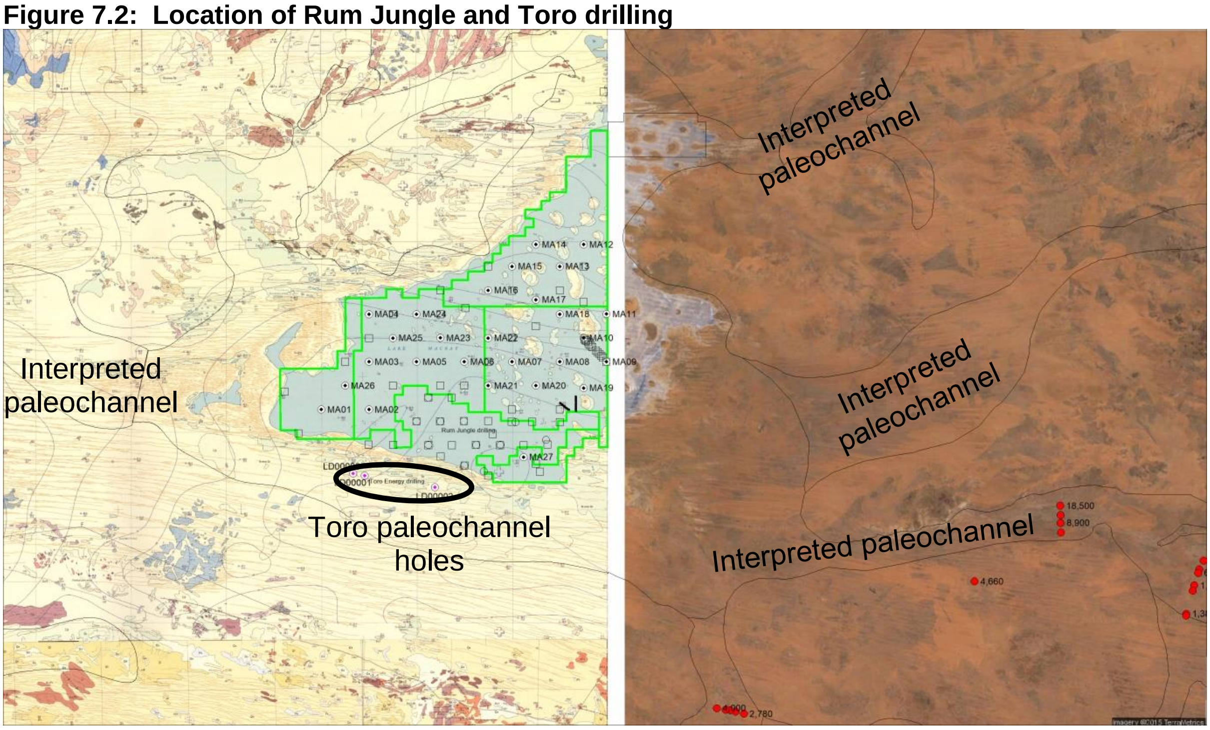

Figure 7.3: The location of Toro drilling and regional interpreted paleochannels

8 SUMMARY OF EXPLORATION ACTIVITIES

Exploration carried out to date consists of the following stages:

- Hand (5) and power auger (34) sampling,
- Aircore (27) drill holes
- Push tube sampling (3 narrow diameter)
- Large diameter push tubes for geotechnical testing (3 larger diameter for geotech)
- Analysis and check sampling of brine samples (150 samples to ALS, 126 to Intertek)
- Taking 5000 litres of bulk brine sample for process test work
- Development of a conceptual model

The sampling techniques are documented in the following sections.

9 DRILLING AND RELATED ACTIVITIES

9.1 Drilling and well installation methodology

Drilling was conducted with a purposed built helicopter portable aircore drill rig, build by Sid Colling of Colling Exploration (Figure 9.1). This rig used 3 m steel drill rods and an aircore bit to advance as deep as 30 m in drill holes in the east of the lake. The drill rig was relatively low powered, limited by the compressor size to allow transportation by helicopter. The drilling rig and compressor each weighed around 950 kg, close to the helicopter legal lift limit of 1000 kg. The location of drill holes, auger holes and wells installed is shown in Figure 9.2 and in Tables 9.1 and 9.2.

9.1.1 Planned program and field modifications

- The intention of the program was to install up to 10 100 mm test production bores, with 1 or more 50 mm observation wells to measure the drawdown cone related to pumping from the test bore.
- Slow drilling required a change of strategy to maximise the number of holes drilled and bores installed.
- This required a substition of 50 mm wells for 100 mm bores, forgoing installation of additional wells for monitoring at any of the pumping sites. Pumping drawdowns were consequently only measured in the pump bores
- Pump testing was subsequently conducted with samller submersible pumps, with lower flow rates to test the aquifer production.

Figure 9.1: Aircore drilling rig and associated equipment

9.1.2 Well head installation

The first 8 holes of the drilling program (MA01-MA08 – see Figure 9.2) were drilled to 2.5 m, then reamed with a 8 inch blade bit to allow installation of nominal 150 mm ID PVC bore casing to this depth. Generally the bore casing was pushed into the underlying clay, to provide the best possible seal at the top of the hole. The bore casing was installed with a length of black (~18 mm diameter) irrigation piping duct taped to the side of the casing (Figure 9.3). This was installed above the intended depth where the casing was pushed into the clay.

Two part expansion foam was mixed in a plastic bag or bottle and compressed air was used to inject this to the base of the hole, to displace some of the water and allow the expanding foam to fill the annulus and return to the surface in expanded form. Additional foam was added around the top of the casing, where not filled by foam ascending from below, to seal the hole as best possible. It was not possible to remove all the brine from the hole prior to installing the foam and the effect of the brine on the foam structure and life of the foam is unknown. In the case of MA27 a PVC surface monument was constructed, but there is no well installed in the hole. Drill locations details are provided in Tables 9.1 and 9.2.

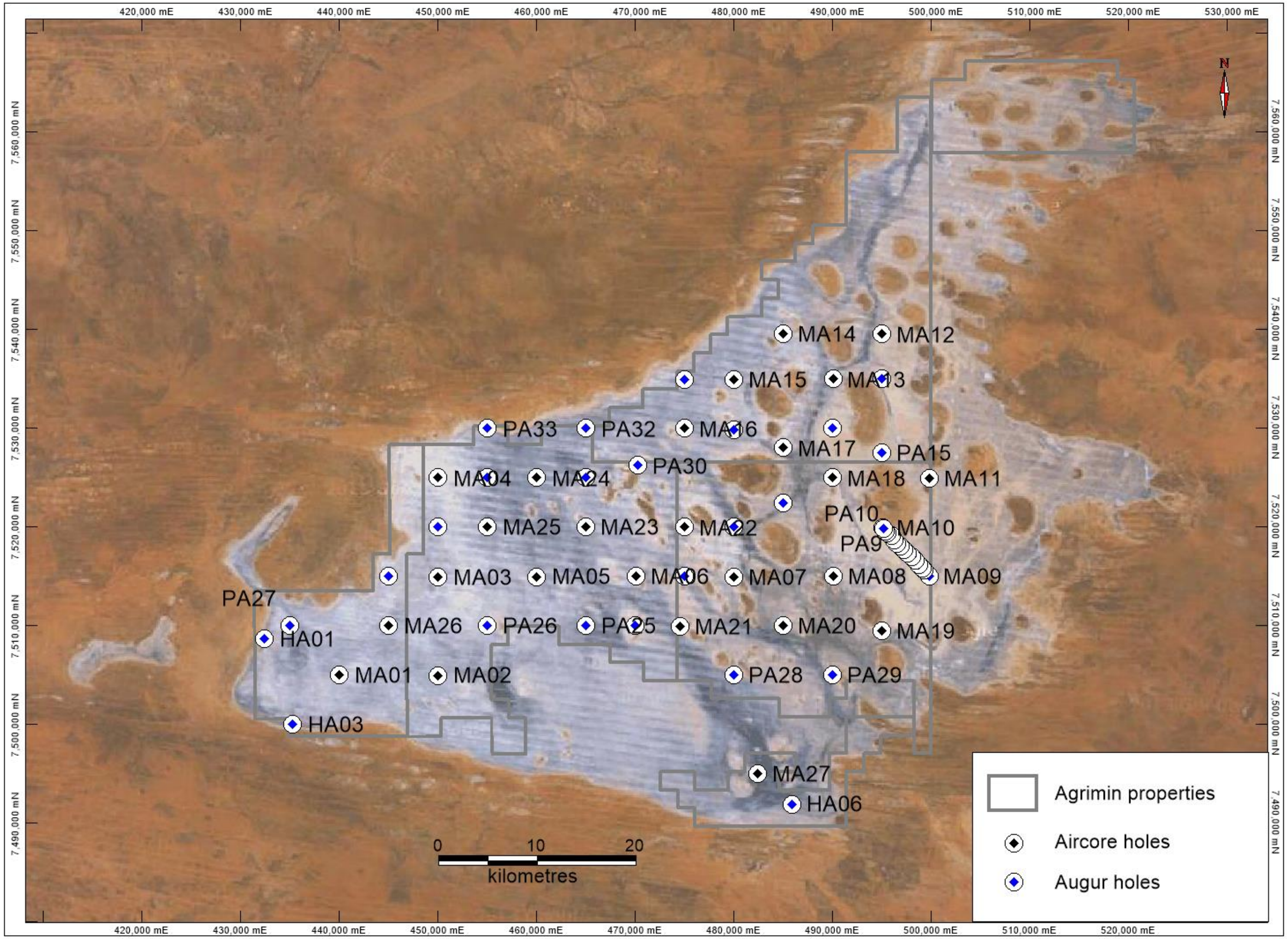

Figure 9.2: Aircore and auger holes and well locations

Hole ID	Easting	Northing	Total Depth (m)	K (mg/l)	Mg (mg/l)	SO4 (mg/l)	SO4/K	SO4/Mg	K/Mg
MA01	440018	7505016	24	3,315	3,151	30,185	9.1	9.6	1.1
MA02	450003	7504992	16.7	3,308	3,584	25,825	7.8	7.2	0.9
MA03	449969	7514950	19	4,548	4,020	24,506	5.4	6.1	1.1
MA04	450003	7524996	24	4,111	3,653	24,467	6.0	6.7	1.1
MA05	460003	7514992	18.7	3,495	2,751	21,927	6.3	8.0	1.3
MA06	470022	7515008	22.5	3,649	2,867	22,653	6.2	7.9	1.3
MA07	479996	7514981	27	3,872	2,573	21,265	5.5	8.3	1.5
MA08	490050	7515074	30	3,305	3,476	22,727	6.9	6.5	1.0
MA09	499801	7515003	30	3,223	3,362	23,968	7.4	7.1	1.0
MA10	495031	7519985	29	2,691	1,953	15,425	5.7	7.9	1.4
MA11	499807	7524974	30	3,140	2,915	19,869	6.3	6.8	1.1
MA12	495000	7539595	27	3,177	1,883	21,220	6.7	11.3	1.7
MA13	490028	7534995	26	3,364	2,824	22,482	6.7	8.0	1.2
MA14	485014	7539617	20	3,560	3,697	24,166	6.8	6.5	1.0
MA15	480001	7534993	25	3,373	3,039	22,373	6.6	7.4	1.1
MA16	475005	7529997	27	3,370	3,193	20,483	6.1	6.4	1.1
MA17	485007	7528035	30	4,031	2,876	23,386	5.8	8.1	1.4
MA18	489998	7525007	26.8	3,164	2,514	21,092	6.7	8.4	1.3
MA19	494995	7509521	27	3,381	2,094	23,060	6.8	11.0	1.6
MA20	484997	7510000	21.5	3,590	2,621	25,303	7.0	9.7	1.4
MA21	474508	7509959	22	4,175	3,480	22,070	5.3	6.3	1.2
MA22	474993	7519995	28	3,570	2,744	24,337	6.8	8.9	1.3
MA23	464982	7520024	24	3,807	2,972	21,006	5.5	7.1	1.3
MA24	460000	7524999	18	3,830	3,704	22,336	5.8	6.0	1.0
MA25	454987	7520000	26.5	3,897	3,181	22,771	5.8	7.2	1.2
MA26	444989	7510006	22.5	3,930	4,180	24,480	6.2	5.9	0.9
MA27	482410	7495004	25	4,395	2,658	29,008	6.6	10.9	1.7
AVERAGE OF AIRCORE DRILL HOLES			**24.7**	**3,603**	**3,036**	**23,051**	**6.4**	**7.8**	**1.2**
SHALLOW VIBRACORE DRILL ASSAYS			**2.7**	**3,063**	**3,326**	**22,116**	**7.3**	**6.7**	**0.9**
% Difference relative to 2009 drilling				**16.2%**	**-9.1%**	**4.1%**	**-12.7%**	**15.6%**	**27.4%**

Table 9.1: Aircore drill hole coordinates, assays and ratios

Hole ID	Easting	Northing	K (mg/l)	Mg (mg/l)	SO4 (mg/l)	SO4/K	SO4/Mg	K/Mg
HA01	432353	7508719	4,109	2,906	31,395	7.6	10.8	1.4
HA03	435206	7500041	5,239	6,319	34,481	6.6	5.5	0.8
HA04	499822	7515003	2,927	1,987	23,901	8.2	12.0	1.5
HA05	489999	7530002	2,276	1,333	18,719	8.2	14.0	1.7
HA06	485860	7491930	3,462	2,650	26,417	7.6	10.0	1.3
PA1	499228	7515653	3,468	2,496	30,694	8.8	12.3	1.4
PA2	499042	7515874	3,941	3,162	22,716	5.8	7.2	1.2
PA3	498770	7516208	3,481	2,607	22,185	6.4	8.5	1.3
PA4	498390	7516601	3,228	1,753	21,930	6.8	12.5	1.8
PA5	497996	7516981	3,142	1,942	22,377	7.1	11.5	1.6
PA6	497600	7517377	3,094	2,643	20,354	6.6	7.7	1.2
PA7	497230	7517742	4,523	3,971	27,048	6.0	6.8	1.1
PA8	496814	7518095	3,500	2,744	19,766	5.6	7.2	1.3
PA9	496509	7518372	3,336	2,127	20,805	6.2	9.8	1.6
PA10	496199	7518660	3,351	1,988	21,298	6.4	10.7	1.7
PA11	495927	7519113	3,405	2,280	21,107	6.2	9.3	1.5
PA12	495540	7519432	3,146	2,072	18,583	5.9	9.0	1.5
PA13	495307	7519609	1,953	1,440	13,142	6.7	9.1	1.4
PA14	495155	7519829	2,474	1,635	14,564	5.9	8.9	1.5
PA15	495004	7527573	2,936	1,589	17,715	6.0	11.1	1.8
PA16	494996	7535003	2,954	1,780	18,413	6.2	10.3	1.7
PA18	480008	7529895	3,637	3,056	23,708	6.5	7.8	1.2
PA19	474988	7534981	3,844	2,949	24,112	6.3	8.2	1.3
PA21	485011	7522434	4,446	3,418	23,021	5.2	6.7	1.3
PA22	480008	7520004	5,019	3,387	27,841	5.5	8.2	1.5
PA23	475000	7515002	3,464	3,413	23,890	6.9	7.0	1.0
PA24	470000	7510001	3,987	2,414	24,729	6.2	10.2	1.7
PA25	465000	7509997	3,533	3,314	23,687	6.7	7.1	1.1
PA26	455001	7509999	3,463	3,243	24,593	7.1	7.6	1.1
PA27	435000	7510000	3,903	4,030	31,629	8.1	7.8	1.0
PA28	480000	7505000	4,199	3,272	26,193	6.2	8.0	1.3
PA29	490000	7505000	4,118	3,793	27,584	6.7	7.3	1.1
PA30	470234	7526253	3,924	3,075	22,096	5.6	7.2	1.3
PA31	465000	7524999	3,559	3,011	20,645	5.8	6.9	1.2
PA32	465000	7530001	3,728	3,516	21,160	5.7	6.0	1.1
PA33	454999	7530001	6,520	7,857	44,747	6.9	5.7	0.8
PA34	454999	7525001	4,168	3,870	23,611	5.7	6.1	1.1
PA35	450001	7520001	4,212	3,988	23,814	5.7	6.0	1.1
PA36	445005	7515004	4,226	3,068	25,341	6.0	8.3	1.4
AVERAGE OF AUGER DRILL HOLES			**3,690**	**2,977**	**23,846**	6.5	8.6	1.3
SHALLOW VIBRACORE DRILL ASSAYS			**3,063**	**3,326**	**22,116**	7.3	6.7	0.9
% Difference relative to 2009 drilling			**18.6%**	**-11.1%**	**7.5%**	**-11.7%**	**25.3%**	**35.4%**

Table 9.2: Auger hole coordinates, assays and ratios

Figure 9.3: Precollar installation with tremie pipe for expansion foam

9.1.3 Well installation

50 mm monitoring wells were installed in 14 holes, with most of these installed at the beginning of the program. The 50 mm pipe is machine slotted with 0.8 mm slots and threads that allow easy connection of the 3 metre pipe lengths. The general intention was to install wells with a 3 m solid (non-slotted) section to surface and additional solid pipe to approximately 0.5 m above the lake surface. This construction excludes the superficial aquifer present in places within gypsum sands, which is the most productive aquifer in the lake sediments.

The 50 mm monitoring well materials were purchased for the program to install monitoring wells a short distance from test production wells and the trenches, however due to the slow progress drilling it was decided to install 50 mm wells instead of 100 m wells in general, to save the time required for reaming the holes to a larger diameter. However, due to collapse of some holes there were several holes where the surface section was slotted and the upper brine is not excluded from the well. Wells were installed with internal end caps cemented into the bottom of the threaded section, using a PVC cement compound.

The PVC was installed in the well and within 0.5 m of the base of casing or ~2-3 m below surface a seal was installed around the PVC. This consisted of cutting a donut shape from stiff plastic that was duct taped onto the pipe in the appropriate position. This was then lowered into position on the last length of PVC. Mixed expansion foam was then poured down the annulus between the 50 mm PVC and the 150 mm bore casing or natural hole walls, expanding to surface to fill this void. At times more than one application of foam was required for the foam to reach above ground level.

100 mm PVC was purchased for the project as test production bores, however only three of these were installed across the lake, for reasons discussed above. These were installed also with internal end caps cemented in place and with a donut-shaped plastic cut-out used at the top of the hole to contain expansion foam between from extending below the depth of the cut-out and blocking the screens on the well.

PVC end caps were added to the tops of wells, with the hole name (and generally the completion date) written on the inside of the well caps. These were partially cut through on the sides, to allow the caps to be removed relatively easily.

9.2 Power and hand auger sampling

Several hand auger holes were constructed and a number of samples taken. These (HA02 and HA03) showed the western area of the lake is predominantly red-brown clay from surface, with minor gypsum sand (10-20 cm) above the water table. Holes HA04 and HA05 showed there are significant areas of gypsum sand in the east of the lake.

Subsequent to the initial hand auger sampling it was decided to obtain a power auger and conduct sampling across the lake, to fill in areas where the aircore drilling was less than the preferred spacing. A detailed power auger transect was also conducted between holes MA09 (LMD77) and MA10 (LMD72) at approximately 200 m spacing, to evaluate the change in brine concentration and lithology between the two islands adjacent to these drill sites. This information is presented in section 12 (Brine Chemistry). Power augering in the east of the lake confirmed the presence of gypsum sand in places to the base of augering at 1.5 m.

9.3 Trenching

Trench LT1 (Figure 9.4) was established at the site of the proposed trench LMT2 in the west of the lake, close to the access track that continues north to Balgo. This consisted of two segments of trench at an angle to each other, to evaluate whether there is any anisotropy in the distribution of thin gypsum layers which appeared to contribute a significant amount of the brine inflows. Trench MP1 was located at the site of MA19. The trench is shown in Figure 9.5. Brine samples were taken from both trenches at different times during the pump testing.

Figure 9.4: Trench LT1 in the west of the lake

Figure 9.5: Test pit/hand dug trench MP1 in the east of the lake

9.4 Push tube sampling

Push tube sampling was undertaken at three sites using the aircore rig, consisting of holes MA01 (west), MA18 (east) and MA23 (central) at different locations across the lake. The push tubes are driven into the ground using a hydraulic hammer and they are collected in 1.2 m long plastic tubes of ~40 mm diameter within the steel sample tube. The tube is recovered and tight fitting end caps are then fitted and the contact tapped with duct tape, with the top and bottom of the tubes labelled. This material has been used to select shorter intervals for permeability test work. Figure 9.6 shows an example of recovered cores from MA18.

Figure 9.6: Push tubes taken from hole MA18

9.5 Large diameter push tube sampling

Larger diameter (~10 cm) push tube samples were also taken in three locations across the lake to obtain material for an evaluation of engineering properties. These cores were collected based on the requirements provided by geotechnical and engineering consultants GHD. Permeability and grainsize analysis was conducted on this material. Additional water samples were taken from the water used as the camp water supply, from a slightly brackish lake between the camp and the salt lake.

9.6 Aircore drill spacing

A total of 27 aircore holes were drilled on the project. This corresponds to 1 hole per 47 km^2 of the property held by Agrimin in WA. The average spacing between drill holes is approximately 7.5 km. Power auger sampling was undertaken between drill holes, to reduce the spacing between drill hole sampling points, to assist resource estimation. Brine analyses have shown the brine in the upper 1.5 metres is similar to the overall brine composition of the sequence overall, except in the vicinity of islands where lenses of fresh to brackish water are interpreted to lower the brine grade.

9.7 Geological logging

Aircore sampling was conducted on three metre intervals, equivalent to the drilling rod length. Samples were collected in a bucket under the cyclone, and it was generally necessary to use a shovel to clean out the cyclone into every three metre sample bucket, as the thick clay stuck inside the cyclone caking the walls. As water was not generally injected the clay recovered in the bucket was stiff and probably not much changed from the in-situ state. Drilling tended to recover material in pulses, with the clay blocking the sample tube from the rig to the cyclone and being liberated in pulses, marked by a rush of air as the sample entered the cyclone or bucket, clearing the sample tube.

Samples were laid out in rows on the ground and the geologist felt the material to establish whether there were any cuttings present. The cuttings were recovered and then washed in a bucket with a sieve to clean them up for observation with a hand lens. A representative handful of material from each three metre interval was placed in a snap top plastic bag, sealed and labelled with the hole number and depth. Photographs were taken of the samples laid out on the ground for the first 10 holes, but not the remaining 17.

Additional information was obtained on the important upper part of the hole by digging a test pit close to the rig and noting the lithological detail in the top ~60-70 cm from surface. A measurement of the standing water level was also made in these pits, before a brine sample was taken or water used by the driller for injection (volumes used were low – equivalent to a one or several small coke bottles). Pits were dug for ~ the first 11 holes. Subsequently on later holes push tubes were hand inserted to a depth of about 1 metre, capped at the upper end and withdrawn to observe the lithology over this depth.

Representative sample from each 3 m drilling interval and the more detailed sampling at the top of each hole was logged and drill cuttings observed with a hand lens. This information was entered into a logging sheet recording the depth intervals, lithology, texture, approximate percentages of different size fractions, colour and engineering properties of the materials. The log sheet information was then compiled into an excel database which was used to plot drill sections and support resource estimation. Lithologies encountered are summarized in Table 9.3.

Power auger samples were geologically logged (by Murray Brooker) after the field program was complete, as this sampling was undertaken during a short time frame at the end of the program and it was not possible to log the samples before demobilization from the site. Photographs of the chip trays were taken for reference.

The geological codes used for logging drill cuttings are outlined in Table 9.3, below.

CODE	DESCRIPTION
CLY	CLAY - ORGANIC OR WITH GYPSUM
CLYRB	CLAY RED
CLYB	CLAY BROWN
CLYG	CLAY GREEN
GRAG	GYPSUM **VERY COARSE SAND TO GRIT/FINE GRAVEL (> 2 MM GRAINS)**
SNDC	SAND COARSE **- Loose gypsum sand**
SNDF	SAND FINE **- Loose gypsum sand**
GPSD	GYPSUM "SAND" - **Compact, cemented layer**
GYP	CRYSTALLINE GYPSUM **- Generally transparent/translucent**
SAP	SAPROLITIC BLEACHED CLAYS
WTHR	BLEACHED HEMATITIC WEATHERED ROCK
SS	SANDSTONE
SNCL	SANDY CLAY/ CLAYEY SAND MIX
SISD	SILTY SAND/SANDY SILT MIX
SILT	SILT

Table 9.3: Summary of lithological codes

A summary of the different lithological units encountered in aircore and auger drilling is presented in Figure 9.7.

- Aircore drilling primarily intersected clay units, with coarse and fine gypsum sand layers (SNDC and SNDF) in the upper 1.5-2 m of the lake sediments, overlying clays.
- There are some layers of crystalline gypsum at depths from <1 to 27 metres, but compact granular gypsum is more common (visually this is cemented and has minimal porosity) and is distributed throughout the holes.
- Some silt is present, generally within the upper 2 metres, but this is much less common than clay.
- Power auger sampling confirmed that up to a metre of fine to coarse gypsum sand to grit/gravel overlies sandy and silty clays to a depth of around 2 metres. Below this is consistent stiff brown/red-brown clay.

9.8 Porosity sampling

Porosity samples were taken from push tubes in aircore holes MA01 (0-3.6 m), MA18 (0-7.2 m) and MA23 (0-4.8 m). The sample intervals tested are presented in sections 10 and 11 discussing permeability and porosity.

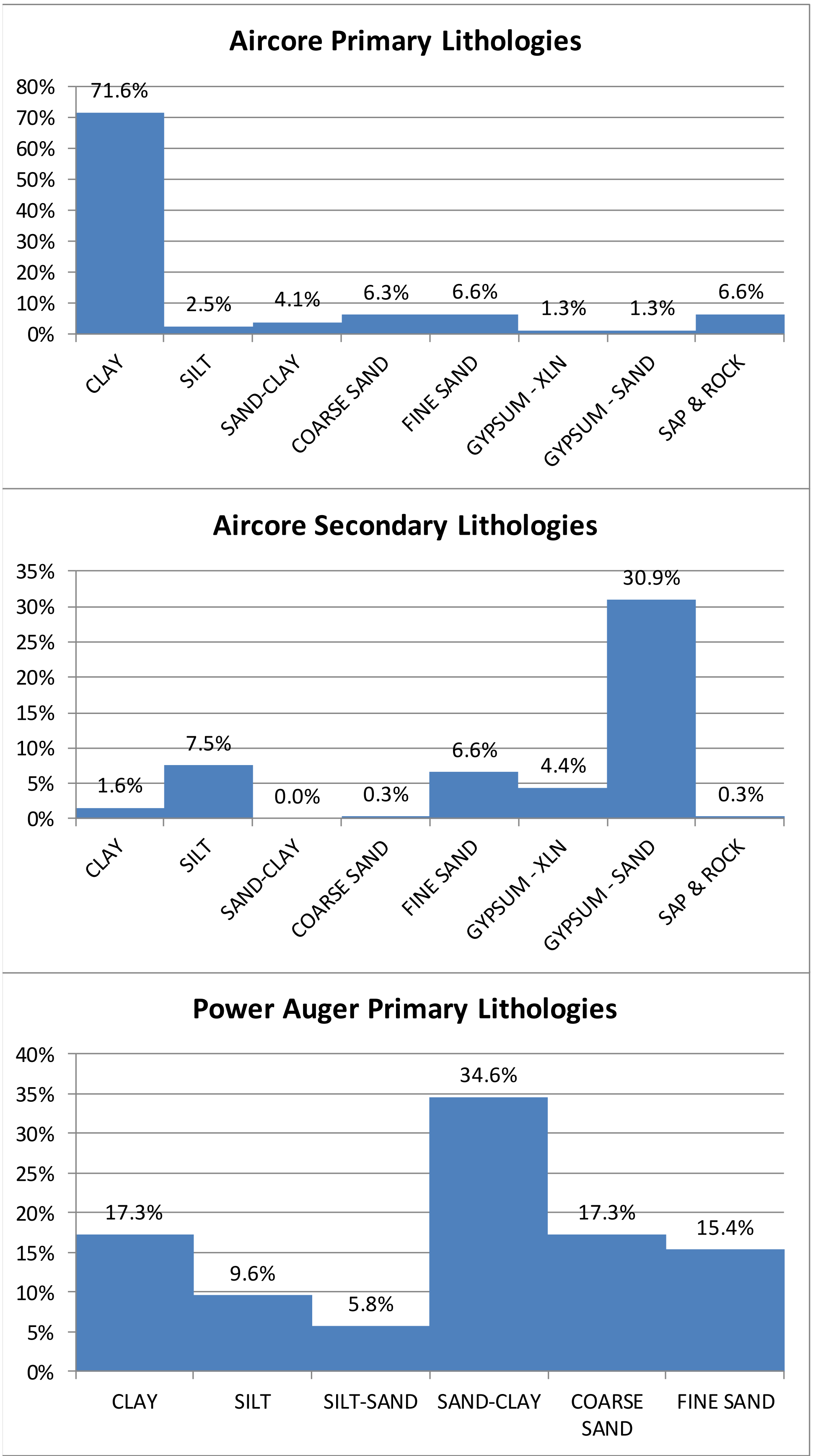

Figure 9.7: Lithologies and their frequency of observation in drill holes

9.9 Brine sampling

Brine sampling was undertaken in aircore holes by a combination of sampling methods.

- A surface sample was collected from hand pits directly into a 1 litre bottle
- Samples were recovered by airlifting in intervals where water inflows were detected. These were recovered at the cyclone, or in some cases when the drill hole had outside return around the rods from the mouth of the drill hole
- Where PVC casing was installed samples were also obtained by pump testing.

Brine samples were collected in 10 litre buckets under the cyclone or 2 litre buckets from the drill hole mouth. As for pump testing the sample was then transferred to a 1 litre sample bottle which was labelled and transported to camp in an esky (without ice) for filtration. Bottles were labeled with the hole and sample depth with permanent marker pens,

Field parameters were measured in the field using a Hanna pH meter and EC meter. The EC meter had a maximum of 200 mS in temperature compensated mode, so it was necessary to use the equipment in non-compensated mode, as samples typically had EC above 200 mS. The temperature of the samples was also noted, as was the density – which was measured with a floating pycnometer. Five of these were purchased to cover the range from densities of 1.0 to 1.25 g/cc in 0.05 g/cc increments. These are pre-calibrated glass tubes that do not require ongoing calibration, and float at the level corresponding to the sample density on the scale.

Where samples were turbid with suspended material they were filtered to produce a 150 ml sample of filtered water for the laboratory. Before being sent to the laboratory the 150 ml bottles of fluid were sealed with tape and labeled with a unique sample number. The hole number, depth, date of collection, and physical parameters of each sample number were recorded in a spreadsheet control of samples. Photographs were taken of the original 1 litre sample bottles and the 150 ml bottles of filtered water, to document the relationship of sample numbers, drill holes and depths.

Samples for analysis were transported to the Perth office of Agrimin, from which they were delivered to the ALS, Intertek and Bureau Veritas laboratories in Perth. A selection of samples was sent by Courier to the University of Antofagasta laboratory in Perth. Additional sample have been retained in the Perth office for future reference. Laboratory standards, and duplicate samples were inserted in the sample batches prior to sending to the laboratory.

9.10 Sample security

The samples were transported by the company to the shed used to store equipment in Alice Springs. The samples were then delivered in eskies sealed with tape to the office of a courier company for transport to the office of the ALS laboratory in Perth. Chain of Custody forms provided by the ALS laboratory accompanied the samples to the laboratory. A sample list, analytical instructions and details of the person submitting the samples was sent to the laboratory by email.

Duplicate samples were maintained in the storage shed in Alice Springs for security. Photographs were taken of sample bottles for reference during the first half of the program, as an additional sample control.

10 BRINE SAMPLE ANALYSIS

10.1 Sample nomenclature

Samples were given a unique sample number based on the type of hole, depth, sampling, type, and time.

- Aircore holes. Hole ID and depth, for example AC09_30 (a 30 m sample from the aircore hole MA09).
- Pump test holes. Hole number from aircore hole, sequential labelled time from start of the pump testing. (i.e. PT3a, PT3b).
- Power auger samples (i.e. PA04).
- Trench samples labelled by trench (i.e. LMT2A)

10.2 Sample preparation

The field parameters of fluid samples were measured at the drill site, with density, pH, electrical conductivity and temperature measured and recorded for samples. Samples were filtered at the field camp using a vacuum hand pump or syringe fitted to a disposable filter. Samples were generally allowed to settle for at least 24 hours before extracting the brine for filtering, as there were a considerable amount of clay particles in suspension. A 250 ml unpreserved sample bottle was sent to the laboratory for major anions and cations analysis, with a 60 ml bottle sent for metals analysis (with acidification upon receipt in the laboratory).

Four batches of samples were sent to the ALS laboratory with the smallest initial batch of 13 samples sent without QA/QC samples and the three subsequent batches sent with standards, field duplicates and blanks.

10.3 Standard preparation

Prior to the field program discussions were held with laboratories regarding the contract for analyses. As part of discussions with laboratories they were asked to provide quotations for preparation of standards, with the intention for standards to a recipe provided by Consultant Process Engineer Peter Ehren to be similar to the original Reward minerals brine samples from 2009.

When the contract for analyses was given to ALS the SGS lab was not willing to prepare the samples and consequently these were prepared at the ALS laboratory. However, the original recipe was changed slightly, due to the issue of HCl used in the proposed recipe, with corresponding loss of CO2 from carbonate. Consequently, following consultation with Agrimin ALS modified the recipe and produced the two standards. However, following fabrication of the standards and during the analyses to certify them the lab staff noted some precipitation of salts.

The subsequent standards were consequently of a higher potassium grade than originally designed, with:

- Standard 1 certified at 3780 mg/l K (compared with a planned grade of 2500 mg/l K); and
- Standard 2 certified at 5120 mg/l K, (compared to a planned grade of 4000 mg/l K).

The certified values of the standards are shown in Table 12.1. Of note are the high differences in ionic balance, for what are synthetic samples.

10.4 QA/QC metrics

10.4.1 Evaluation using relative percentage differences (RPD)

Standard and duplicate samples have been evaluated by calculating the relative percentage difference between the two or more samples for each standard sample. The standard formula used consists of:

Relative percent difference = ABS (value 1-value 2) / AVERAGE (value 1, value 2)
Where ABS = the absolute value of the difference between the two (or more) samples. In the case of more than two samples the greatest difference was used, with the average of all the samples used. In addition the mean and standard deviation has been calculated for each standard analysed.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	STD 1	STD 2
			Client sampling date / time	[22-Jul-2015]	[22-Jul-2015]
Compound	CAS Number	LOR	Unit	EP1512262-001	EP1512262-002
				Result	Result
EA005P: pH by PC Titrator					
pH Value	----	0.01	pH Unit	9.38	9.14
EA010P: Conductivity by PC Titrator					
Electrical Conductivity @ 25°C	----	1	µS/cm	197000	225000
ED037P: Alkalinity by PC Titrator					
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	428	168
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	32	2
Total Alkalinity as CaCO3	----	1	mg/L	460	171
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA					
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	19700	27400
ED045G: Chloride by Discrete Analyser					
Chloride	16887-00-6	1	mg/L	109000	130000
ED093F: Dissolved Major Cations					
Calcium	7440-70-2	1	mg/L	239	92
Magnesium	7439-95-4	1	mg/L	3000	3660
Sodium	7440-23-5	1	mg/L	64800	74000
Potassium	7440-09-7	1	mg/L	3780	5120
EN055: Ionic Balance					
^ Total Anions	----	0.01	meq/L	3490	4240
^ Total Cations	----	0.01	meq/L	3170	3660
^ Ionic Balance	----	0.01	%	4.82	7.43

Table 10.1: Certified values for brine standards prepared by ALS

10.4.2 Relative standard deviation

The relative standard deviation of the standards was calculated, to assess deviation from the certified values. This is the standard deviation x 100 / the sample mean.

10.5 Sample analysis – ALS

ALS is NATA Accredited Laboratory 825, accredited for compliance with ISO/IEC 17025. The four sample batches received at ALS (Environmental) laboratories in Perth were analysed for major anions and cations (Ca, Mg, K, Na), major anions (Cl and SO4) and trace metals (As, Li, Mn, Sr, B, Fe). The analytical techniques are summarized in Table 12.2 below. The ALS Environmental Lab is distinct from the ALS Minerals lab. Due to the extremely high content of dissolved solids fixed dilution of filtered samples is undertaken before direct aspiration into an induced coupled plasma instrument. In the laboratory density, conductivity, pH, temperature and total dissolved solids were measured to provide a check on field parameters.

The intention was to send a subset of the ALS samples to a secondary laboratory as an inter-laboratory check. However, following receipt of results from the four batches Agrimin was advised by ALS that the results from the Environmental Lab had been found to be up to 20% higher than other check laboratories in their assessment of the Environmental Laboratory performance. Unfortunately this information was received the same day, immediately following release of public release of the ALS results.

10.6 Sample analysis – Intertek

On the basis all of the samples analysed at ALS were sent to Intertek for analysis. There was however insufficient sample for 29 of the original samples (including the 13 samples in the first batch) and no re-analysis was obtained for those samples.

Trace metals and alkalinity were not analysed at Intertek, as these were present in low concentrations as detected by ALS. Sulphate concentration was calculated from the analysis of elemental Sulphur by ICP.

Analysis	ALS Method	Detection limit	Intertek Method & Detection limit	Detection limit	Bureau Veritas Method	Detection limit
Physical Parameters						
Density			Gravimetric	0.001	Liquid picnometry	0.01 g/cc
Electrical Conductivit	EA010P: Conductivity by PC Titrator	1 µS/cm				
Total dissolved solids	EA015: Total Dissolved Solids	10 mg/L	Gravimetric	0.02 (g/kg)	Total Dissolved Solids @180oC	20 mg/kg
pH	EA005P: pH by PC Titrator	0.01				
Chloride	ED045G: Chloride by Discrete Analyser	1 mg/L	ICP Optical Emission Spectrometry		Colourimetrically	50 mg/l
Sulphate	ED041G: Sulfate (Turbidimetric) as SO4 2- by DA	1 mg/L	ICP Optical Emission Spectrometry for S, SO4 calculated	0.3 mg/l	ICP Optical Emission Spectrometry for S, SO4 calculated	10 mg/l
Alkalinity	ED037P: Alkalinity by PC Titrator	0.01				
Ca, Mg, Na, K	ED093F: Dissolved Major Cations. ICP-AES or ICP-MS techniques.	1 mg/L	ICP Optical Emission Spectrometry	0.1 mg/l (Na, K); 0.01 mg/l Ca, Mg	ICP Optical Emission Spectrometry	10 mg/l (Na, K); 1 mg/l Ca, 5 mg/l Mg
As, Li, Mn, Sr	EG020T: Total Metals by ICP-MS	0.001 mg/l				
B, Fe	EG020T: Total Metals by ICP-MS	0.05 mg/l				

Table 10.2: Analytical methods and detection limits
Note that these are limits that apply to samples prior to dilution and the actual limits are consequently different in some analytical reports

10.7 Sample analysis – Bureau Veritas

Bureau Veritas was chosen as the check lab to compare results with Intertek, following the notification by ALS. A total of 14 samples were sent for analysis, also determining the Sulphate concentration by calculation from the analysis of elemental Sulphur by ICP. Trace metals were not analysed.

10.8 QA/QC sampling and protocols

The QA/QC protocol objective was to have a minimum 1 in 10 QA/QC samples. For the program there were 27 QA/QC samples for the 156 samples (17% QA/QC samples).
Of the original 156 samples sent to ALS there were a total of:

- 4 standard samples Standard1 and 5 standard samples Standard2
- 4 Blanks
- 13 field duplicates
- Subsequent analysis at Intertek and Bureau Veritas provided 10 triplicate samples across the three laboratories.

These samples are summarized in Table 12.3.

Sample type	Number of samples	Comments
Samples analysed at ALS		
HOLES&PUMPING	82	MA01-MA27
TRENCH	3	LMT1
AUGERS	39	Includes 5 Hand augers, 34 power augers
QAQC		
STANDARD 1	4	3780 mg/l K
STANDARD 2	5	5120 mg/l K
BLANKS	4	
DUPLICATES	13	
TOTAL	**150**	
Samples analysed at Intertek		
HOLES&PUMPING	63	MA01-MA27
TRENCH	1	LMT1
AUGERS	36	Includes 2 Hand augers, 34 power augers
QAQC		
STANDARD 1	3	3780 mg/l K
STANDARD 2	5	5120 mg/l K
BLANKS	3	
DUPLICATES	12	
TOTAL	**123**	2 samples submitted with insufficient sample - not included in this total
Samples analysed at Bureau Veritas		
HOLES&PUMPING	7	MA01-MA27
TRENCH	1	LMT1
AUGERS		Includes 2 Hand augers, 34 power augers
QAQC		
STANDARD 1		3780 mg/l K
STANDARD 2	2	5120 mg/l K
BLANKS		
DUPLICATES	4	
TOTAL	**14**	

Table 10.3: Summary of samples sent to the three laboratories used in the program

10.9 Results of ALS QA/QC sampling/comparison

10.9.1 Standards

When plotted against the nominal values standard the ALS analyses were consistently higher for K, Mg and sodium, but lower for calcium, and chloride and slightly lower for sulphate. The analyses of the standards (plotted in sequential order in which they were received) show an upward drift. The results are shown in Table 12.4 and Figure 12.1. The ALS analyses show much higher RPD and RSD values than the Intertek analyses.

	Ca mg/l	Mg mg/l	K mg/l	Na mg/l	Sulphate mg/l	Chloride mg/l
Standard 1						
Standard	**239**	**3000**	**3780**	**64800**	**19700**	**109000**
# samples	4	4	4	4	4	4
Average	109	3,315	3,898	74,675	19,150	104,250
Std Dev	5	136	62	6,116	755	1,708
RSD%	5	4	2	8	4	2
Max	114	3480	3980	81000	19800	106000
Min	103	3180	3830	68900	18400	102000
RPD%	10%	9%	4%	16%	7%	4%
Standard 2						
Standard	**92**	**3660**	**5120**	**74000**	**27400**	**130000**
# samples	5	5	5	5	5	5
Average	85	4,264	5,560	91,780	25,400	127,400
Std Dev	5	278	262	4,085	1,164	1,949
RSD%	6	7	5	4	5	2
Max	91	4590	5880	97100	26600	129000
Min	80	3860	5170	87600	24000	124000
RPD%	13%	17%	13%	10%	10%	4%

Table 10.4: Comparison of standard analyses and nominal values

10.9.2 Duplicates

Analytical quality was monitored through the use of randomly inserted quality control samples, which included duplicate samples every ~10 original samples, in addition to standards.

Six of the 14 duplicate pairs showed RPD values above 10% (blue lines around the 1:1 correlation line) and the exceedance of this level was more common in the later analyses of the program. This is a significant difference with the samples in the duplicate pair. Results are presented in Figure 12.2 and Table 12.5. Note the difference with the Intertek and Bureau Veritas samples later in this section. Calcium and chloride show the best r2 correlation, with Mg, K and Na having values <0.8.

10.9.3 Blanks

Blanks returned non-detect results for potassium and other ions, except chloride – which returned values < 10 mg/l.

10.9.4 Anion- Cation balances

Anion-cation balances were conducted on all samples collected during the drilling program. The cation-anion balance is calculated as follows when values are converted from mg/l to miliequivalents:

$$\frac{\textbf{Sum (cations – anions)}}{\text{Sum (cations + anions)}} \times \mathbf{100}$$

As the fluids should be electrically neutral, with a balance of ~ zero, the size of the balance provides a good indicator of the accuracy of the corresponding analysis. Analyses with balances of <+/-5% are generally considered to be accurate, with analyses having higher values likely to be less reliable. However, this is often difficult to achieve with brine samples, with a high content of dissolved ions.

The anion-cation balance was observed to change significantly between the four sample batches (Figure 12.3) and to show a significant number of exceedance of 5%. In this case it can be clearly seen that the third batch (unfortunately the one with the most samples) shows a much larger range of ionic balances than batches 1, 2 and 4. This is likely to reflect the ICP calibration and the samples which preceded analysis of this sample batch.

	Ca		Mg		K	
# Samples	13		13		13	
Average mg/l	669	669	3082	3188	4588	4691
Std Dev	211	178	311	331	599	589
Graph r^2	0.9456		0.6484		0.7265	
	Na		SO4		Cl	
# Samples	13		12		12	
Average mg/l	108946.2	112153.8	20466.67	20933.33	153416.7	151166.7
Std Dev	11471	13490	3534	4087	17769	16519
Graph r^2	0.7329		0.8043		0.9824	

Table 10.5: Lake Mackay duplicate sample statistics

Overall analysis shows the ALS results are poor quality, in addition to the issue raised by ALS Environmental regarding the correlation between laboratories.

10.10 Results of <u>Intertek</u> QA/QC sampling/comparison

10.10.1 Standards

The values for the K standards 1 and 2 consistently report below the standard values for K, whereas the values for the Mg and sulphate report very close to the standards (Table 12.6, Figure 12.4). Chloride also reports less than the standard values. Similarly to ALS analyses the values reported for Ca are much lower than the standard values – raising the possibility some gypsum has precipitated from the samples. Sodium reports higher than both standards.

10.10.2 Duplicates

All but one or two duplicate analyses are within 10% of the primary analyses. The values outside the 10% envelope are significant outliers, which appear to represent bad analyses and are concerning in their own right. These analyses are in the order of 20% different between the primary and secondary analyses. Results are shown in Figure 12.5.

10.10.3 Blanks

Blanks show low but non-zero values, with ions in higher concentrations, like Na and Cl, recorded as being present in concentrations up to 250 mg/l. Potassium concentrations were up to 25 mg/l. This probably suggests these values are the actual detection limits of these elements, rather than contamination between samples, as the values for each element are similar for the analysis of each element (Ca up to 2 mg/l; K 25-28.6 mg/l; Mg 2.2-2.4 mg/l; Na to 214 mg/; SO4 15-35.0 mg/l; Cl 200 mg/l).

10.10.4 Anion- Cation balances

Anion cation balances for Intertek analyses (Figure 12.6) were < 5%, with the exception of one sample and in general were less than +2%, compared to the wide spread of values observed in the ALS data.

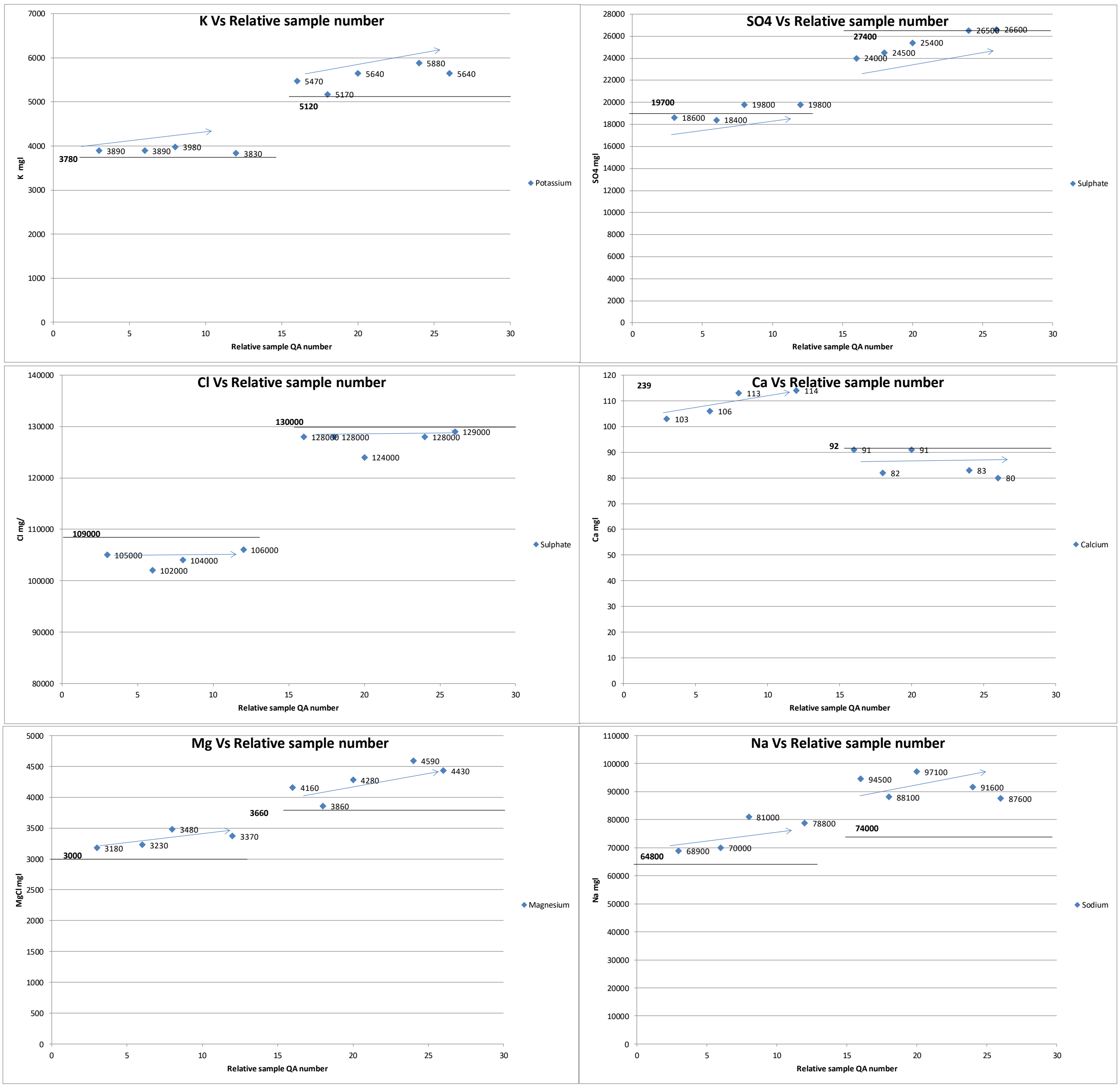

Figure 10.1: Standard analyses relative to nominal values, showing upward drift for most analyses

10.10.5 Comparison of ALS and Intertek analyses

Standards

The ALS standard analyses (Standards 1 and 2 in Figure 12.7) compared with the Intertek analyses show that the best performance of the standards was Intertek with sulphate, with quite consistent values between analyses. Both labs returned Ca values less than the standard values, with Intertek displaying lower, but relatively consistent results. Magnesium was the most consistent of the elements in analyses for both laboratories, with Intertek values lower and closer to the standard values than ALS, as for sodium. K analyses for Intertek were much more repeatable than ALS but lower than the standard values in all cases, whereas ALS standard analyses were both above and below the standard value. This raises the possibility that Intertek are under-reporting K, while ALS were over reporting.

Comparison of samples as duplicates

Scatter plots (Figure 12.8) show a consistent bias to higher values for the ALS samples, with a similar R^2 correlation for K, Mg, Ca and Cl. Na shows a poorer correlation and sulphate shows slight but consistently higher values from the Intertek laboratory.

10.11 Results of Bureau Veritas QA/QC sampling/comparison

10.11.1 Standards

There were no standards included in the samples sent to Bureau Veritas, so it is not possible to confirm the analytical values relative to the standards.

10.11.2 Duplicates

One duplicate sample was included in the batch analysed by Bureau Veritas. The relative percentage differences for this were small and are shown in Table 12.7. However, it is noted that the sample was described as AC08_00Rpt, so is not a blind duplicate. No blanks were included with this sample batch.

10.11.3 Anion-cation balances

The anion cation balance varies between zero and 5% for the Bureau Veritas sample. The balance is shown in Figure 12.9.

10.11.4 Triplicates

A comparison of the difference between the three laboratories is presented in Table 12.8 and in Figures 12.10, 12.11 and 12.12. This shows that:

- The Intertek and Bureau Veritas laboratories generally show a <10% difference for all elements, with the exception of potassium,
- Potassium was the worst performing element between the laboratories, with a difference of 11.7% between Intertek and Bureau Veritas. For ALS and Intertek; and Bureau Veritas values were 23.9% and 37.5% respectively, with ALS having the highest values.
- A similar situation was observed for Ca, Mg and Na.
- Chloride showed up to 7% difference between ALS and Intertek, with lower differences between the other laboratories.
- Sulphate showed an average difference of 3% between ALS and Bureau Veritas. Whereas the difference between Intertek and these labs was 12%

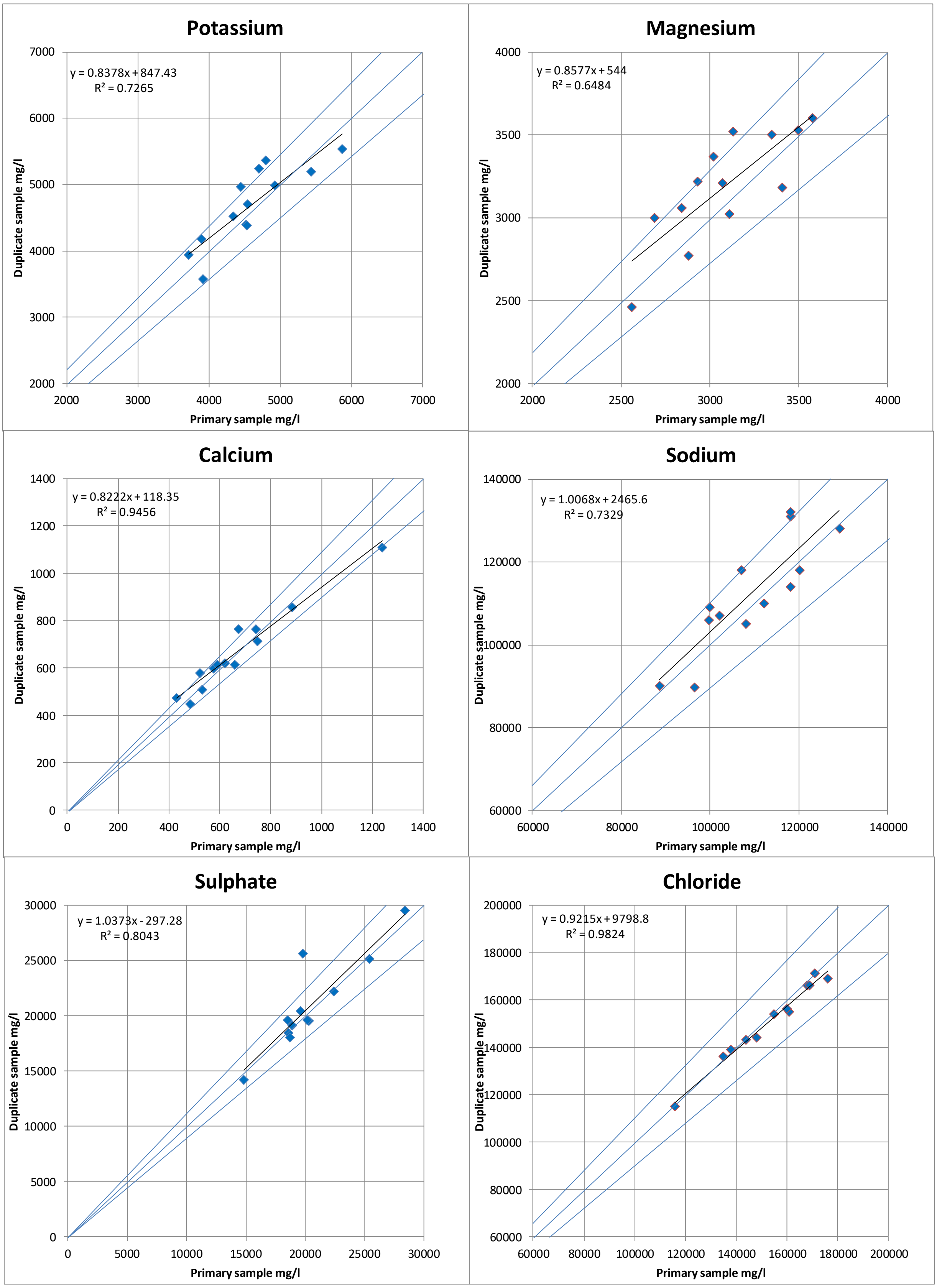

Figure 10.2: Duplicate plots for ALS samples

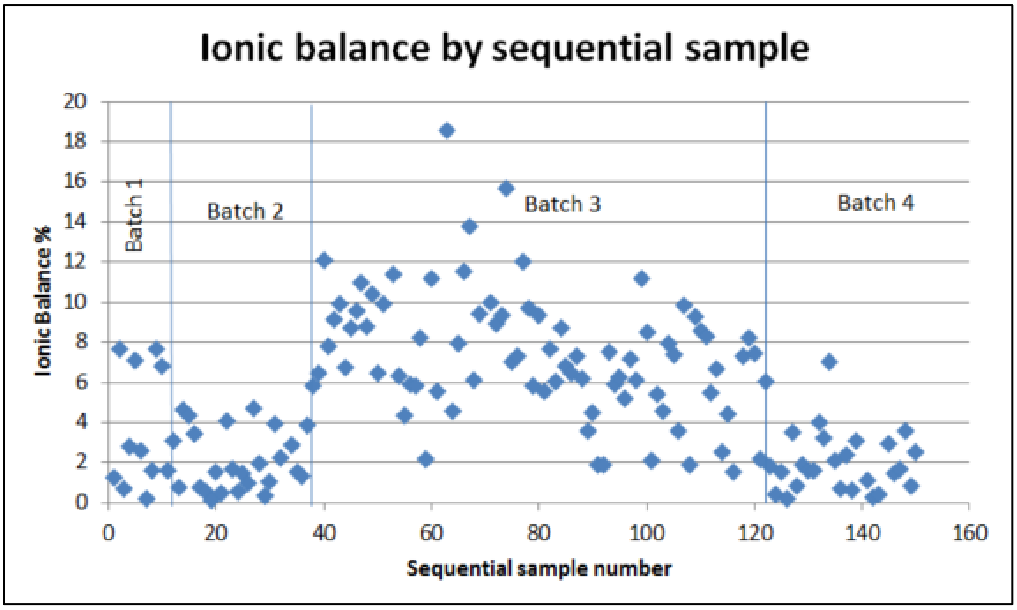

Figure 10.3: ALS Ionic balance varying by sample batch

	Ca mg/l	Mg mg/l	K mg/l	Na mg/l	Sulphate	hloride mg/l
Standard 1						
Standard	**239**	**3000**	**3780**	**64800**	**19700**	**109000**
# samples	3	3	3	3	3	3
Average	97	2,833	3,087	67,946	20,834	98,567
Std Dev	2	4	22	1,155	2,304	1,856
RSD%	2	0	1	2	11	2
Max	99	2,837	3,109	68,655	22,256	100,500
Min	95	2,831	3,065	66,613	18,176	96,800
RPD%	4%	0%	1%	3%	20%	4%
Standard 2						
Standard	**92**	**3660**	**5120**	**74000**	**27400**	**130000**
# samples	5	5	5	5	5	5
Average	78	3,591	4,482	82,602	27,757	125,220
Std Dev	2	48	60	1,243	546	8,367
RSD%	2	1	1	2	2	7
Max	81	3,634	4,534	83,747	28,312	140,100
Min	77	3,515	4,534	80,564	26,850	120,600
RPD%	5%	3%	0%	4%	5%	16%

Table 10.6: Summary of Intertek standard sample results

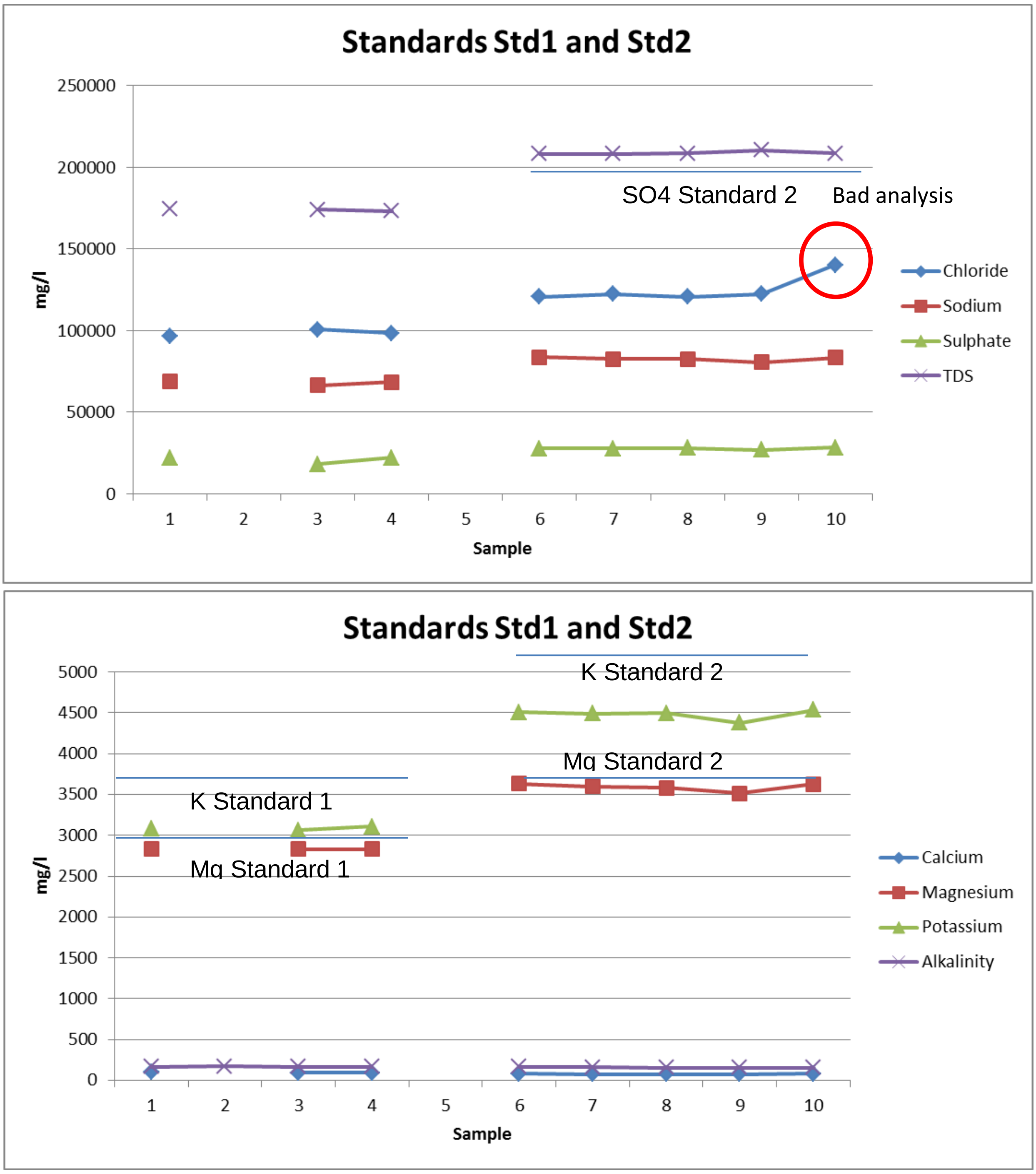

Figure 10.4: Intertek standard results

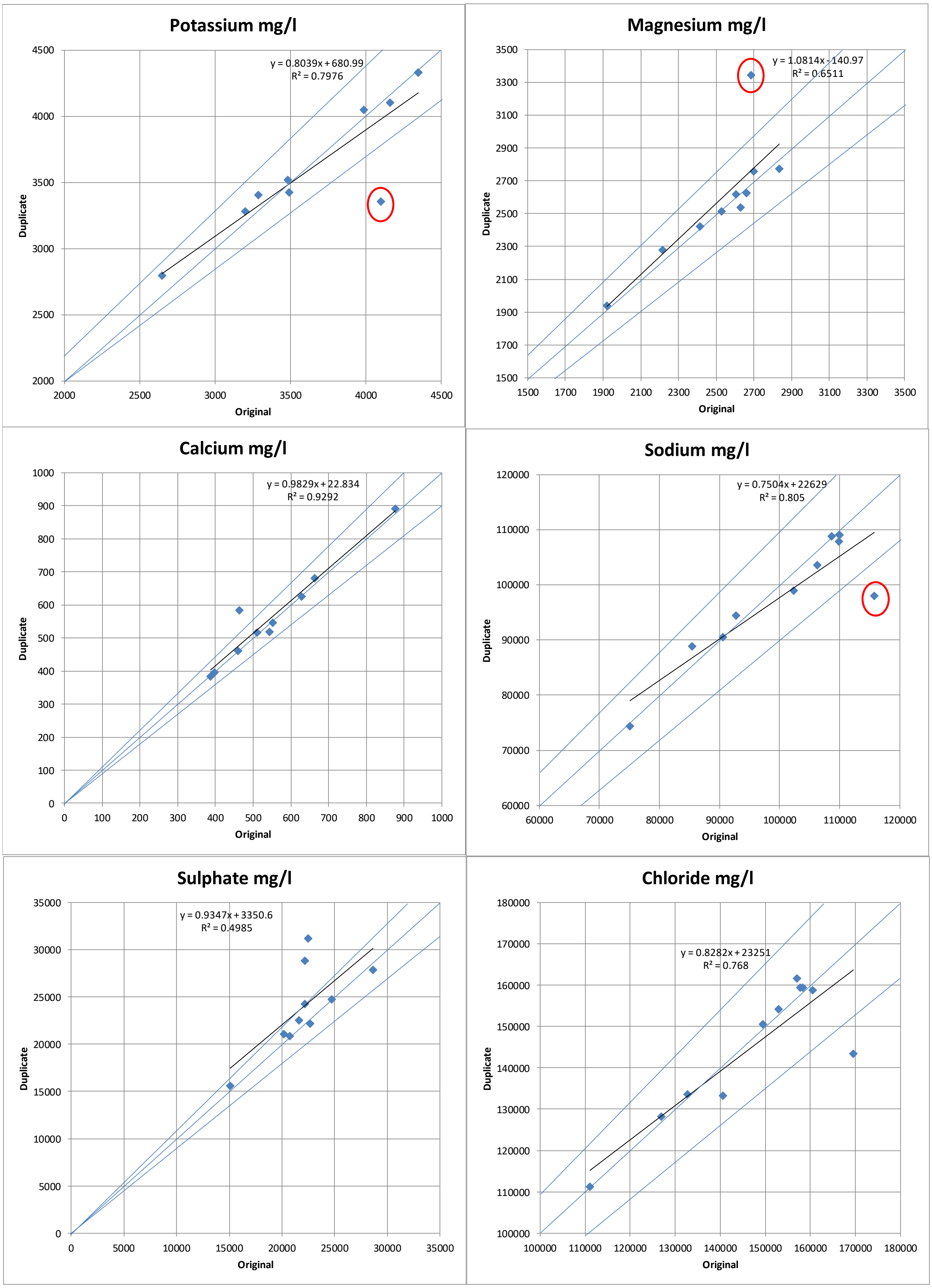

Figure 10.5: Intertek duplicate plots

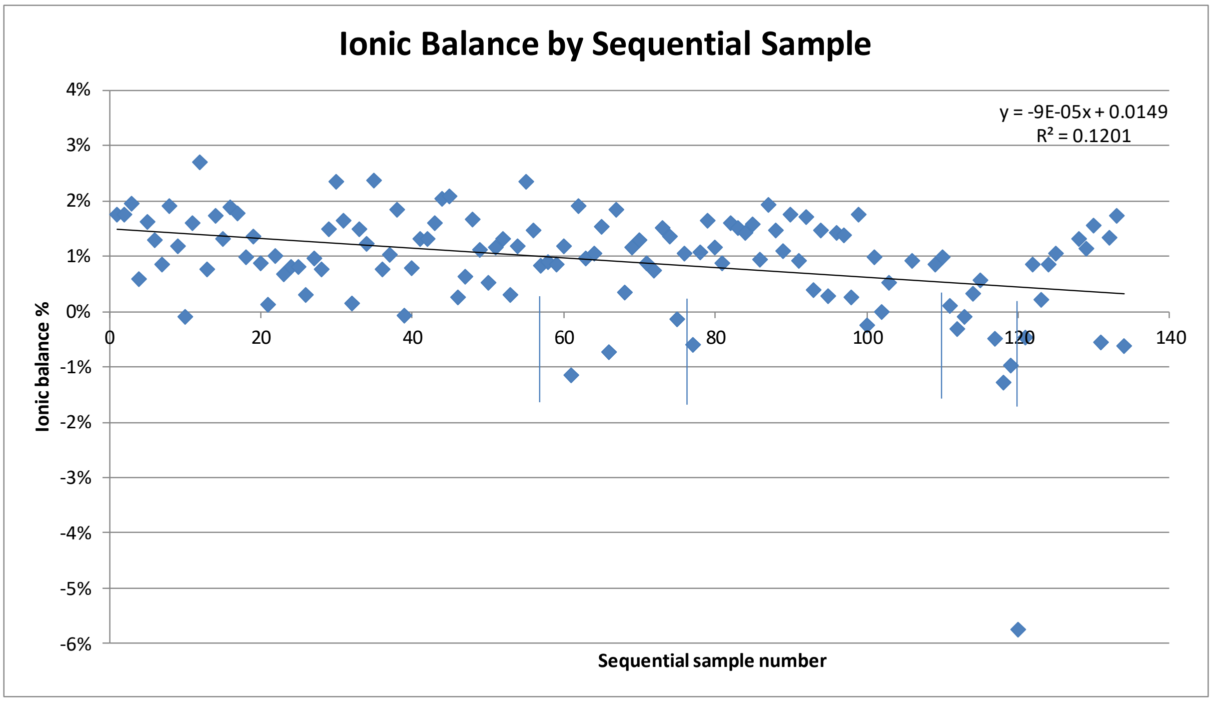

Figure 10.6: Ionic balance of Intertek data

10.12 University of Antofagasta check samples

Due to concerns regarding the accuracy of the analyses with respect to the actual analytical values, particularly for potassium, which appears to show the greatest variation between the laboratories, a batch of samples was sent to the University of Antofagasta lab in Chile (Table 12.9). This is a lab with extensive experience analyzing brine samples with Atomic Absorption Spectrometry from projects such as the Salar de Atacama potash and lithium brine project. Comparison with ALS is included in Figure 12.13 and 12.14 and Table 12.10.

This batch of samples included:

- Two samples of standard1
- Two samples of standard2
- Triplicate of LMD35_1A from well MA06 brine pod
- Four samples from trench LMT1
- Pump test samples PT02 and PT04
- Power auger sample PA30
- Five brine samples from aircore holes

Results show:

- A high level of repeatability of University Antofagasta blind duplicates and duplicates included in the sample batch, with RPD of 4% or less for all elements except Ca which rises to almost 10%
- Comparison to Standard1 shows Ca Mg, below, Na, SO4, above and K and Cl significantly below the certified standard value
- Comparison to Standard2 shows Ca Mg, SO4 below, Na, above and K and Cl significantly below the certified standard value
- There is a good correlation of Intertek-University Antofagasta sample pairs, much better than with ALS, (although the R2 values of graphs do not always suggest this).
- For Standard1 and Standard2 Intertek-University Antofagasta samples showed <5% difference, except for Ca and K (32.8 and 13.4% 8.4 and 11.8%) respectively.

- Overall Intertek-University Antofagasta samples compared with <5% difference, except for Ca (differences up to 20.5%) and K (differences to 16.6%) - with Intertek samples higher in all cases.
- The only Bureau Veritas sample (AC07_27A) shows a difference of <4% for elements except Ca (6.4%). Potassium showed 0.5% difference.
- Ionic balances were < 2% for all samples – the best result of any lab.

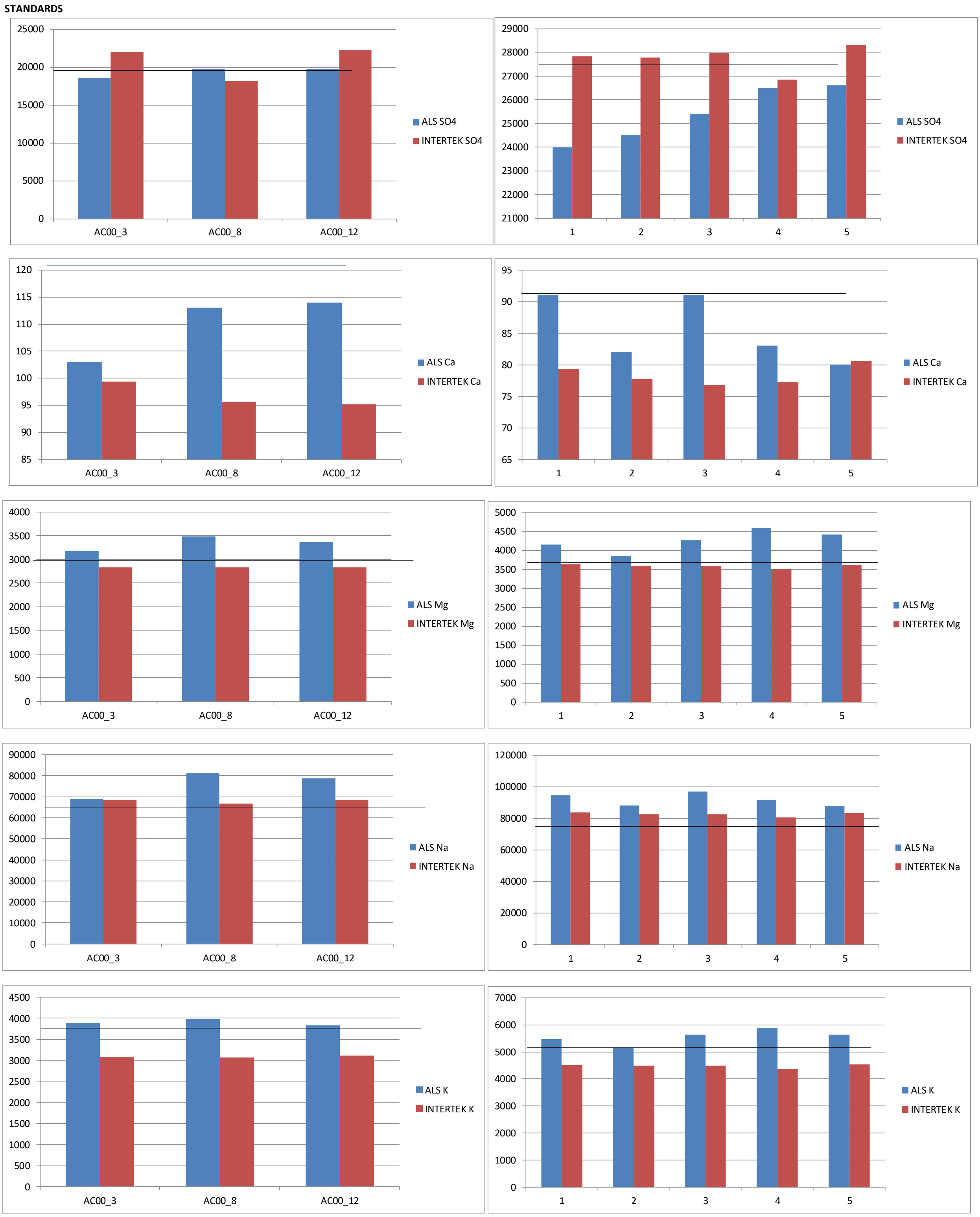

Figure 10.7: Comparison of ALS and Intertek standards, showing ALS standards are generally higher than Intertek

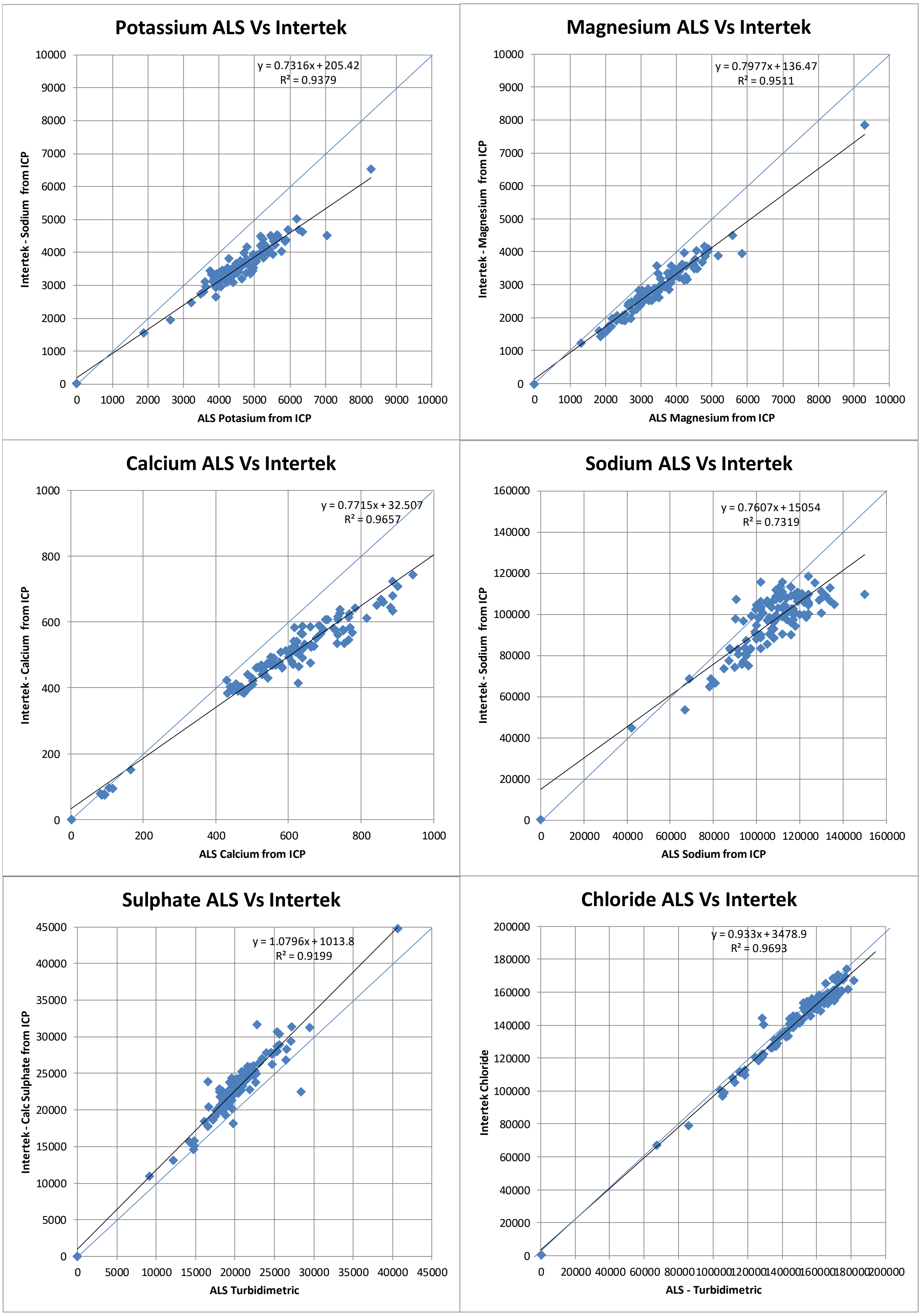

Figure 10.8: Comparison of ALS and Intertek analyses for the same samples

Sample	Ca	Mg	K	Na	S	Cl
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
AC08_00	485	3390	2630	97400	6690	149400
AC08_00 Rpt	482	3380	2620	97000	6740	149800
RPD%	1.2%	0.6%	0.8%	0.8%	1.5%	0.5%

Table 10.7: Duplicate sample analysed with the Bureau Veritas sample batch

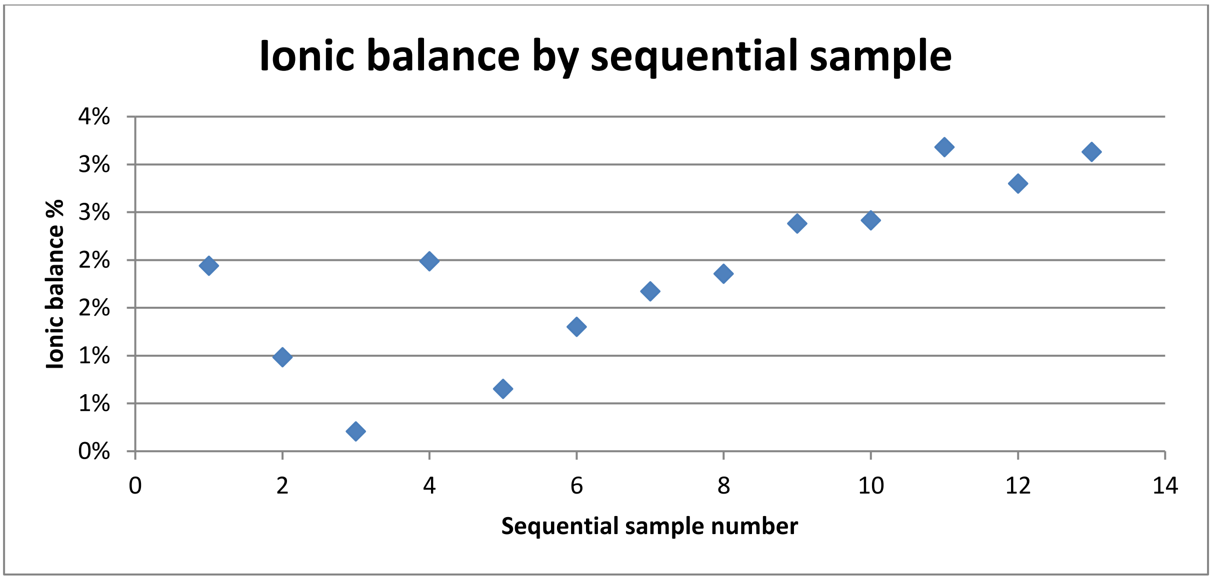

Figure 10.9: Ionic balance versus sequential sample number for Bureau Veritas samples

Sample	AC01_21	AC05_18	AC07_27A	AC08_00	AC08_00	AC18_27	AC18_27	AC18_27	AC24_1	AC26_9	AC27_1.5	AC27_1.5	LMT2c	PT22
Calcium	495	577	578	599	599	741	741	741	599	525	485	485	430	620
		510				629	629	629	495	442	398	398	386	543
	398	483	495	485	482	581	585	580	471	411	371	373	356	500
RPD% ALS + Intertek		12.3%				16.4%	16.4%	16.4%	18.9%	17.1%	19.7%	19.7%	10.7%	13.3%
RPD% ALS + Bureau Veritas	21.7%	17.7%	15.5%	21.0%	21.6%	24.2%	23.5%	24.4%	23.9%	24.4%	26.6%	26.1%	18.8%	21.4%
RPD% Intertek + Bureau Veritas		5.5%				7.9%	7.2%	8.1%	5.0%	7.3%	7.1%	6.5%	8.2%	8.2%
Magnesium	4,240	3,070	2,630	4,250	4,250	2,840	2,840	2,840	4,730	4,800	3,410	3,410	3,020	2,930
		2,700				2,530	2,530	2,530	3,704	4,180	2,661	2,661	2,834	2,631
	3,340	2,570	2,280	3,390	3,380	2,380	2,390	2,380	3,530	3,850	2,510	2,510	2,580	2,440
RPD% ALS + Intertek		12.8%				11.6%	11.6%	11.6%	24.3%	13.8%	24.7%	24.7%	6.3%	10.7%
RPD% ALS + Bureau Veritas	23.7%	17.7%	14.3%	22.5%	22.8%	17.6%	17.2%	17.6%	29.1%	22.0%	30.4%	30.4%	15.7%	18.2%
RPD% Intertek + Bureau Veritas		4.9%				6.1%	5.7%	6.1%	4.8%	8.2%	5.8%	5.8%	9.4%	7.5%
Potassium	5,420	4,540	4,340	3,990	3,990	3,900	3,900	3,900	5,250	5,080	5,870	5,870	4,800	4,340
		3,445				3,201	3,201	3,201	3,830	3,930	4,348	4,348	4,160	3,491
	3,020	3,180	3,150	2,630	2,620	2,870	2,840	2,860	3,450	3,410	3,870	3,880	3,590	3,070
RPD% ALS + Intertek		27.4%				19.7%	19.7%	19.7%	31.3%	25.5%	29.8%	29.8%	14.3%	21.7%
RPD% ALS + Bureau Veritas	56.9%	35.2%	31.8%	41.1%	41.5%	30.4%	31.5%	30.8%	41.4%	39.3%	41.1%	40.8%	28.8%	34.3%
RPD% Intertek + Bureau Veritas		8.0%				10.9%	11.9%	11.2%	10.4%	14.2%	11.6%	11.4%	14.7%	12.8%
Sodium	115,000	102,000	100,000	105,000	105,000	99,600	99,600	99,600	112,000	109,000	118,000	118,000	118,000	99,800
		106,271				90,598	90,598	90,598	103,073	108,779	109,890	109,890	108,644	102,324
	102,000	102,000	100,000	97,400	97,000	87,300	87,100	86,700	102,000	105,000	106,000	107,000	109,000	98,800
RPD% ALS + Intertek		4.1%				9.5%	9.5%	9.5%	8.3%	0.2%	7.1%	7.1%	8.3%	2.5%
RPD% ALS + Bureau Veritas	12.0%	0.0%	0.0%	7.5%	7.9%	13.2%	13.4%	13.8%	9.3%	3.7%	10.7%	9.8%	7.9%	1.0%
RPD% Intertek + Bureau Veritas		4.1%				3.7%	3.9%	4.4%	1.0%	3.5%	3.6%	2.7%	0.3%	3.5%
Sulfate as SO4 - Turbidimetric	28,700	18,600	17,500	18,800	18,800	18,900	18,900	18,900	19,800	21,700	25,400	25,400	28,400	19,600
		21,625				20,748	20,748	20,748	22,336	24,480	28,672	28,672	22,465	22,700
	25,708	19,745	18,097	20,045	20,195	18,517	18,846	18,757	19,506	21,513	25,618	25,558	27,446	19,745
RPD% ALS + Intertek		15.0%				9.3%	9.3%	9.3%	12.0%	12.0%	12.1%	12.1%	23.3%	14.7%
RPD% ALS + Bureau Veritas	11.0%	6.0%	3.4%	6.4%	7.2%	2.0%	0.3%	0.8%	1.5%	0.9%	0.9%	0.6%	3.4%	0.7%
RPD% Intertek + Bureau Veritas		9.1%				11.4%	9.6%	10.1%	13.5%	12.9%	11.3%	11.5%	20.0%	13.9%
Chloride	177,000	155,000	157,000	149,000	149,000	138,000	138,000	138,000	166,000	173,000	168,000	168,000	169,000	160,000
Chloride		153,000				132,800	132,800	132,800	154,900	166,400	157,800	157,800	160,600	149,500
Chloride	154,700	156,500	156,300	149,400	149,800	135,000	135,800	135,800	157,700	164,600	160,900	162,000	160,600	151,700
RPD% ALS + Intertek		1.3%				3.8%	3.8%	3.8%	6.9%	3.9%	6.3%	6.3%	5.1%	6.8%
RPD% ALS + Bureau Veritas	13.4%	1.0%	0.4%	0.3%	0.5%	2.2%	1.6%	1.6%	5.1%	5.0%	4.3%	3.6%	5.1%	5.3%
RPD% Intertek + Bureau Veritas		2.3%				1.6%	2.2%	2.2%	1.8%	1.1%	1.9%	2.6%	0.0%	1.5%

Table 10.8: Comparison of analytical results between the three laboratories (ALS top, Intertek middle, BV bottom)

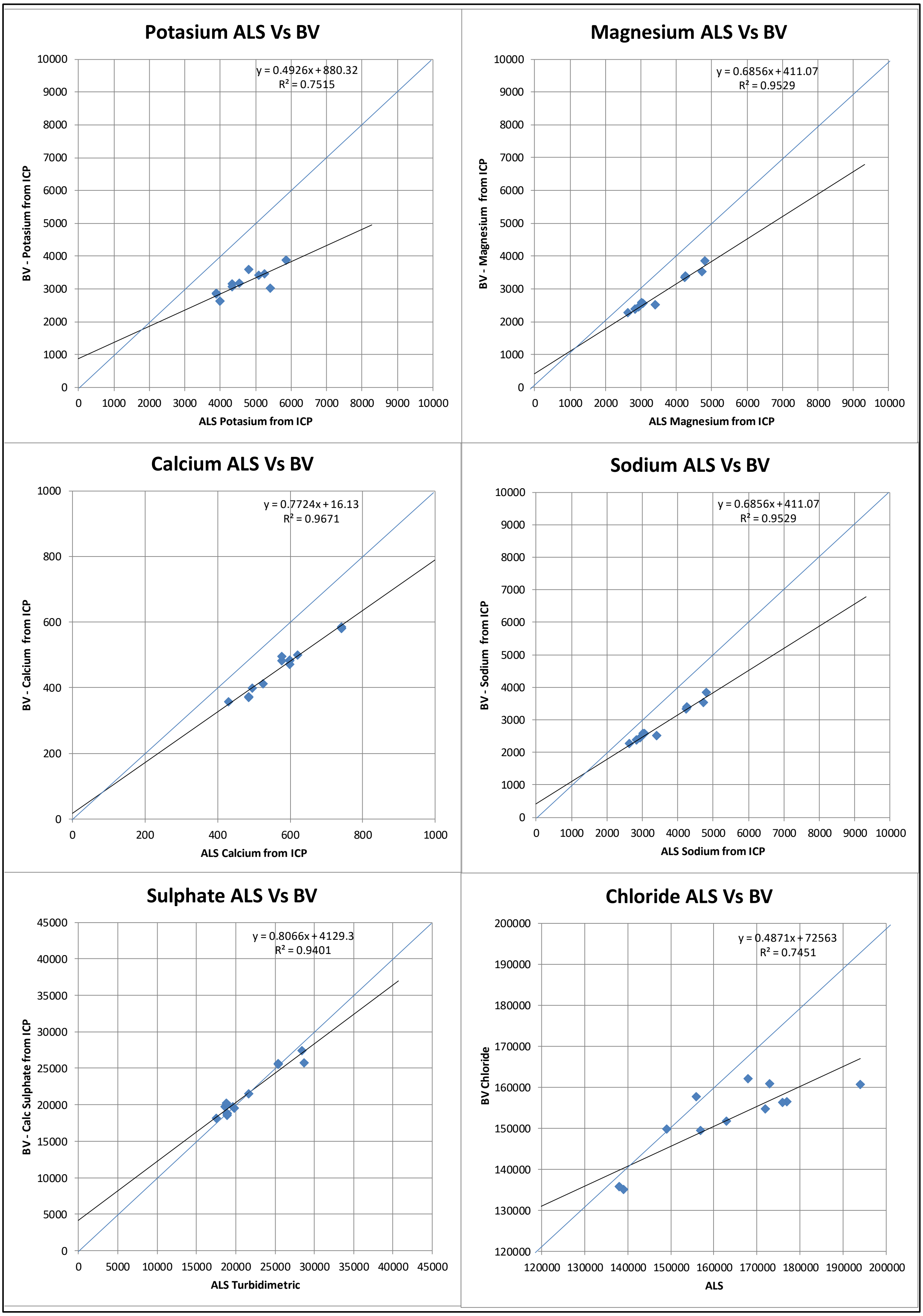

Figure 10.10: Correlation of ALS and Bureau Veritas analyses. Bias is similar to that observed with Intertek samples

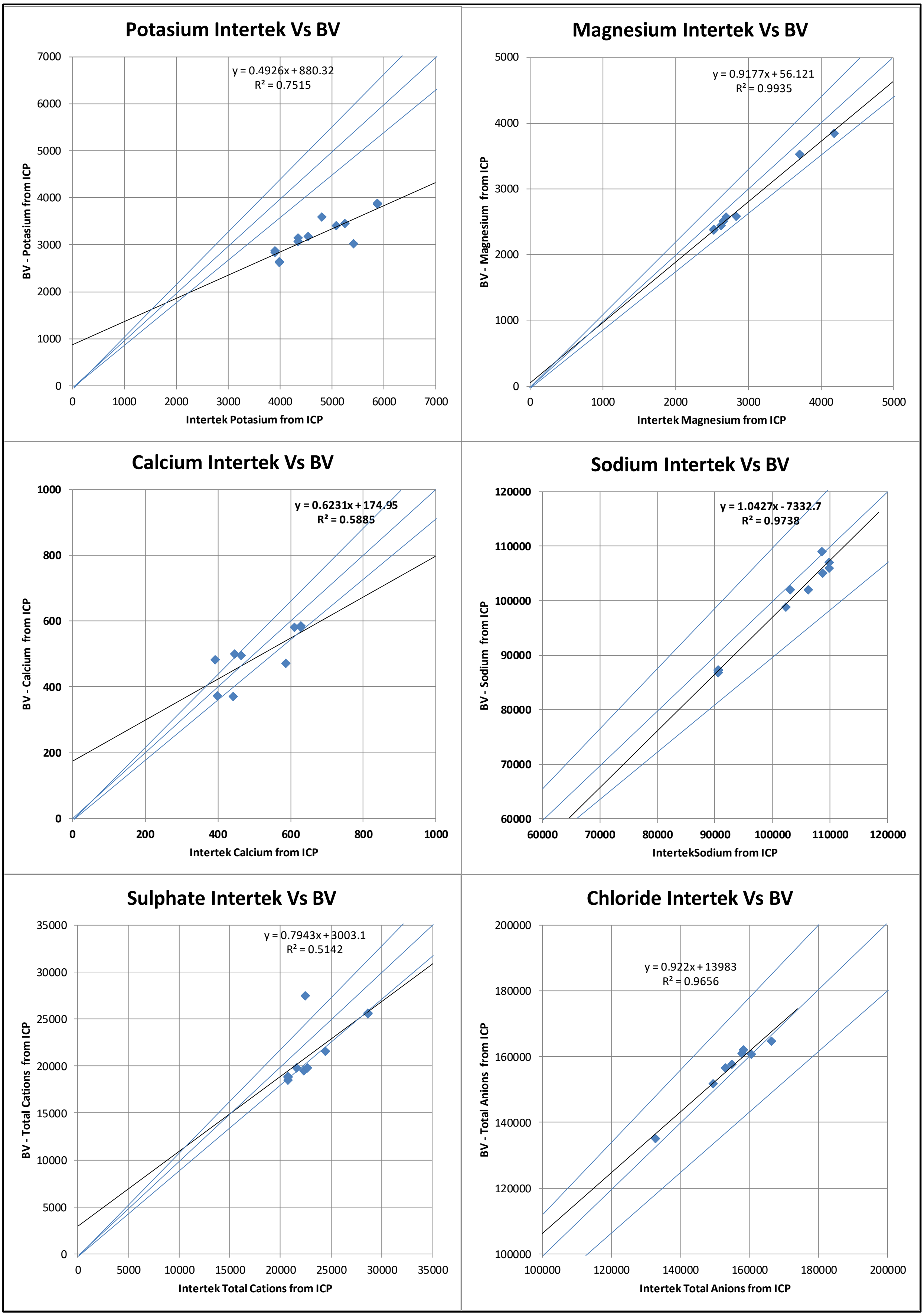

Figure 10.11: Comparison of Intertek and Bureau Veritas samples

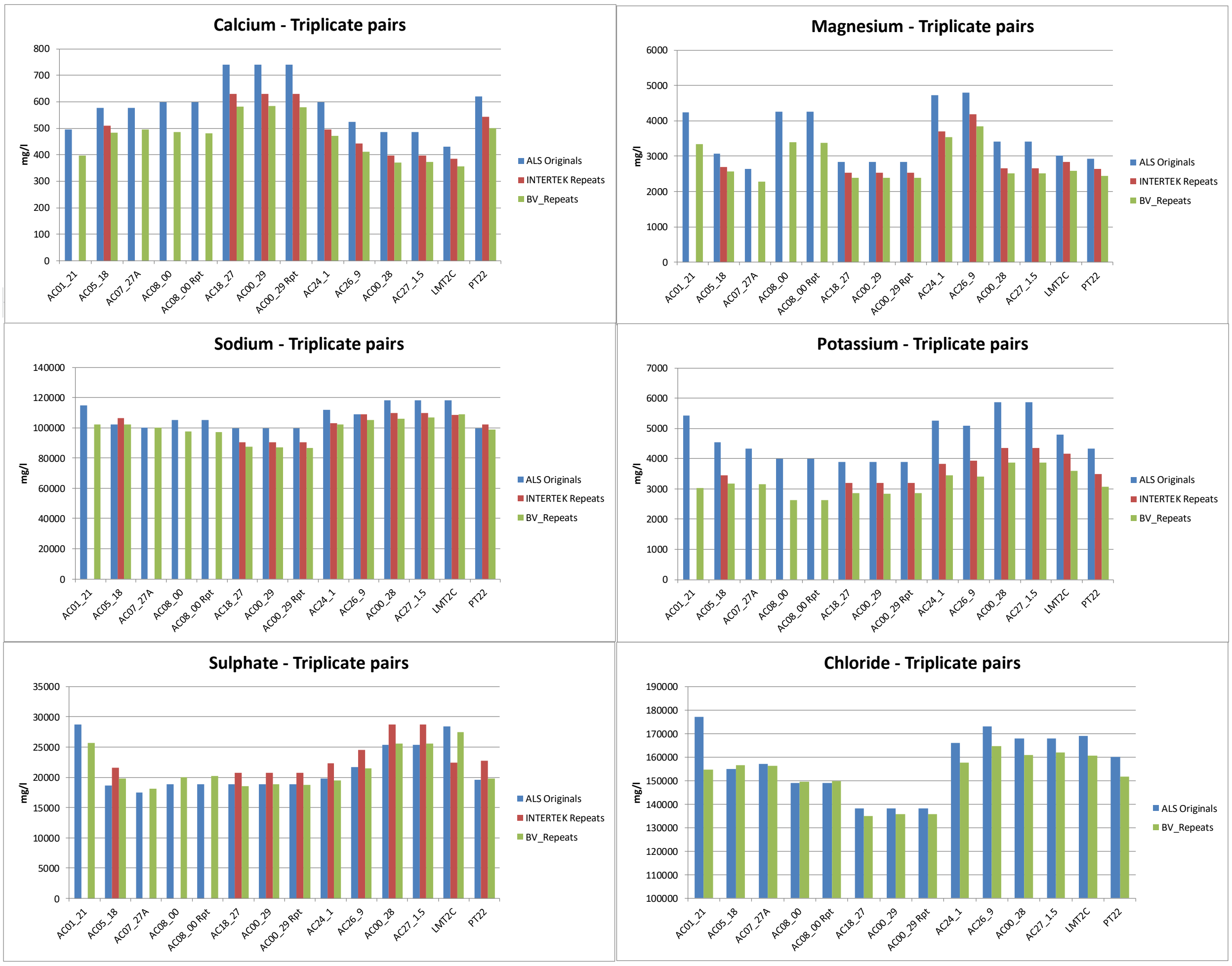

Figure 10.12: Comparison of ALS, Intertek and Bureau Veritas triplicate samples

UNIVERSITY ANTOFAGASTA						
	Ca mg/l	Mg mg/l	K mg/l	Na mg/l	SO4 mg/l	Cl mg/l
Average S1	70	2,744	2,838	66,000	21,079	100488.4
Average S2	524	2,300	3,023	98,894	18,898	153446.2
LMD35_2A (Brine pod sample from MA06)	538	2,325	2,925	99,500	18,790	154058.9
Average LMD35_2	474	2,750	3,580	108,125	29,995	161411.7
Average All TB_1	369	2,735	3,570	109,750	29,450	159001.6
LMD35_1A (Brine pod sample from MA06)	525	2,338	3,010	98,750	18,841	153,534
AC00_30 (Duplicate of LMD35_1A)	523	2,263	3,035	99,038	18,954	153,359
TB_1A (Brine pod sample from trench)	350	2,788	3,570	108,625	29,831	161,237
AC00_31 (Duplicate of TB_1A)	598	2,713	3,590	107,625	30,160	161,587
TB_1A (Brine pod sample from trench)	350	2,788	3,570	108,625	29,831	161,237
TB_2A (Brine pod sample from trench)	355	2,725	3,570	107,875	29,625	160,186
TB_3A (Brine pod sample from trench)	360	2,775	3,560	108,625	29,460	161,587
PT02	395	3,525	2,800	102,500	24,171	159,311
PT04	438	3,113	3,070	100,500	22,124	156860
AC09_18	475	3,238	2,875	94,875	22,864	146180.9
AC17_03	445	2,863	3,615	103,000	22,298	160711.4
PA30	448	3,000	3,380	99,750	20,498	154934.2
AC03_17 (appeared poorly filtered - requested filtering)	443	2,925	2,945	103,750	22,082	155,459
AC07_27B	528	2,275	3,135	97,875	18,738	151,258
AC10_00 mislabelled in AC10_00 by ANTO	1,000	1,450	2,083	57,125	12,286	90,159

Table 10.9: Results from University of Antofagasta

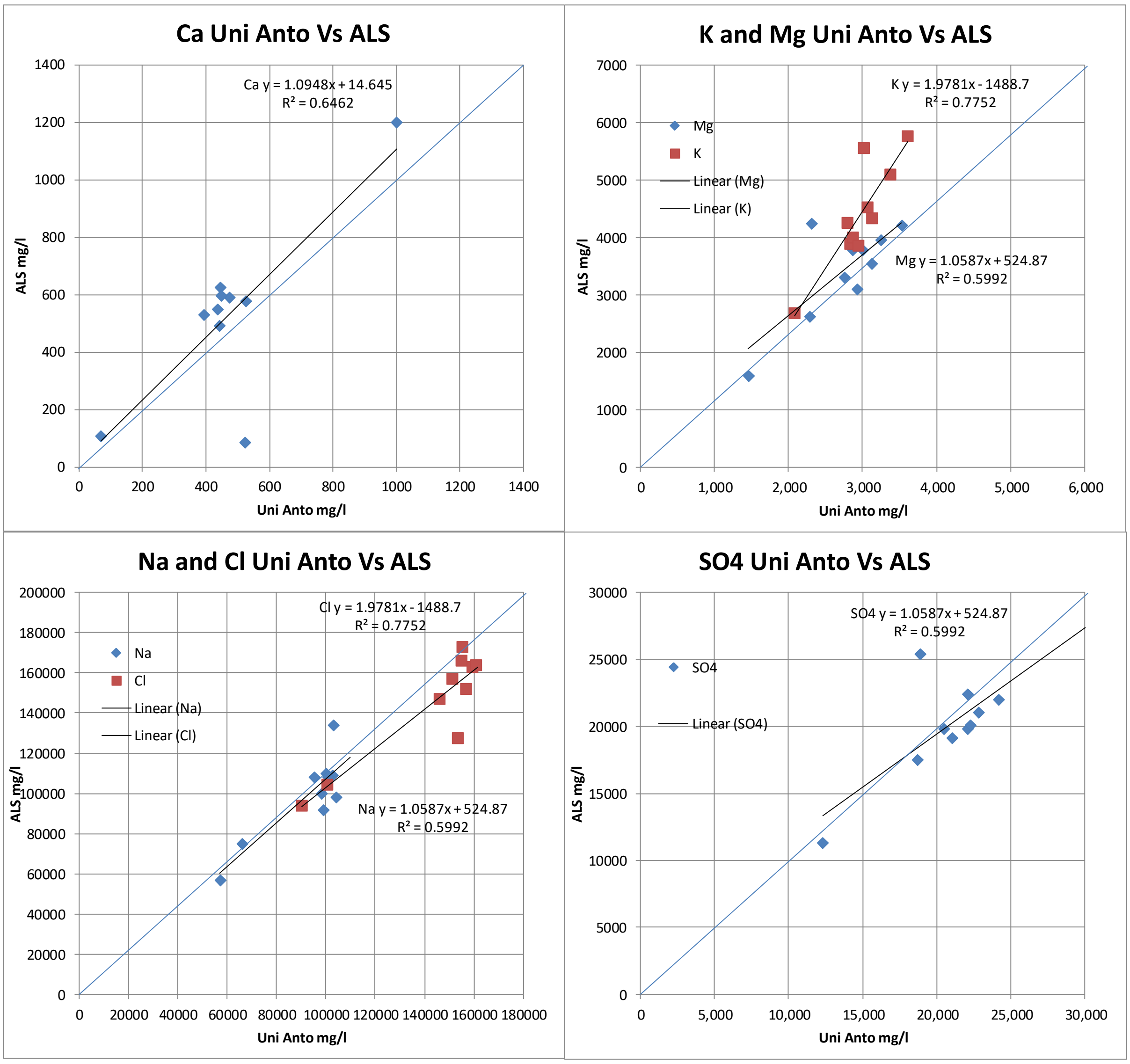

Figure 10.13: Comparison of results from University of Antofagasta with ALS samples

University of Antofagasta results show a high degree of correlation with the Intertek samples, with the difference of 10 sample pairs being -9% for potassium (University Antofagasta values being lower) and much less for all other elements. For reference the average difference between Intertek and Bureau Veritas samples as -11.7% for Potassium (BV average being lower).

It appears the “real” sample values are in the range between Intertek and Bureau Veritas, with the University of Antofagasta falling between these two and probably closer to Bureau Veritas. Potassium values from ALS appear to be massively overstated.

10.13 Comparison of 2009 and 2014 sample results

Reanalysis by Agrimin of a selection of the original 2009 Reward Minerals brine samples from Lake Mackay showed a significant difference between the analyses. The original analyses were by the Ultratrace laboratory which is now part of Bureau Veritas, whereas the re-analyses were done by ALS. The difference between the laboratories (Figure 12.15, Table 12.11) is largest for K, SO4 and Mg. For K the differences exceed 30%, which is similar to the average 37% difference between these labs for the 2015 sampling program.

The reward press release was from 13 October, so presumably they did work around early September, the same time as Agrimin – as it is important to consider the potential seasonal impact on grades due to rainfall. However, as pointed out by Process Engineer Peter Ehren the ionic balance of the Ultratrace lab analyses were very poor – averaging ~15% difference between cations and anions.

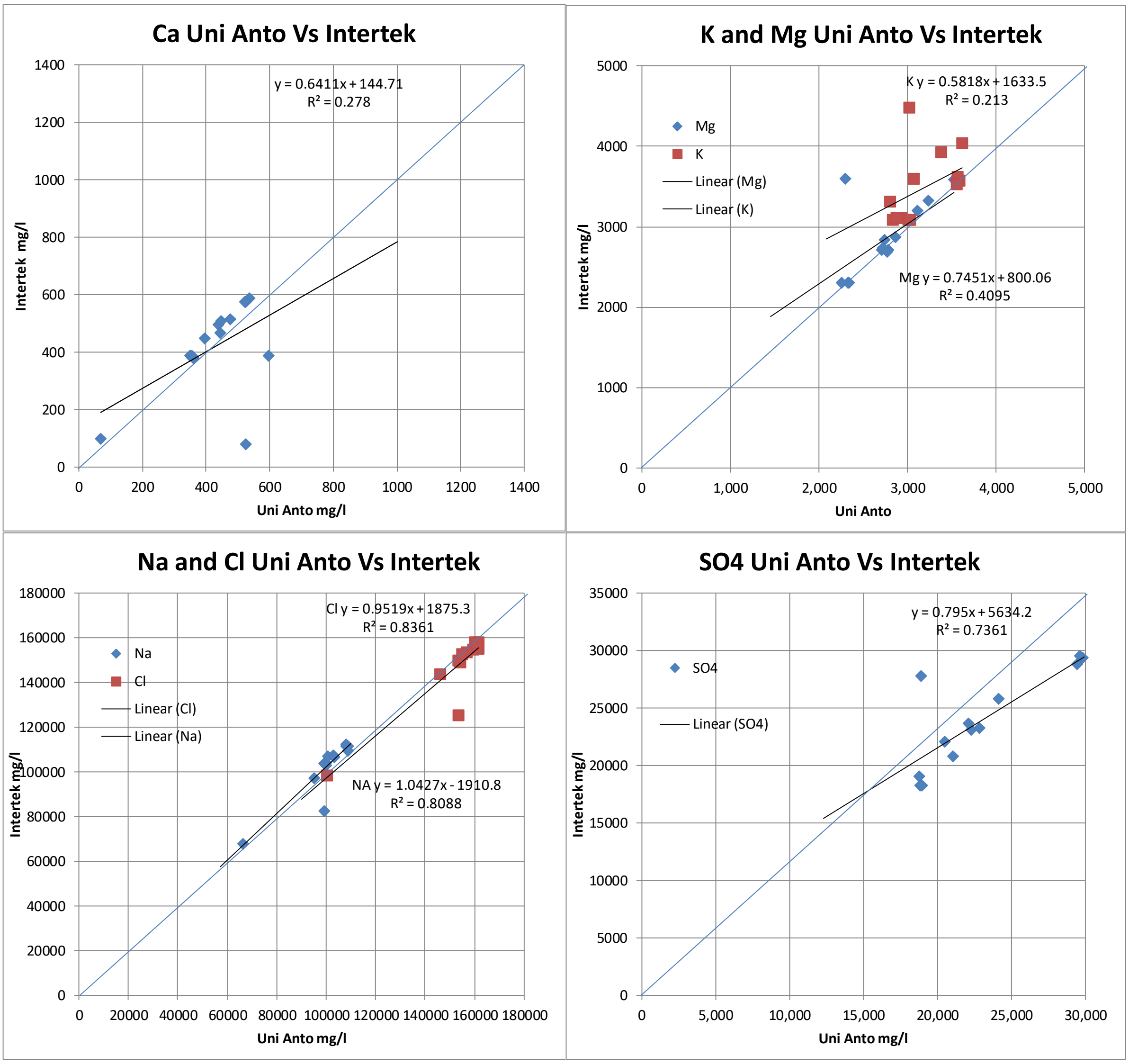

Figure 10.14: Comparison of results from University of Antofagasta with Intertek samples

Sample	Ca mg/l	Mg mg/l	K mg/l	Na mg/l	SO4 mg/l	Cl mg/l
Planned standard value	200	2,500	2,500	70,000	18,000	104,245
S Nominal value	**239**	**3000**	**3780**	**64800**	**19700**	**109000**
ALS AVERAGE	**109**	**3315**	**3897.5**	**74675**	**19150**	**104250**
INTERTEK AVERAGE	**97**	**2833**	**3087**	**67946**	**20834**	**98567**
S1 (standard 1)	70	2,775	2,800	65,625	21,064	100,488
AC00_32 (Duplicate of S1)	70	2,713	2,875	66,375	21,094	100,488
Average	70	2,744	2,838	66,000	21,079	100,488
RPD Difference	0.0%	2.3%	-2.6%	-1.1%	-0.1%	0.0%
Difference with ALS	-44.3%	-18.9%	-31.5%	-12.3%	9.6%	-3.7%
Difference with Intertek	**-32.8%**	**-3.2%**	**-8.4%**	**-2.9%**	**1.2%**	**1.9%**
Planned standard value	100	3500	4000	80000	25000	118868.9
S Nominal value	**92**	**3660**	**5120**	**74000**	**27400**	**130000**
ALS AVERAGE	**85**	**4264**	**5560**	**91780**	**25400**	**127400**
INTERTEK AVERAGE	**78**	**3591**	**4482**	**82602**	**27757**	**125220**
S2 (standard 2)	66	3,575	4,030	81,875	26,353	123,422
AC00_33 (Duplicate of S2)	71	3,475	3,935	82,875	26,548	124,122
Average	69	3,525	3,983	82,375	26,450	123,772
RPD Difference	-7.3%	2.8%	2.4%	-1.2%	-0.7%	-0.6%
Difference with ALS	-22.0%	-19.0%	-33.1%	-10.8%	4.1%	-2.9%
Difference with Intertek	**-13.4%**	**-1.9%**	**-11.8%**	**-0.3%**	**-4.8%**	**-1.2%**
LMD35_1 INTERTEK	575	2,301	3,083	103,706	18,292	150,000
LMD35_1A (Brine pod sample from MA06)	525	2,338	3,010	98,750	18,841	153,534
AC00_30 (Duplicate of LMD35_1A)	523	2,263	3,035	99,038	18,954	153,359
Average	524	2,300	3,023	98,894	18,898	153,446
RPD Difference	-0.5%	-3.3%	0.8%	0.3%	0.6%	-0.1%
Difference with Intertek	**-9.4%**	**-0.1%**	**-2.0%**	**-4.8%**	**3.3%**	**2.3%**
LMD35_2 INTERTEK	588	2,303	3,104	103,937	19,020	149,000
LMD35_2A (Brine pod sample from MA06)	538	2,325	2,925	99,500	18,790	154,059
RPD Difference	-9.0%	0.9%	-5.9%	-4.4%	-1.2%	3.3%
TB_1 INTERTEK	386	2,706	3,573	111,666	29,363	155,000
TB_1A (Brine pod sample from trench)	350	2,788	3,570	108,625	29,831	161,237
AC00_31 (Duplicate of TB_1A)	598	2,713	3,590	107,625	30,160	161,587
Average	474	2,750	3,580	108,125	29,995	161,412
RPD Difference	52.2%	-2.7%	0.6%	-0.9%	1.1%	0.2%
Difference with Intertek	**20.5%**	**1.6%**	**0.2%**	**-3.2%**	**2.1%**	**4.1%**
TB_1 INTERTEK	386	2,706	3,573	111,666	29,363	155,000
TB_1A (Brine pod sample from trench)	350	2,788	3,570	108,625	29,831	161,237
TB_2 INTERTEK	388	2,730	3,622	112,330	29,564	158,000
TB_2A (Brine pod sample from trench)	355	2,725	3,570	107,875	29,625	160,186
TB_3 INTERTEK	377	2,683	3,524	109,377	28,854	158,000
TB_3A (Brine pod sample from trench)	360	2,775	3,560	108,625	29,460	161,587
Average All	369	2,735	3,570	109,750	29,450	159,002
Average INTERTEK	384	2,707	3,573	111,124	29,260	157,000
Average ANTOFAGASTA	355	2,763	3,567	108,375	29,639	161,003
RPD Difference TB_1	-9.7%	3.0%	-0.1%	-2.8%	1.6%	3.9%
RPD Difference TB_2	-9.0%	-0.2%	-1.4%	-4.0%	0.2%	1.4%
RPD Difference TB_3	-4.6%	3.4%	1.0%	-0.7%	2.1%	2.2%
Max	388	2,788	3,622	112,330	29,831	161,587
Min	350	2,683	3,524	107,875	28,854	155,000
RPD Difference ALL	-10.4%	-3.8%	-2.7%	-4.0%	-3.3%	-4.2%
Difference Antofagasta Average with Intertek Average	**-7.8%**	**2.0%**	**-0.2%**	**-2.5%**	**1.3%**	**2.5%**
PT2 ALS	530	4,230	4,250	109,000	22,000	163,000
PT2 INTERTEK	446	3,584	3,308	107,295	25,821	154,900
PT02	395	3,525	2,800	102,500	24,171	159,311
Difference with ALS	-29.2%	-18.2%	-41.1%	-6.1%	9.4%	-2.3%
Difference with Intertek	**-12.2%**	**-1.7%**	**-16.6%**	**-4.6%**	**-6.6%**	**2.8%**

Sample	Ca mg/l	Mg mg/l	K mg/l	Na mg/l	SO4 mg/l	Cl mg/l
PT04 ALS	550	3,560	4,520	108,000	19,800	152,000
PT4 INTERTEK	496	3,195	3,591	106,897	23,649	153,500
PT04	438	3,113	3,070	100,500	22,124	156,860
Difference with ALS	-22.8%	-13.4%	-38.2%	-7.2%	11.1%	3.1%
Difference with Intertek	**-12.5%**	**-2.6%**	**-15.6%**	**-6.2%**	**-6.7%**	**2.2%**
AC09_18 ALS	591	3,970	4,010	108,000	21,000	147,000
AC09_18 INTERTEK	515	3,329	3,111	97,382	23,297	143,600
AC09_18	475	3,238	2,875	94,875	22,864	146,181
Difference with ALS	-21.8%	-20.3%	-33.0%	-12.9%	8.5%	-0.6%
Difference with Intertek	**-8.1%**	**-2.8%**	**-7.9%**	**-2.6%**	**-1.9%**	**1.8%**
AC17_03 ALS	627	3,790	5,770	134,000	20,100	164,000
AC17_03 INTERTEK	466	2,872	4,038	106,504	23,117	157,600
AC17_03	445	2,863	3,615	103,000	22,298	160,711
Difference with ALS	-34.0%	-27.9%	-45.9%	-26.2%	10.4%	-2.0%
Difference with Intertek	**-4.6%**	**-0.3%**	**-11.1%**	**-3.3%**	**-3.6%**	**2.0%**
PA30 ALS	598	3800	5100	110000	19800	166000
PA30 INTERTEK	508	3,075	3,924	103,048	22,092	152,800
PA30	448	3,000	3,380	99,750	20,498	154,934
Difference with ALS	-28.8%	-23.5%	-40.6%	-9.8%	3.5%	-6.9%
Difference with Intertek	**-12.7%**	**-2.5%**	**-14.9%**	**-3.3%**	**-7.5%**	**1.4%**
AC03_17 ALS	493	3120	3860	97900	22400	173000
AC03_17 (appeared poorly filtered - have requested filtering)	443	2,925	2,945	103,750	22,082	155,459
Difference with ALS	**-18.0%**	**-6.7%**	**-27.2%**	**7.1%**	**-1.5%**	**-12.8%**
AC07_27A ALS	578	2,630	4,340	100,000	17,500	157,000
AC07_27A Bureau Veritas	***495***	***2,280***	***3,150***	***100,000***	***18,097***	***156,300***
AC07_27B	528	2,275	3,135	97,875	18,738	151,258
AC07_27A Difference with ALS	**-9.1%**	**-14.5%**	**-32.2%**	**-2.1%**	**6.8%**	**-3.7%**
AC07_27A Difference with Bureau Veritas	**6.4%**	**-0.2%**	**-0.5%**	**-2.1%**	**3.5%**	**-3.3%**
AC09_00 ALS	1200	1610	2680	56600	11300	93900
AC10_00 mislabelled in AC10_00 by ANTO	1,000	1,450	2,083	57,125	12,286	90,159
Difference with ALS	**-18.2%**	**-10.5%**	**-25.1%**	**0.9%**	**8.4%**	**-4.1%**

Table 10.10: Comparison of University of Antofagasta samples with ALS and Intertek results

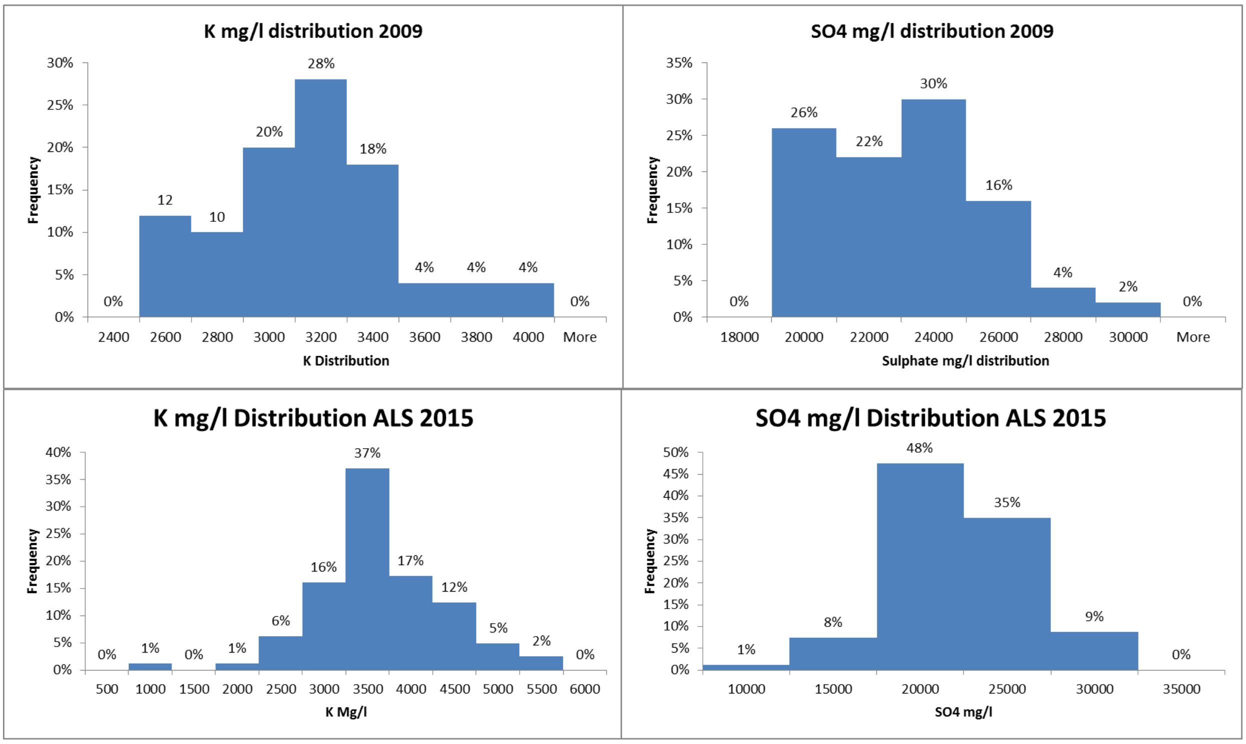

Figure 10.15: Comparison of the 2009 Bureau Veritas (Intertek) and 2015 ALS sample results

Sample	Ca	Ca	Difference	Difference	Mg	Mg	Difference	Difference
Id	mg/L	mg/L	mg/L	%	mg/L	mg/L	mg/L	%
	1	1			5	1		
LM2C	392	354	38	10%	3490	4090	-600	16%
LM4C	441	369	72	18%	4070	4500	-430	10%
LM7A	428	410	18	4%	3150	3520	-370	11%
LM14A	422	420	2	0%	3520	4170	-650	17%
LM19A	445	473	-28	6%	2930	3420	-490	15%
Average	426	405	20.4	5%	3432	3940	-508	14%
	K	K	Difference	Difference	Na	Na	Difference	RPD
	mg/L	mg/L	mg/L	%	mg/L	mg/L	mg/L	%
	5	1			100	1		
LM2C	3,000	4,310	-1310	36%	107000	112000	5000	5%
LM4C	3,930	5,260	-1330	29%	107000	108000	1000	1%
LM7A	2,990	4,080	-1090	31%	108000	107000	-1000	1%
LM14A	3,020	4,390	-1370	37%	95800	101000	5200	5%
LM19A	2,720	3,980	-1260	38%	99900	105000	5100	5%
Average	3,132	4,404	-1272	34%	103540	106600	3060	3%
	SO4	SO4	Difference	Difference				
	mg/L	mg/L	mg/L	%				
	50	1						
LM2C	24,100	14,900	9200	47%				
LM4C	22,500	14,200	8300	45%				
LM7A	23,300	18,800	4500	21%				
LM14A	24,200	18,400	5800	27%				
LM19A	21,200	14,000	7200	41%				
Average	23,060	16,060	7000	36%				

Table 10.11: Bureau Veritas (2009 ultratrace) and 2014 ALS reanalyses

10.14 Conclusions

Analysis of the brine components has proved to be complicated, with significant differences between different laboratories. Even allowing for dilution of samples for analysis the relative concentrations of the ions (particularly Na) probably cause interference issues with the ICP spectra of different elements (particularly K). Experience on other brine projects has shown that calibration of ICP equipment is complicated and, as indicated by the documentation provided by ALS, different configurations of the equipment can produce significantly different results. This experience suggests high Na concentrations lead to augmented (overstated) potassium values and a depression of Ca values, with much less effect on Mg.

Consequently future analyses using a lower technology analysis technique like Atomic Absorption Spectrometry is recommended, to minimize the issues related to ICP calibration:

General

- There are doubts about the validity of the standard values, particularly for potassium new standards should be produced and certified for future work programs.
- Performance of the standards at all laboratories was poor, with potassium the worst element and analyses returning less than the standard values. This most likely reflects the elevated values of the ALS analyses certifying the standard.

- Sulphate values were relatively consistent between laboratories, with sodium and chloride the next most comparable elements (ALS analysed Sulphate by a turbiditrimetric method).
- There was significant variation between laboratories, with **ALS results the highest for K and most other elements, followed by Intertek, with the lowest values from Bureau Veritas** (although the correlation with SO4 with ALS was high).
    - This is consistent with the observation that the 2009 Bureau Veritas (Ultratrace) values were 30-30% lower than the 2014 ALS reassays of these samples.
    - The University of Antofagasta values are above those of BV, but below those of Intertek.
- Ionic balances for ALS (2015) were extremely poor (many analyses > 5% difference) when compared to analyses from Intertek and BV, which had almost no analyses >5% difference and most <3% difference.
    - ALS ionic balances where significantly poorer in Batch 3, which unfortunately was the largest. There looks like very poor analytical results in this batch.
    - All laboratory ionic balances showed an excess of anions over cations
- ALS duplicates showed a number of Ca, Mg, K, Na and SO4 values with >10% difference in duplicate pairs.
- RPD and RSD values where much lower for Intertek duplicates, compared to ALS.
- Intertek duplicates are generally well within 10% difference, although outliers were noted for sulphate and chloride
- Not enough QA/QC samples were included with the batch to Bureau Veritas to understand how the analyses have performed against the standard values.
    - However, when compared to the original samples by Reward Minerals (average 3036 mg/l K; 22116 mg/l SO4) the BV results for 2015 are very similar (3198 mg/l K, 21,580 mg/l SO4)
- Overall there is much better agreement between Intertek and BV for most of the analytes, sulphate being the exception.

It appears the "real" sample values are in the range between Intertek and Bureau Veritas, with the University of Antofagasta falling between these two and probably closer to Bureau Veritas. Potassium values from ALS appear to be massively overstated – which has implications for any company which has used the ALS Environmental (and ALS Minerals?) laboratories.

11 BRINE CHEMISTRY

11.1 Background regional chemical data and processes

There is very little historical water chemistry data available in the Lake Mackay area. Geoscience Australia summarized the available data in Figure 13.1 below. They classified Lake Mackay into 4 different zones, but these do not correlate in any detail to the aircore drilling results, although the highest drilling grades are in the south east of the lake.

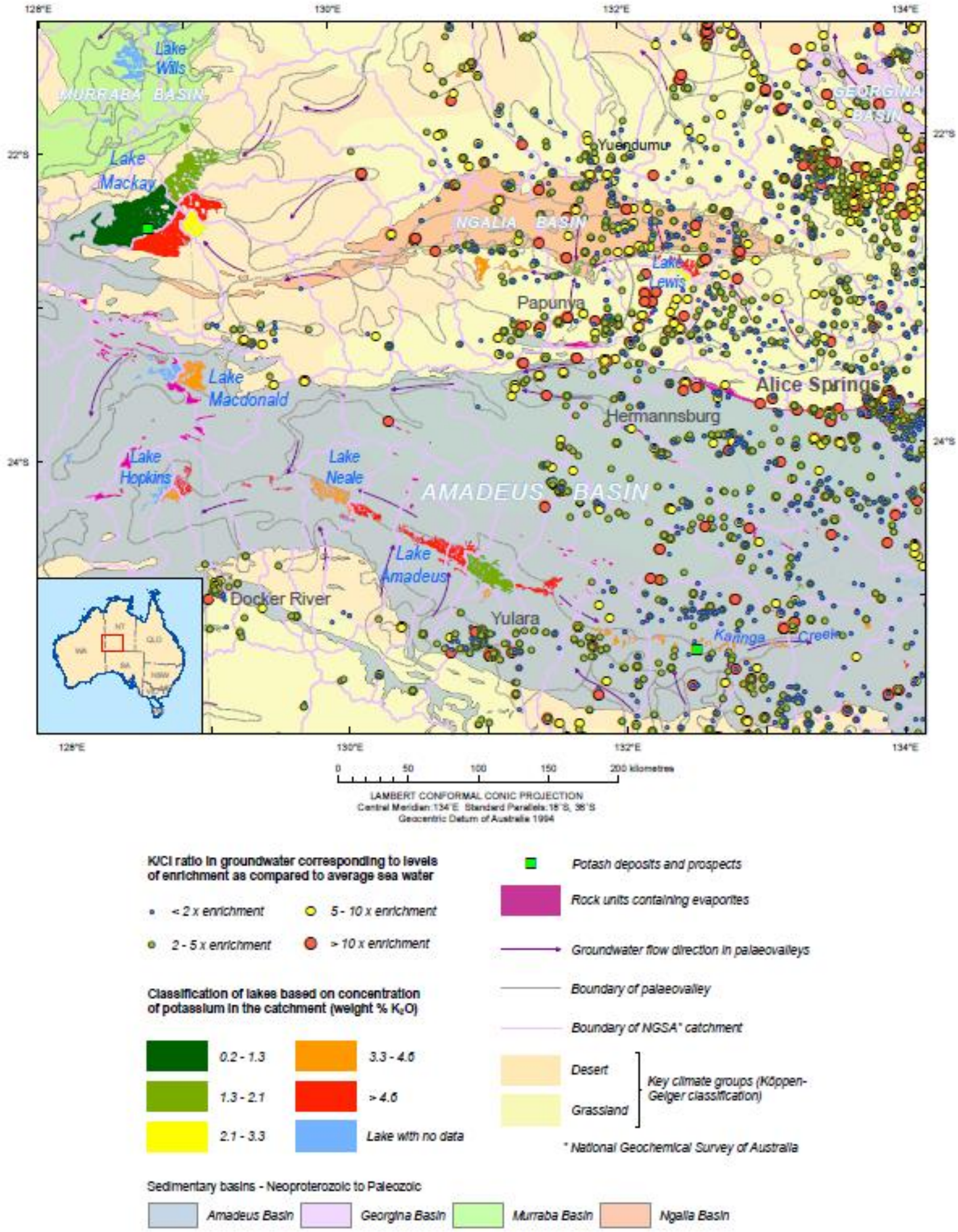

Figure 11.1: Geoscience Australia compilation of regional water chemistry data

In the high evaporation environment it is common for initial groundwaters to have Ca and Mg >> HCO3 with carbonate precipitating after initial evaporative concentration. The calcretes mapped in the Wilkinkarra paleovalley are interpreted as products of this. Once the low HCO3 content is depleted Ca combines with sulphate to form gypsum, which is extensive in the upper levels of the Lake Mackay sediments. As part of the evaporative concentration potassium has been concentrated in many Central Australian salt lakes (Figure 13.2). Exploration results from companies actively exploring show potassium concentrations in the range 3000-5000- mg/l K (see resource section) are typical, with some areas having locally higher concentrations.

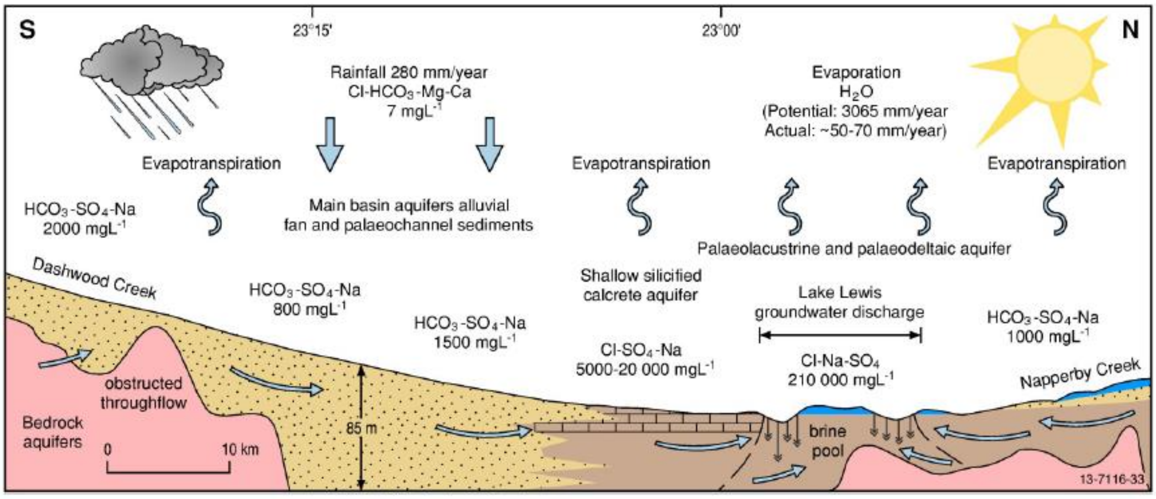

Figure 2.17 A hydrochemical gradient and groundwater flow system through Lake Lewis Basin in central Australia. Solute loads (mg/L) and the main groundwater chemical types are indicated, based on dominant anion and cation compositions. Downward arrows beneath Lake Lewis represent salt plumes or fingers of brine produced by evaporation at the playa surface sinking into the underlying brine pool that infuses the palaeolacustrine clay (from English, 2002).

Figure 11.2: Schematic showing the brine formation process for Lake Lewis (NT), with K contents to 2800 mg/l (from the GA Review of Australian Salt Lakes)

The evolution of the Lake Amadeus and Lake Lewis brines is highlighted in yellow (after GA Salt Lake Review and Jankowski and Jacobson, 1989; English, 2002 in Figure 13.3), following a low alkalinity path with calcite and gypsum forming major minerals precipitated (this is similar to Saline and Death Valley in the US – see photographs of Saline Valley sediments in section 6 above, which are very similar to Lake Mackay). The final brine produces some halite as efflorescent crusts due to dehydration in the capillary fringe, but Na and Cl are predominantly retained in the brine, along with SO4 not precipitated as gypsum. The gypsum is considered to be atmospherically derived. Plots from Jacobson and Jankowski (1989) are included as Figures 13.4 and 13.5, showing evolution through the margins of the Spring Lake (Karinga Lake – RUM project) in central Australia.

The classical salt lake evaporative pattern is regarded as a concentric pattern, with carbonates precipitating in the outer zone, progressing to sulphates, with a central halite zone. Gypsum can occur as displacive gypsum crystals forming in muds in the sub-surface, as gypsum mush following shallow CaSO4-saturated lake waters or as hummocky "gypsum ground" (as described by Chen et., al. 1991b). GA note that large volumes of gypsum are often present in aeolian landforms down wind of salt lakes, attesting to substantial periods of evaporative pumping and conditions favourable for gypsum deposition. Gypsum deposition is correlated with reduction in the Ca content of salt lake brines, with a lesser depletion of sulphate, which is present well in excess of Ca.

11.2 Salt lake brine pool characteristics and dynamics

The Murray–Darling Basin investigations of Ferguson et al. (1992) and Jacobson et al. (1994) identified two main hydrodynamic systems operating within the same climatic regime and the same general environment, with the differences determined by the type of sediment underlying the saline basins. Where permeable sand aquifers are present, salt sinks advectively downward. Where less-permeable clays are present, slow diffusional transport of salt downward occurs. At Spring Lake, east of Lake Amadeus (part of the Karinga Lakes held by RUM), diffusive sinking of accumulated salt occurs despite continuous upward flow of groundwater (Jacobson and Jankowski, 1989).

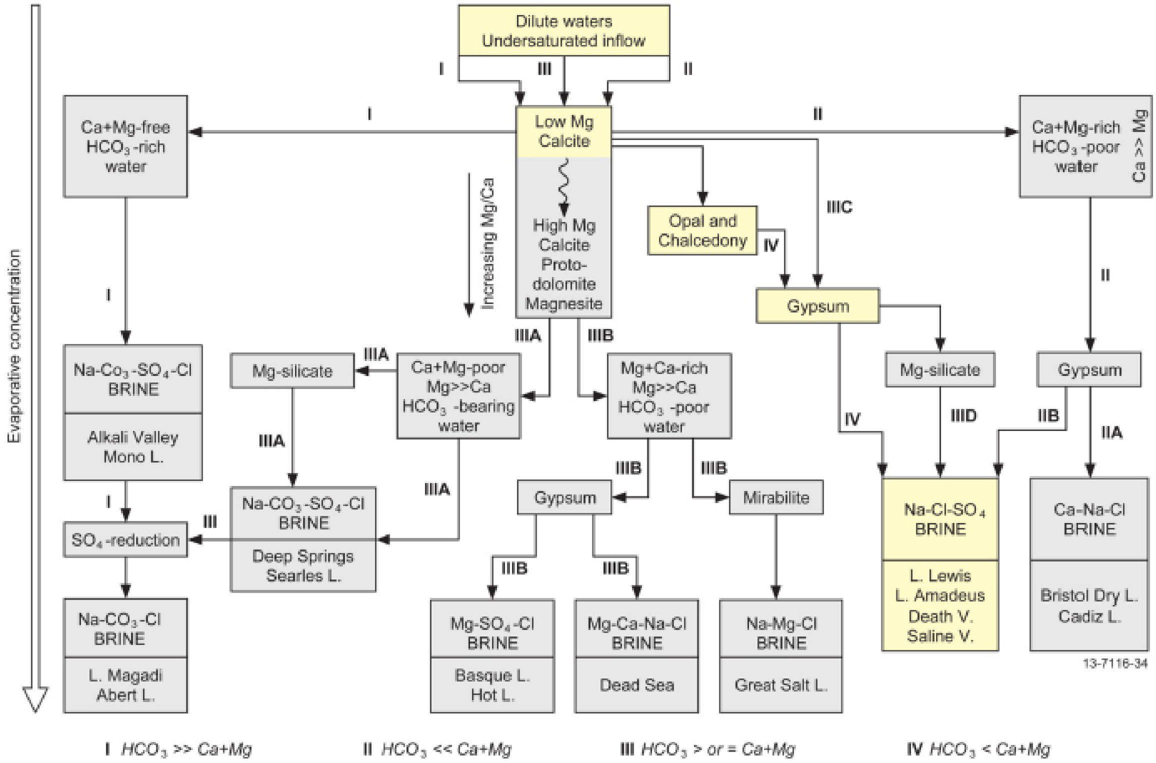

Figure 2.18 Possible paths for groundwater and brine evolution (modified after Figure 5 of Eugster and Hardie, 1978). Solid rectangles represent critical precipitates; rectangles with dashed borders are typical water compositions; evolved brine types, together with examples of representative salt lakes, are surrounded by double rectangles. The evolution of Lake Amadeus and Lake Lewis groundwaters is shaded (from English, 2002).

Figure 11.3: Brine evolution path for typical Central Australian brines (from GA Review of Australian Salt Lakes)

Cartwright et al. (2001) investigated the trend for increasing salinity along groundwater flow paths in the Murray–Darling Basin where dramatic salinity variations from 650 mg/L to >100,000 mg/L TDS occur over distances of a few kilometres in both shallow and deep aquifers. Using hydrochemical data, particularly Br/Cl ratios, they showed that limited dissolution of salt from the aquifer is occurring. Stable isotope data and Mg/Ca/SO4 ratios indicated that brines produced in the saline lakes reflux into underlying aquifers to depths of up to 180 m, implying that there is significant vertical interconnection within the basin.

A distinctive brine pool dynamic is described by Chen et al. (1991a) at Lake Amadeus, where '**gypsum ground**' formed on the playa surface is related to changes in water levels during the Holocene. Gypsum ground is a slightly elevated, rough and patterned surficial crust that has a 'gilgai' texture and is underlain by gypsum. **Chen et al. (1991b) proposed that initial gypsum deposits formed when the water table was high, probably during wetter climatic conditions, causing active seepage and more frequent surface exposure of brine in the playa**. A later decline in the water table, most likely during drier times, caused degradation of the gypsum deposit by dissolution and leaching processes. In this case, brine dynamics have had a direct geomorphological influence in forming distinctive salt lake crusts that have also been recognised in Lake Lewis (English, 2002).

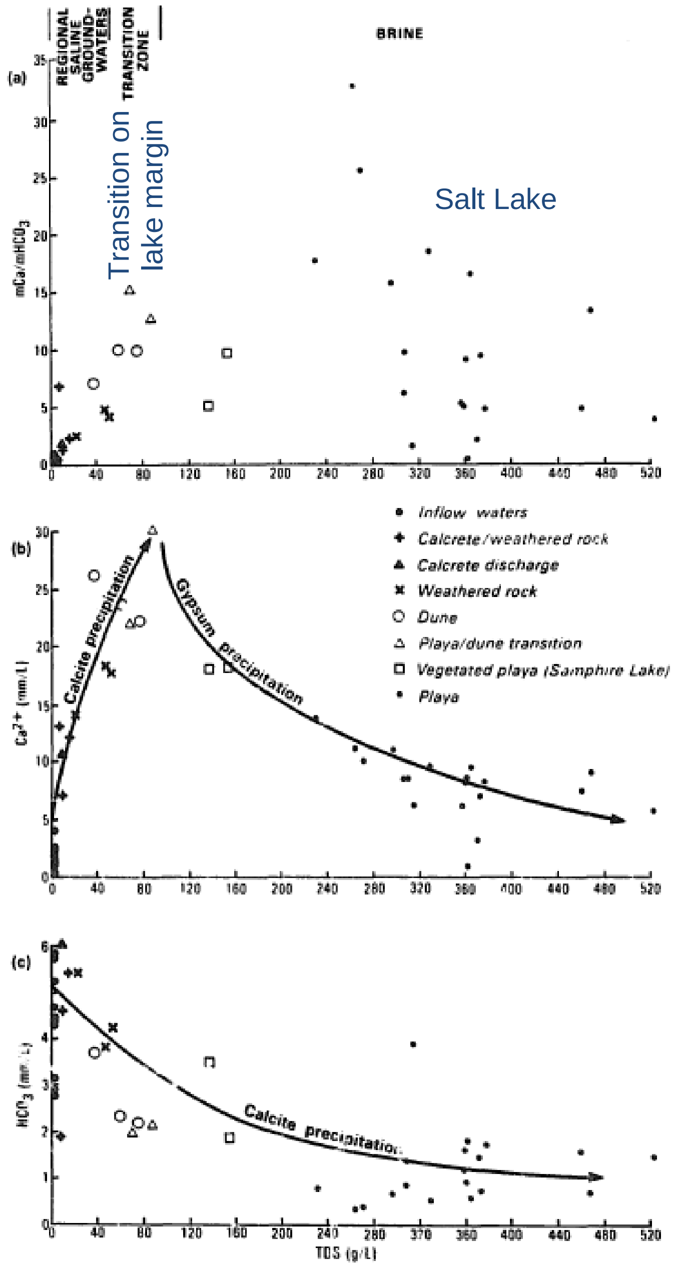

Fig. 10. Relationships of the Ca/HCO_3 ratio, and Ca and HCO_3 concentrations to increased groundwater salinity.

Figure 11.4: Plots from Jacobsen and Jankowski (1989) showing chemical evolution across the margin of a lake in the Karinga Lake with deposition of carbonate and gypsum

English (2002) also proposed that diffusion of salt was the main dynamic process below 1 m depth, i.e., within the bulk of the brine pool, because of poor hydraulic conductivity in the thick, dense paleolacustrine Anmatyerre Clay beneath the playa (diffusion being considered by authors of experimental works to only effectively work on the scale of metres, due to slow transfer). Salt movement downward occurs despite the upward pressure gradient of discharging basinal groundwaters. The arrival of up-gradient saline groundwaters at the discharge zone at Lake Lewis is concentrated along spring zones near the playa margins, with the less-dense basinal groundwaters deflected upwards along the interface with brines. This is analogous to the situation at Lake Tyrrell (Macumber, 1992). The role of buried and outcropping granite highs at Lake Lewis may complicate the movement of both basinal groundwaters and brine.

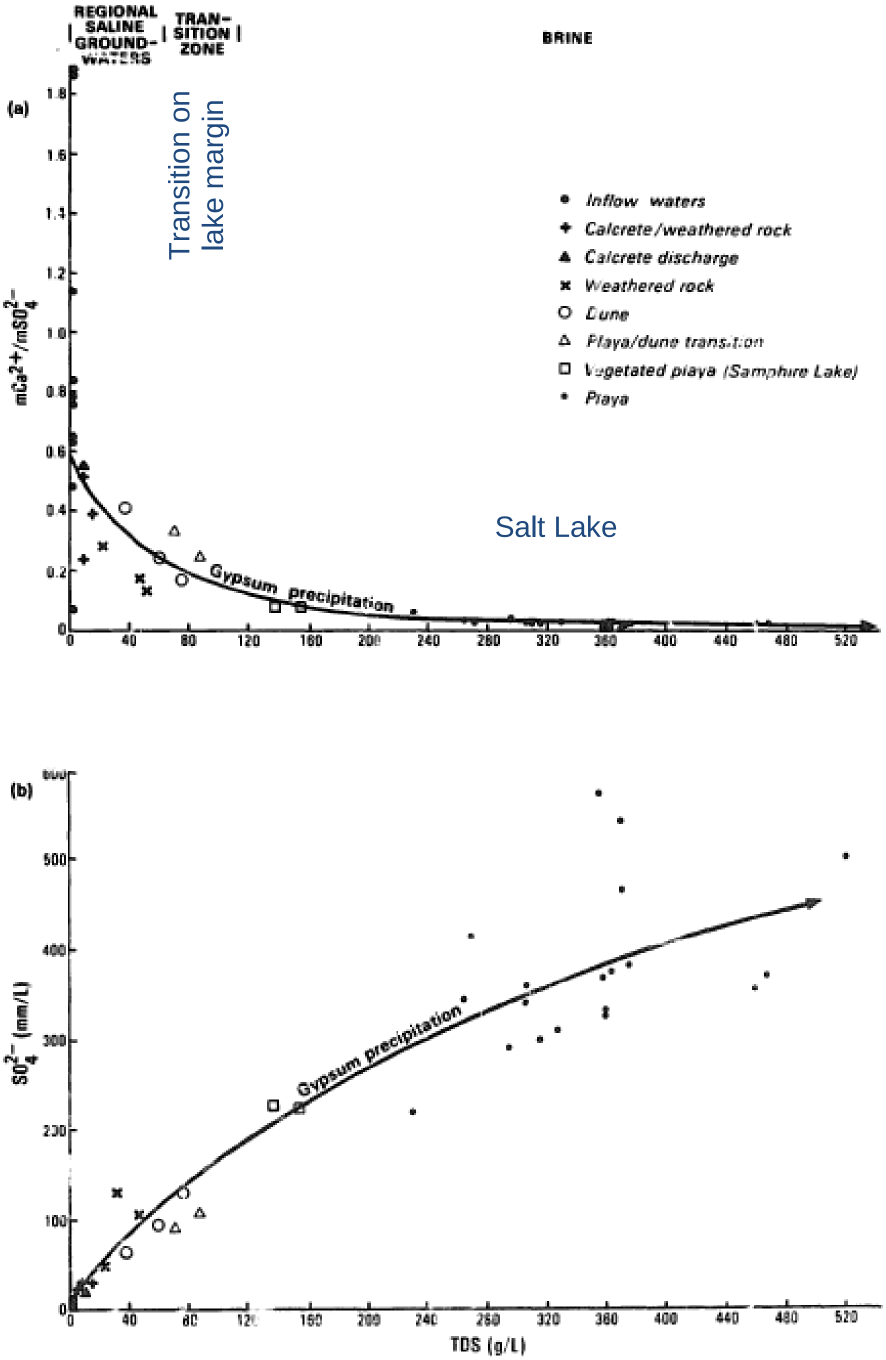

Fig. 11. Relationships of the Ca/SO_4 ratio, and SO_4 concentration to increased salinity.

Figure 11.5: Additional plots from Jacobsen and Jankowski (1989) showing chemical evolution at a Karinga lake with increasing TDS

Carbonate and bicarbonate content is very low in the Lake Mackay lake samples (and only 225 mg/l in the Flake sample taken from a brackish clay pan lake passed by the track from the camp turn off to the Lake Mackay edge. Figure 13.6 and 13.7 plots show brine evolution with loss of Ca in precipitation of gypsum and corresponding subsequent increase in sulphate concentration. There only appears to be one population of samples – given that groundwater off the lake was not sampled, with no difference in ratios with respect to bicarbonate, sulphate and carbonate.

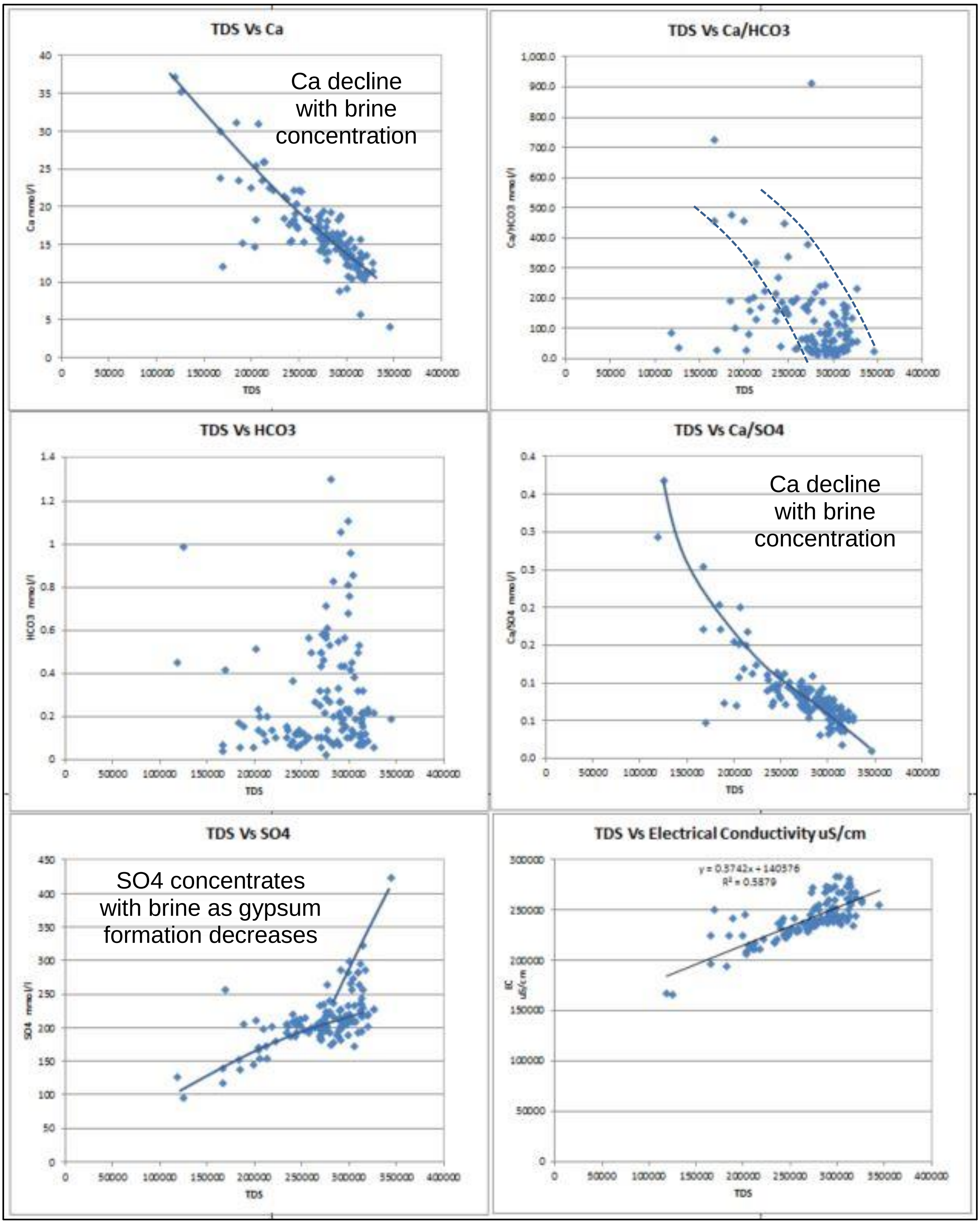

Figure 11.6: Plots of Ca and bicarbonate against brine concentration (from ALS data)

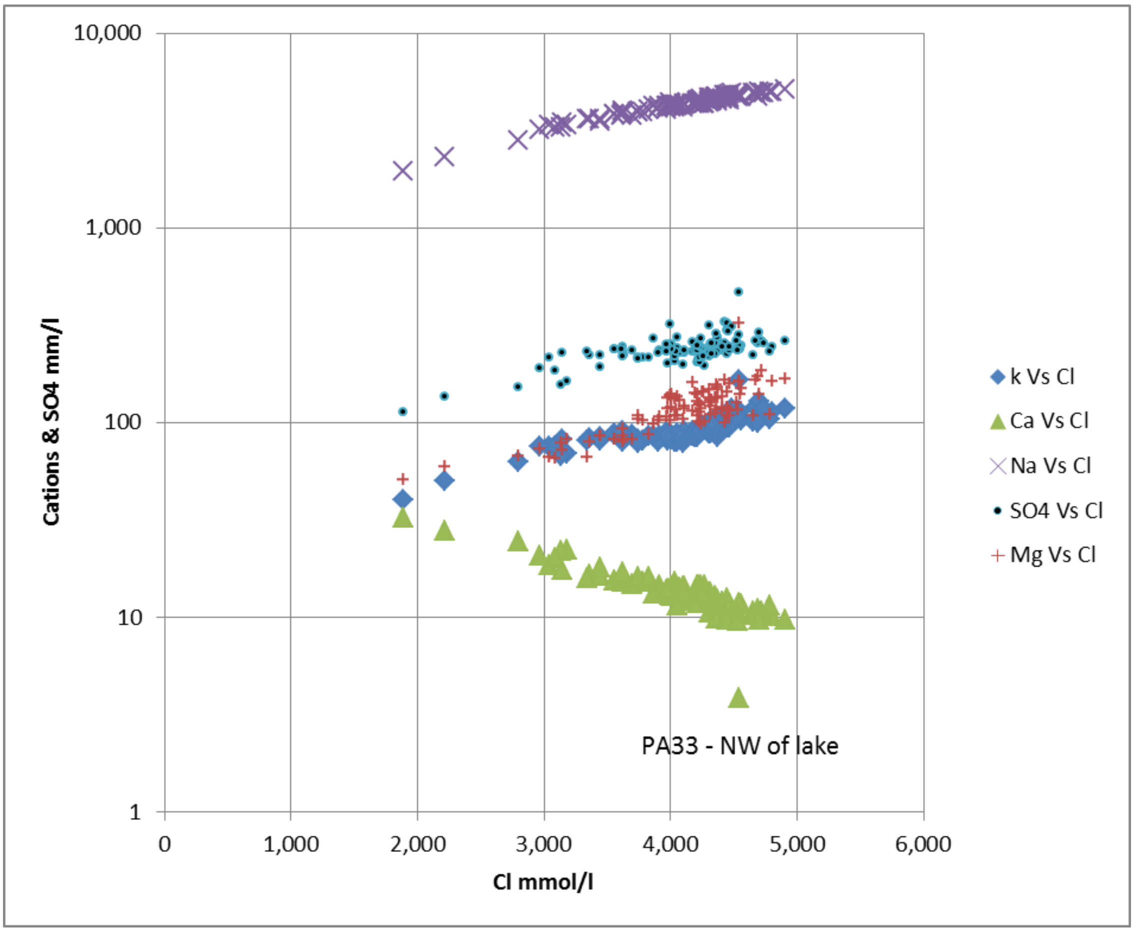

Figure 11.7: Plot of anions and SO4 against chloride for Intertek data

Three sets of fluid sample data were obtained during the drilling investigations at Lake Mackay; brine samples from drilling, brine samples from pump testing and brine samples from auger sampling. A summary of the analytes of interest (K, Mg, Ca, Na, SO4, Cl) in fluid samples **analysed by Intertek** is presented in Table 13.1 (this excludes the AC00 duplicate QA samples) and Figure 13.10. Figure 13.8 compares aircore base, aircore top and auger hole values. There are low standard deviations for Cl and SO4, and larger relative standard deviations for the cations.

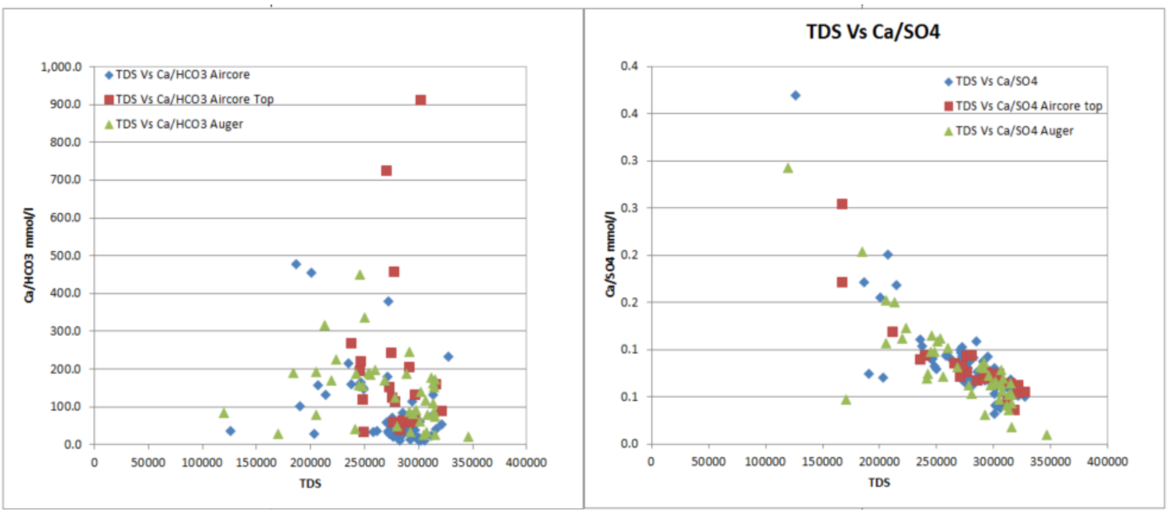

Figure 11.8: Comparison of samples from pump testing, top of aircore holes and auger holes

11.3 Lake Mackay brine characteristics

	Ca mg/l	K mg/l	Mg mg/l	Na mg/l	SO4 mg/l	Cl mg/l	Density	TDS	Mg/K	SO4/K	Cl/SO4
Average	541	3,639	2,924	99,604	23,141	145,469	1.18	233	0.8	6.4	6.3
Std Dev	131	583	830	11,462	3,832	16,968	0.03	24	0.2	0.7	0.8
Min	154	1,953	1,440	53,501	13,140	78,700	1.10	136	0.5	5.2	3.6
Max	1,126	6,520	7,857	118,507	44,740	174,000	1.22	281	1.2	8.8	8.0

Table 11.1: Summary geochemical data from the Intertek analyses

- The pH of the brine is generally weakly acid to weakly alkaline, with an average lab pH of 6.8 (and range from 5.8-8.6 for ALS data), compared to an average field pH of 7.27.
- Lab electrical conductivity averaged 243,112 uS/Cm, ranging from 166,000 to 284,000 (for ALS data)
- TDS (ALS lab data) averaged 273,200, ranging from 126,000 to 327,000 mg/l. These compare to the average TDS determined by Intertek as 233,000 mg/l.
- Intertek determined the average density to be 1.186 g/cc, compared with to an average from field data of 1.21 g/cc.
- Increasing density shows a relationship with increasing K concentrations (Figure 13.9), which is less clear below densities of 1.15 g/cc.

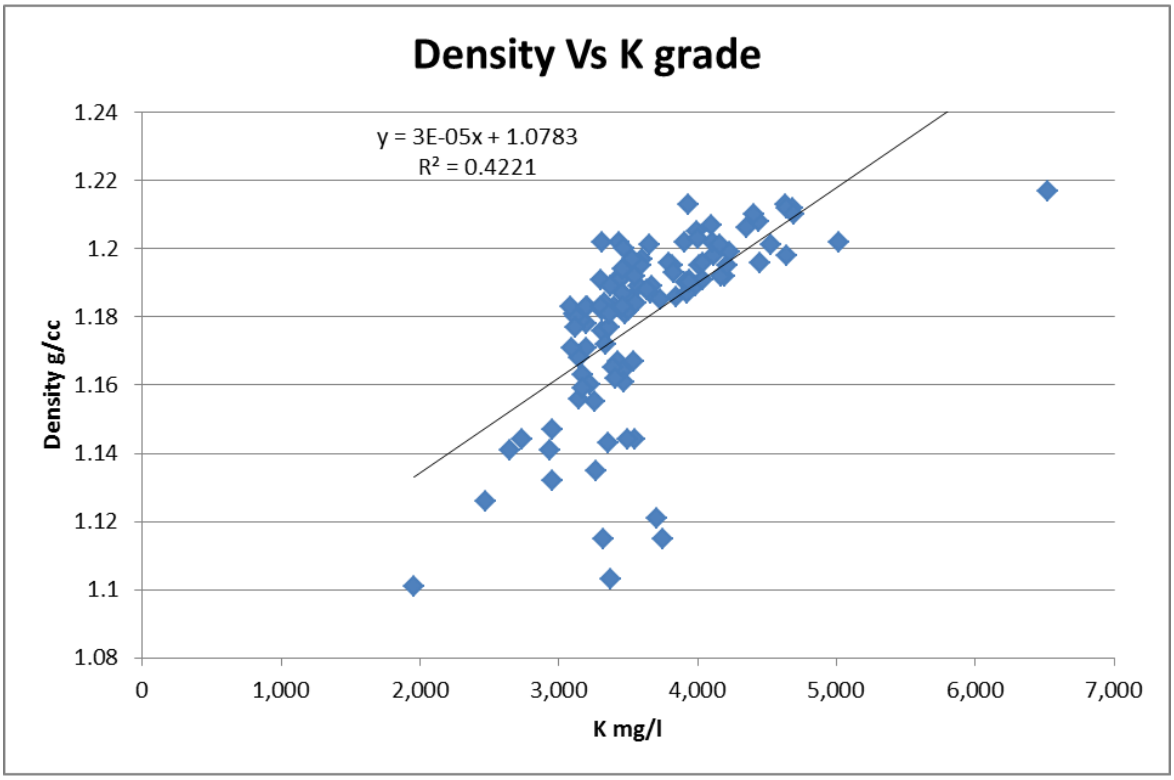

Figure 11.9: The relationship of density and K concentration from the Intertek analyses

Figure 13.10 shows five different columns of data:

- **All data** from Intertek analyses (a total of 105 samples – with 4 of these Intertek lab duplicates of primary samples; compared to the 124 primary samples analysed by ALS).
- **Aircore > 3m –** samples from aircore holes taken at > 3 m deep (to separate shallow brine from deeper brine)
- **Pump testing –** PT samples from pump testing

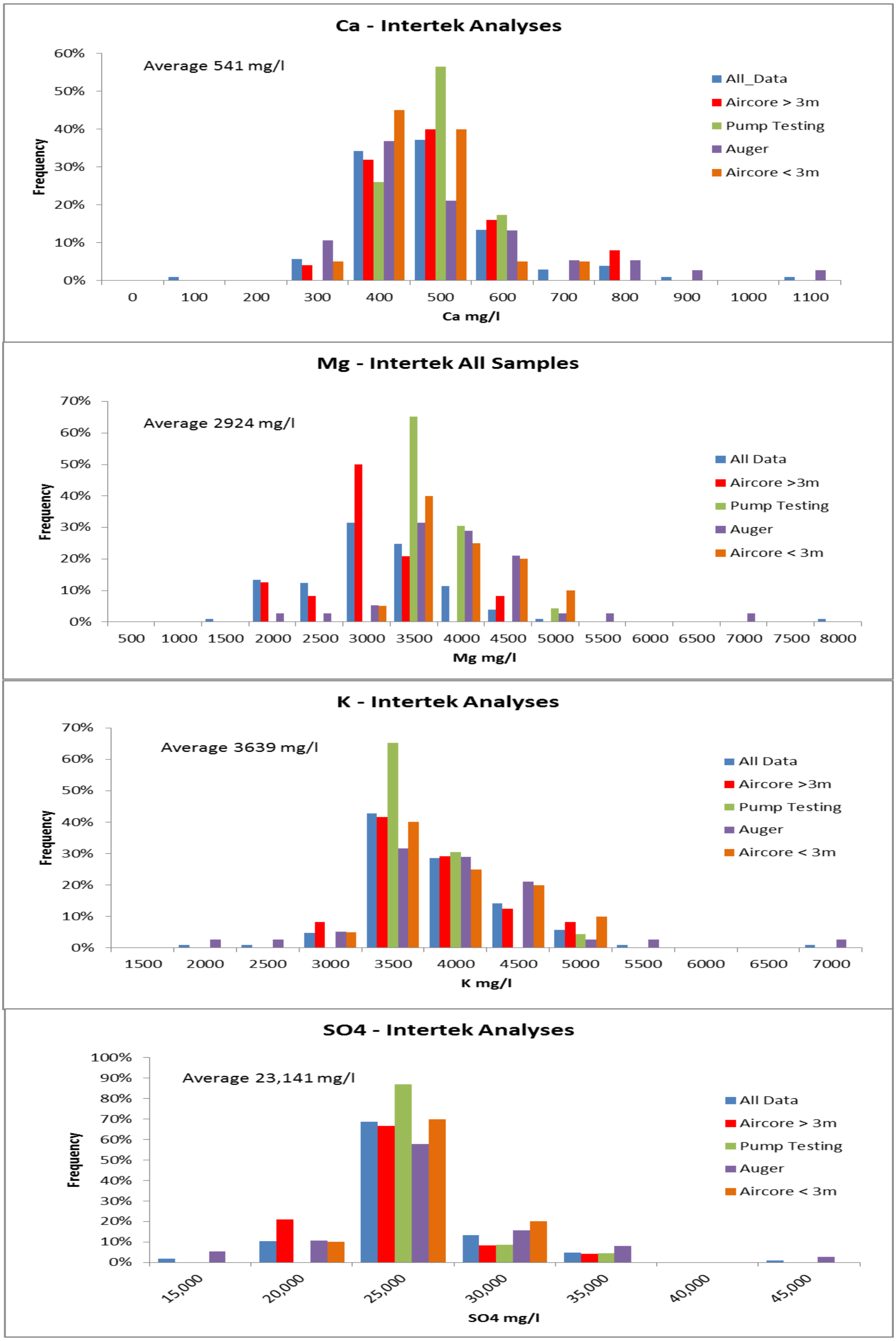

Figure 11.10: Distribution of analytical values by sample sub-type

- **Aircore <3m** – pit samples from drilling sites and any samples above 3 m depth, for comparison with the power auger samples.
- **Auger sampling** – Power auger and 5 hand auger samples – maximum depth 1.5-2 m)

Comparison of the results shows that

- Pump test samples show the least spread in values – reflecting their "all of hole" composition from brine
- The auger and shallow aircore (<3 m) samples have similar results, with the auger samples having some outlying high and low values
- The aircore samples >3 m have a few more lower grade values, reflecting MA10 adjacent to an island – with lower grades.
- The distribution of most elements has an asymmetric distribution with a long upper tail and a "base: to values – which is particularly evident for K values.
- The ratios of elements do not show large ranges, with Mg/K from 0.5-1.2; SO4/K from 5.2-8.8. Cl/SO4 shows a larger range from 3.6-8.

11.3.1 Analyte concentrations by unit and depth

Data shows there is a wider spread of K and other elements in the shallow auger and top of aircore hole data. There is no clear pattern of change in potassium with depth, although a few data points suggest there is a slight decline (Figure 13.11).

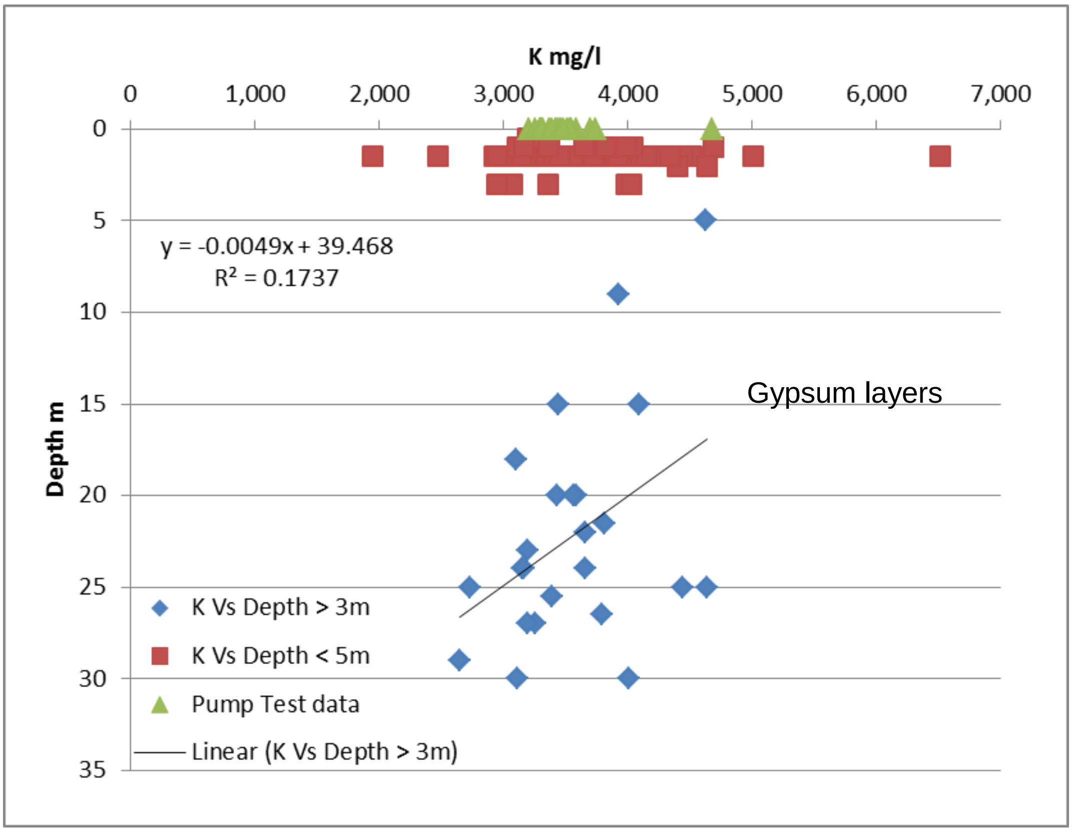

Figure 11.11: Potassium values plotted by depth

Average values were prepared for maps (Figures 13.12-13.16) using the arithmetic mean of all samples in each hole, except if there was a reasonable basis to omit the upper sample, due to lower grades – such as at MA10. All but the upper pit and 5 m sample were averaged. This gives a value of 3487 mg/l K. That would be 3663 if we only average the three deepest samples. Weighted averages did not show significant differences from arithmetic averages (only a couple of 100 mg/l K difference).

Overall brine grades are relatively homogeneous but they show distinct zoning from east to west across the lake, particularly in the eastern gypsum ground. Refer to graphics in Appendix A for more detail.

- Potassium is highest in the west NW and lowest in the east. Magnesium displays a similar pattern
- Calcium is lowest around the margins of the lake and highest in the middle, lowest in the west and highest in the east
- Sodium and chloride are highest in the west and lowest in the eastern gypsum ground
- Sulphate is higher in the west and lowest in the east

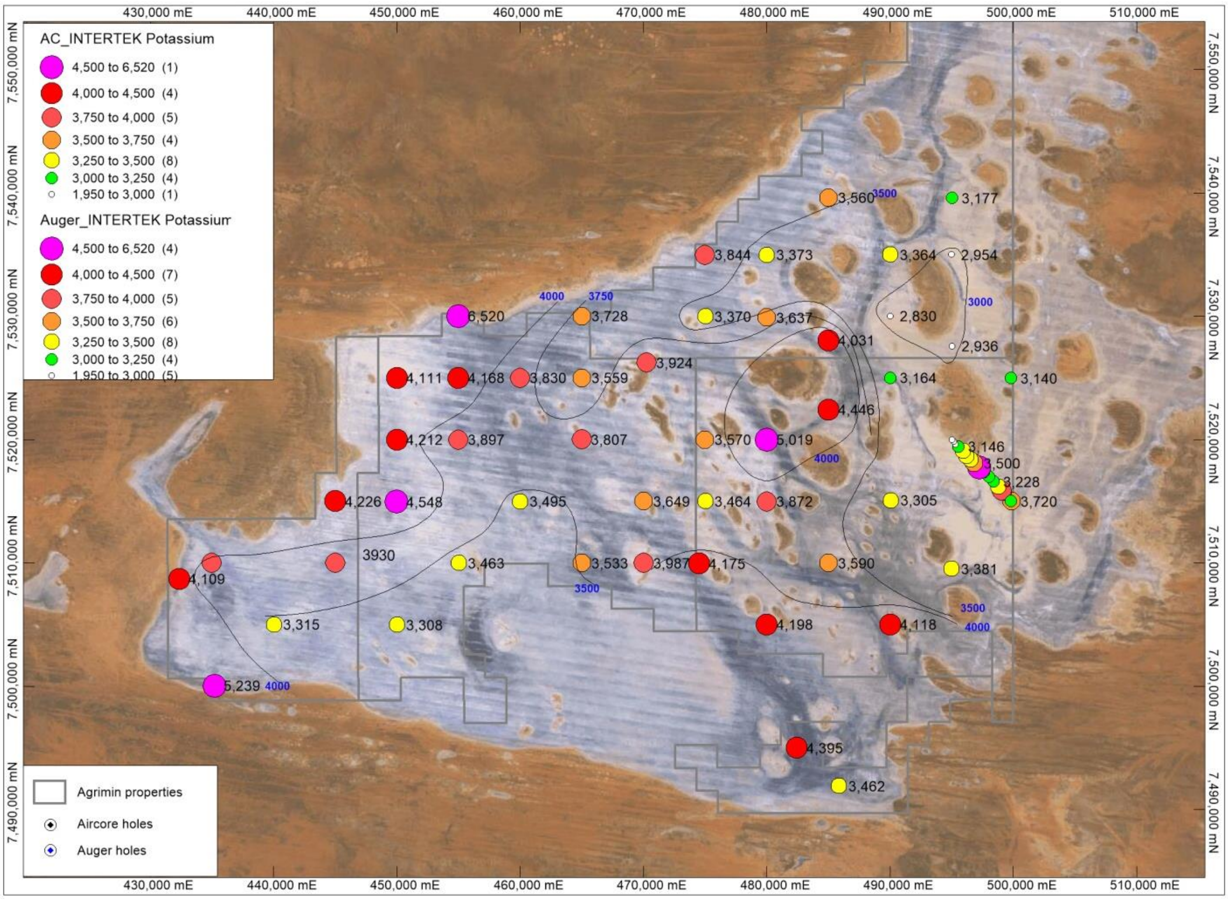

Figure 11.12: Distribution of averaged potassium samples

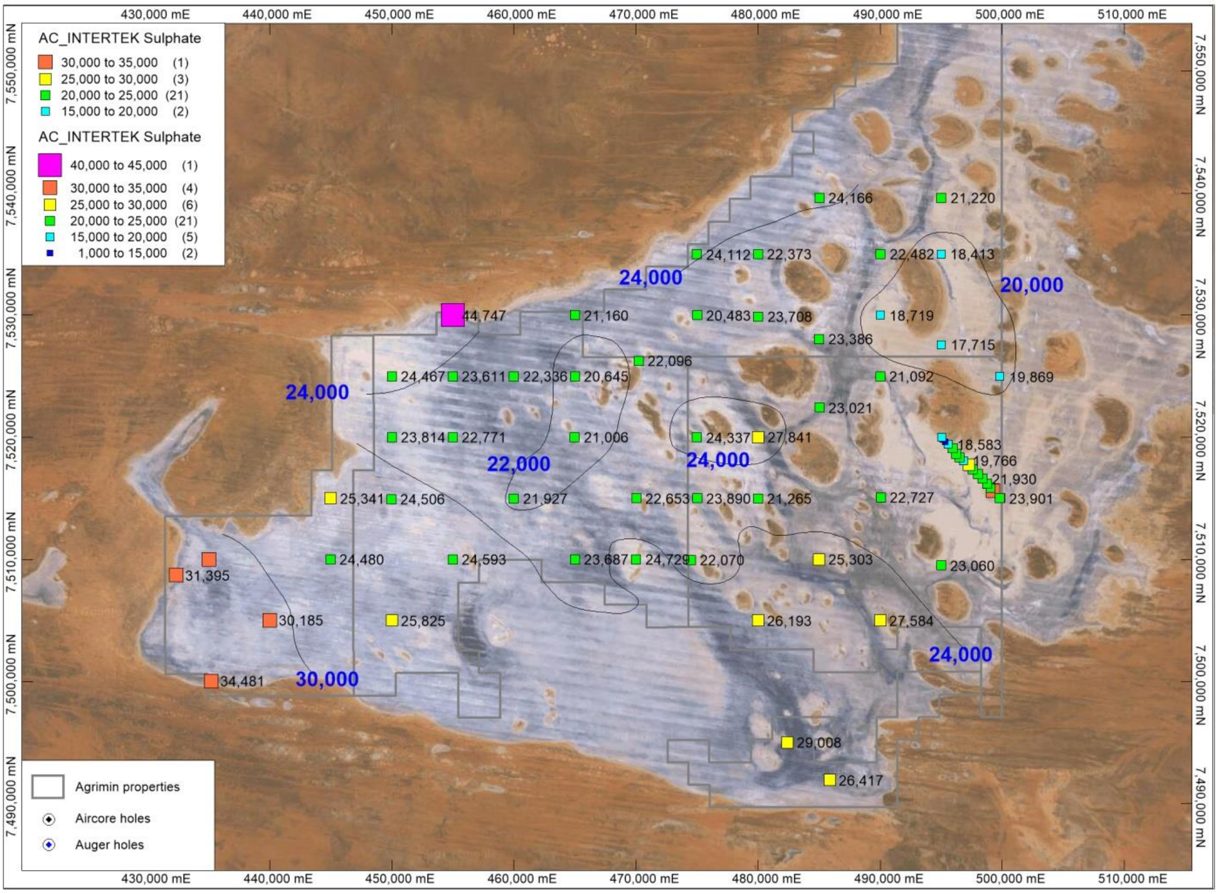

Figure 11.13: Average SO4 concentration across the lake

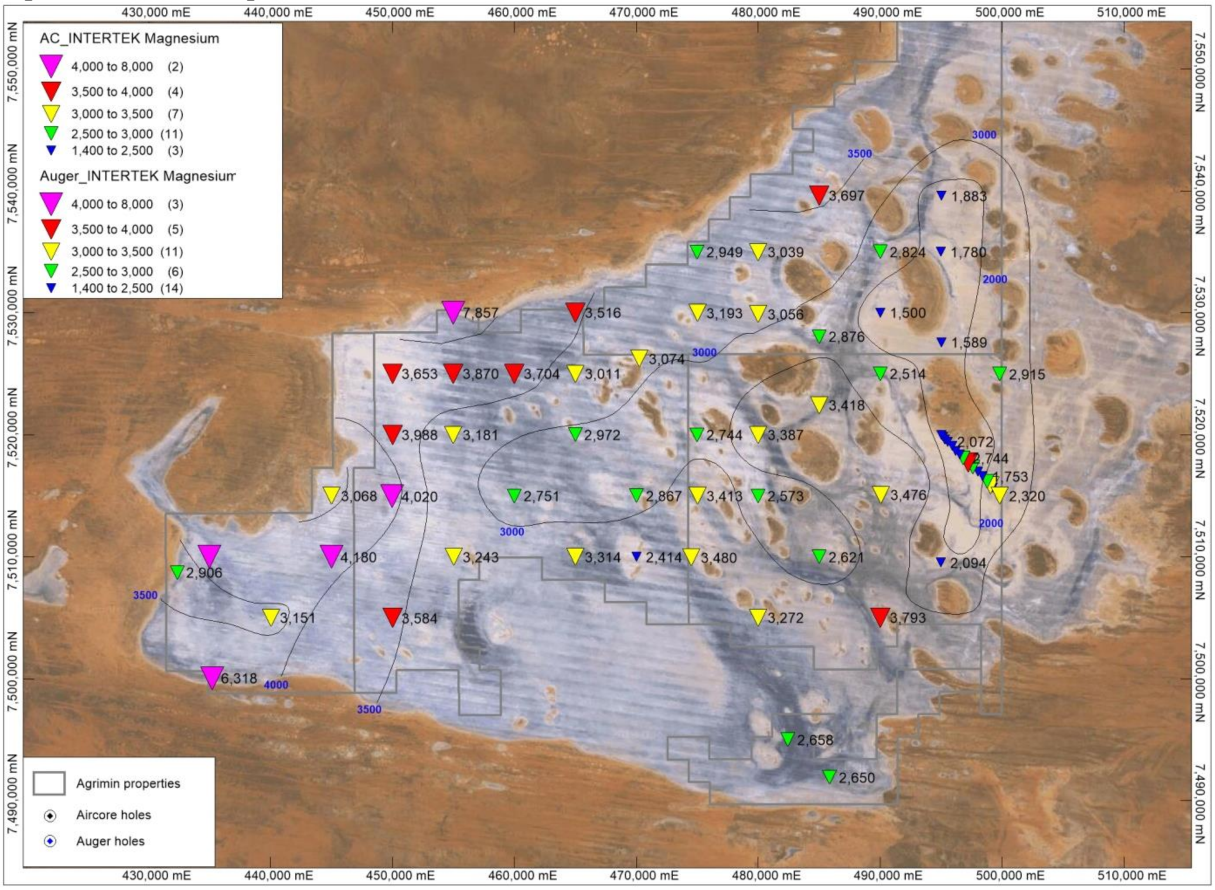

Figure 11.14: Average Mg concentration across the lake

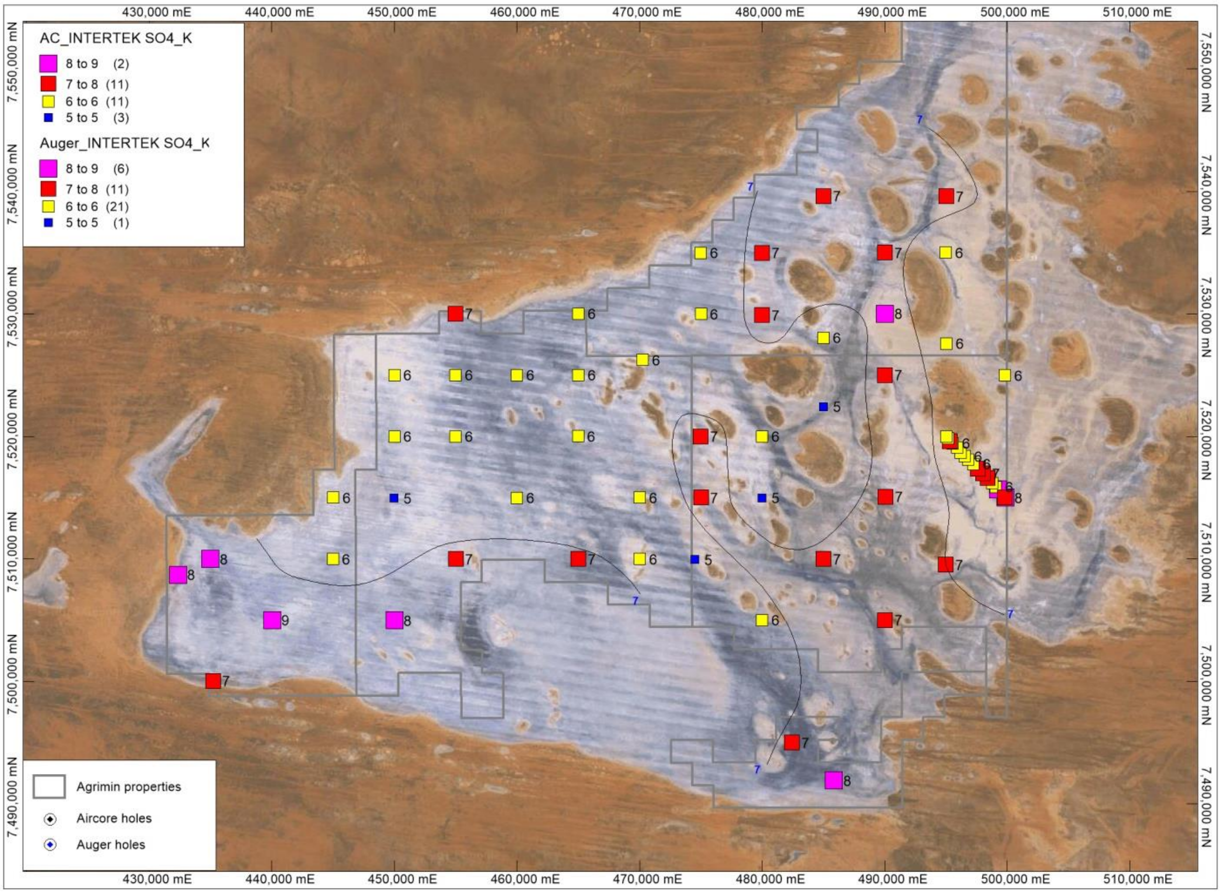

Figure 11.15: Average SO4/K ratio across the lake

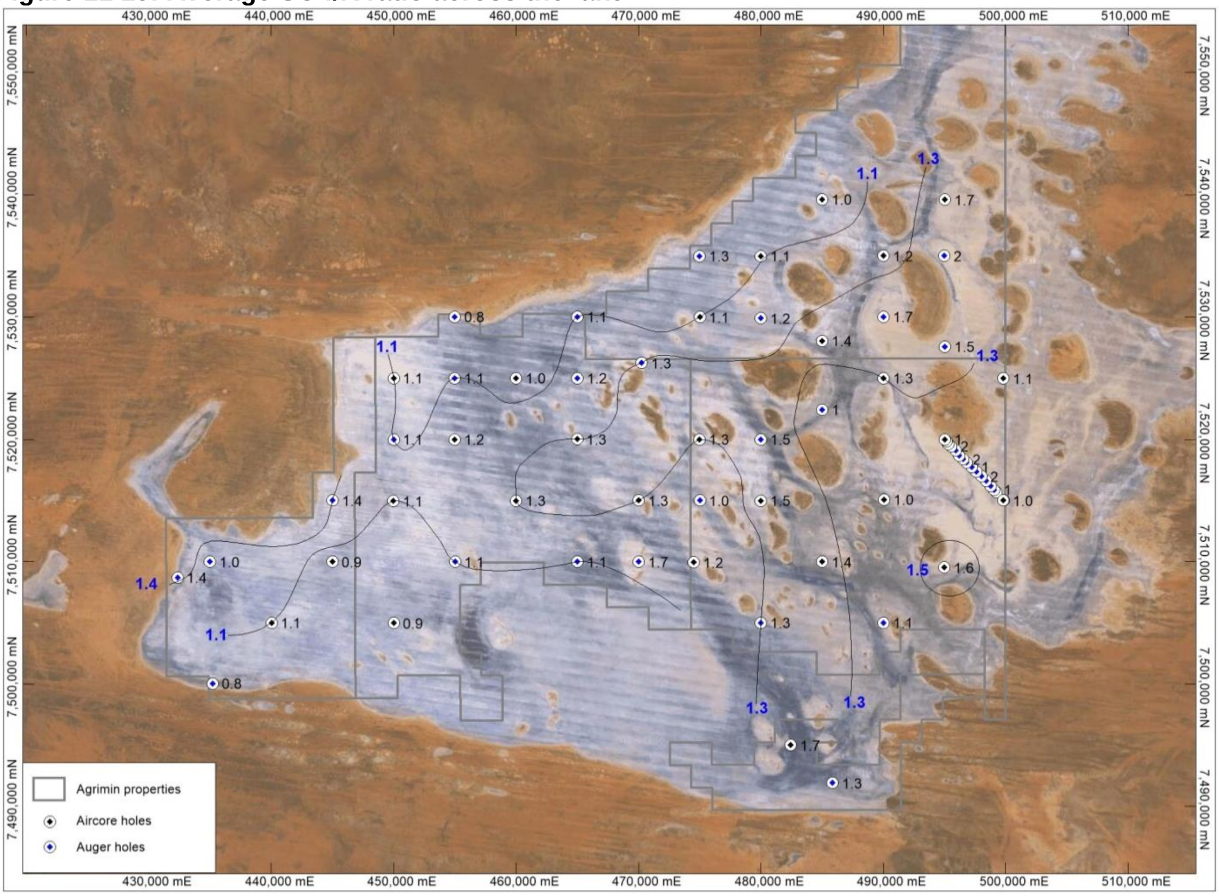

Figure 11.16: K/Mg ratio across the lake

11.3.2 Brine characterization and evolution

The brine chemistry when plotted on a Janecke projection (Figure 13.17) shows the relative position compared to lithium +/-potassium brine projects. This plot does not show analyte concentrations, but provides an indication of the types of salt expected to crystallize during the solar evaporation process. The Lake Mackay brine is located within the Tenardite field.

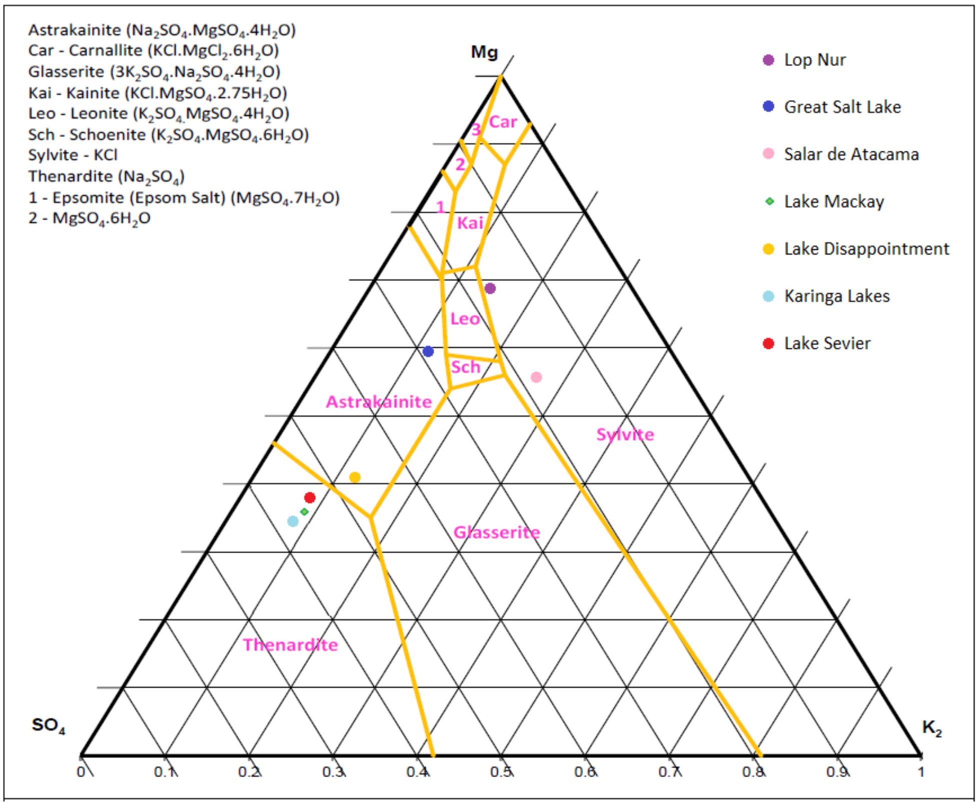

Figure 11.17: Relative composition of average Lake Mackay brine

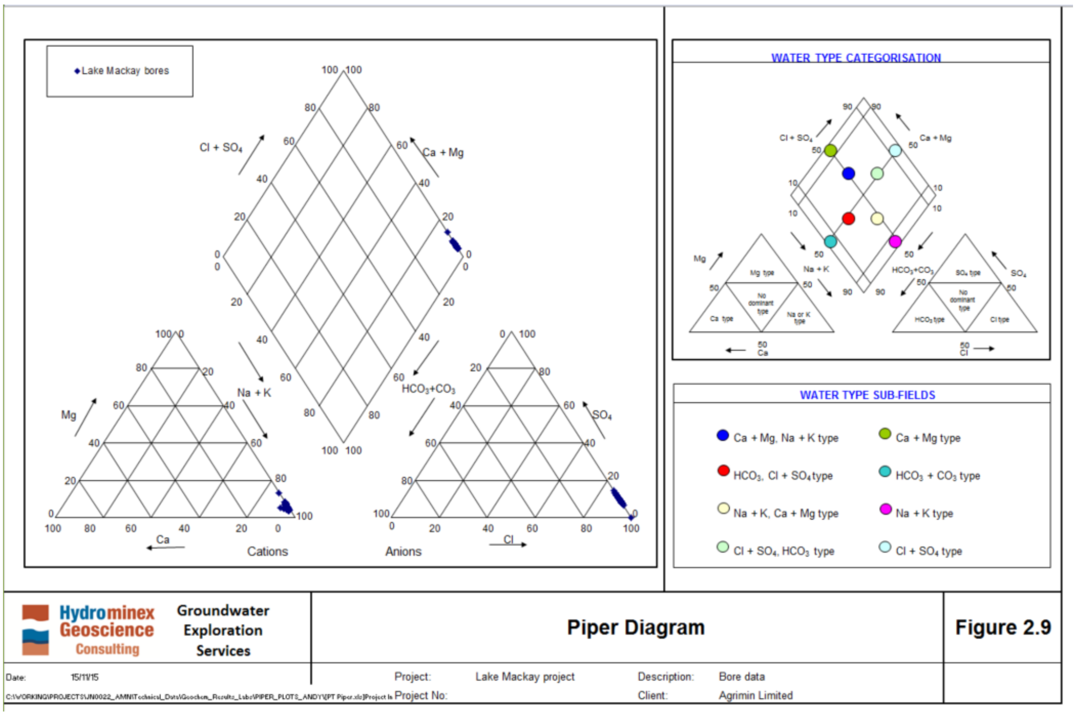

Figure 11.18 Piper plot of average Lake Mackay brine concentrations

11.3.3 Seasonal influences on brine composition

It appears very likely seasonal changes in brine composition will occur in the unconfined aquifer, due to dilution of the brine by direct rainfall precipitation on the salt lake. It is very important to assess the extent of this issue; given the unconfined sand unit is the key aquifer unit for potential production. Evaluation of the difference between 2011 vibracore and 2014 aircore sampling (Table 13.2 & Figure 13.19, 13.20 - most of the brine probably originated in the upper unconfined unit, based on our field observations of the clays) shows an average decrease in 20% in K, and 10% for Mg; however sulphate values show an increase of 2%.

It is not stated how the sulphate values were analysed, but it was probably as S by ICP, with values calculated to SO4. It is not clear why the K, Mg and SO4 show distinct differences, but the uncertainties in the analytical method, probably difference between laboratories and the small number of “repeat” samples (9) may explain this. The sample pairs with the biggest difference are those with LV19 and LV22, with the latter on the margin of the lake, while LV19 is on the northern boundary of RUM properties with Agrimin.

It is noted that Toro Energy, who carried out the 2011 vibracore sampling used ALS Brisbane and Perth for analyses of drilling and surface samples (for uranium and other elements) – so **it is likely that they used ALS for the brine analyses** although no information is available to confirm this. The 2014 analyses by RUM were by Intertek Genalysis – the same lab used by Agrimin. **Given observations in differences between these two labs on Agrimin brine samples it is uncertain whether some of the difference between these sampling campaigns is due to the different laboratories, rather than purely rain dilution prior to the 2014 sampling.**

HoleID	Easting	Northing	Total_Dep	SWL_m	K_mgl	k2SO4_mg	Mg_mgl	SO4_mgl
LMAC005	459999	7502486	9	0.4	3183	7098	2977	26913
LV15	459948	7502471	0.38	0.42	3860	8612	3950	22800
DIFFERENCE 2014-2011					-19.2%	-19.3%	-28.1%	16.5%
LMAC006	462481	7507525	9	0.3	3639	8115	3631	24442
LV21	462491	7507523	1.14	0.45	4020	8969	3410	28600
DIFFERENCE 2014-2011					-9.9%	-10.0%	6.3%	-15.7%
LMAC011	462476	7497539	12	0.3	2929	6531	2409	24770
LV12	462501	7497513	1.53	0.5	3230	7206	2260	19900
DIFFERENCE 2014-2011					-9.8%	-9.8%	6.4%	21.8%
LMAC004	464988	7502499	18	0.3	3053	6808	3334	21880
LV16	464912	7502474	1.01	0.5	3700	8255	3640	25400
DIFFERENCE 2014-2011					-19.2%	-19.2%	-8.8%	-14.9%
LMAC003	469942	7502583	19	0.5	3079	6866	3217	20663
LV17	469895	7502595	1.08	0.57	3460	7719	3230	18100
DIFFERENCE 2014-2011					-11.7%	-11.7%	-0.4%	13.2%
LMAC002	469990	7493275	18	0.5	3694	8237	5026	32695
LV22	470023	7493234	0.67	0.5	5430	12114	7480	22400
DIFFERENCE 2014-2011					-38.1%	-38.1%	-39.2%	37.4%
LMAC010	472472	7497554	12	0.3	2874	6409	2818	19456
LV10	472421	7497555	0.67	0.5	3640	8121	3470	29000
DIFFERENCE 2014-2011					-23.5%	-23.6%	-20.7%	-39.4%
LMAC009	477542	7497552	12	0.1	3264	7278	2658	19624
LV09	477481	7497528	1.18	0.52	4110	9169	2810	25000
DIFFERENCE 2014-2011					-22.9%	-23.0%	-5.6%	-24.1%
LMAC007	480761	7502357	12	0.1	3388	7555	3064	23310
LV19	479954	7502404	0.79	0.38	4600	10263	3240	18800
DIFFERENCE 2014-2011					-30.3%	-30.4%	-5.6%	21.4%
AVERAGE CHANGE					-20.5%	-20.6%	-10.6%	1.8%

Table 11.2: Comparison of RUM 2014 aircore and 2011 vibracore sampling

11.3.4 Bulk water sampling

Bulk water samples were collected in 1000 litre pods from the trench LMT1 and from 50 mm bore MA06. A total of 5 pods were flown off the lake and trucked to Perth for laboratory test work.

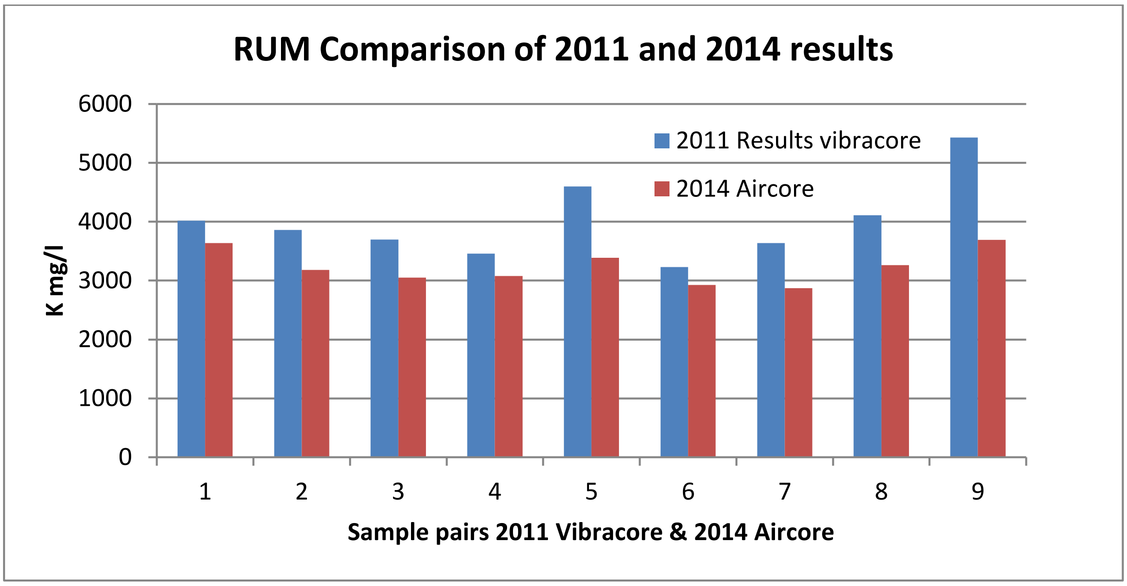

Figure 11.19: Comparison of RUM potassium results from 2011 and 2014 sampling

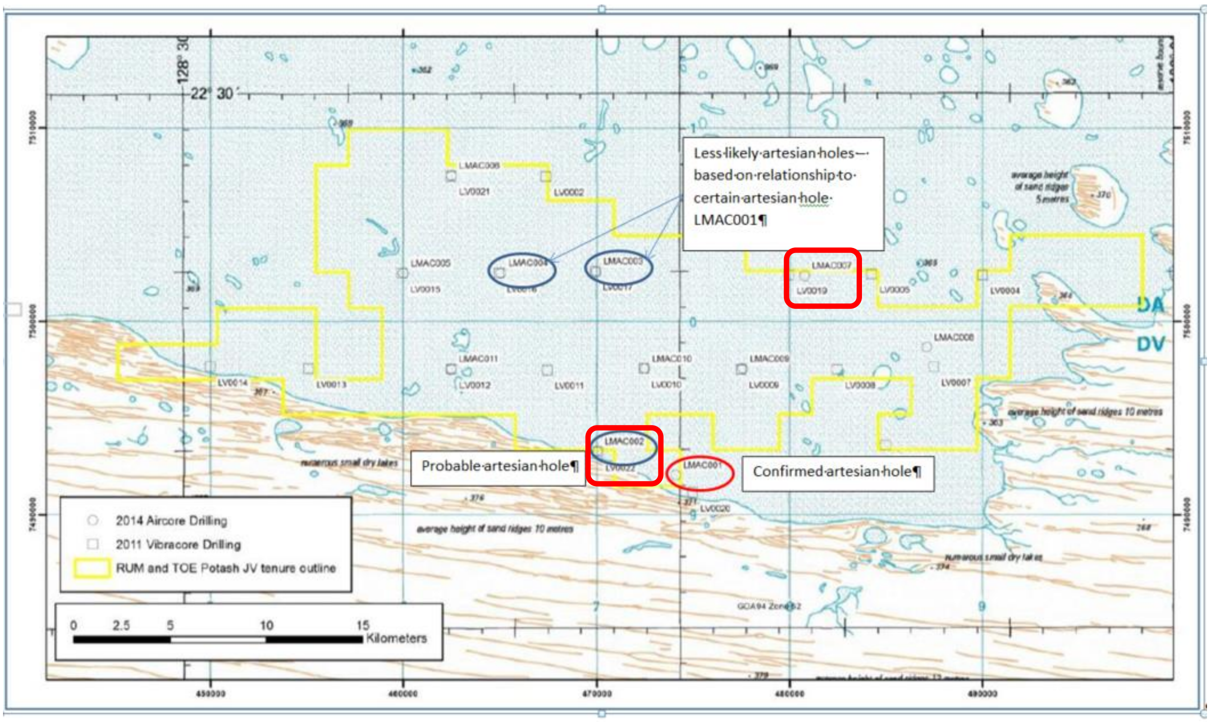

Figure 11.20: Location of RUM sample pairs with the greatest differences 2011-2014 (red squares)

11.4 Conclusions

- There is some zoning in the potassium and other elements throughout Lake Mackay. Potassium shows highest values in the south and west of the lake.
- Potassium values are lower in the gypsum ground to the east, probably due to seasonal dilution in this more porous area.
    - It is not clear why the values are high in the south, coincident with a major inflow channel to the lake.
    - The other high is in the west of the lake, which doesn't appear to inundate. It is also not clear why values are higher on the western side of the lake. The area around MA04 was noted to be the softest underfoot of all the drill sites, suggesting continual recharge in this area.
- Surficial/upper samples have higher values than deeper samples in the west and north, and lower values in the east – where the permeable gypsum sand is present.
- Overall results from top of hole to deeper samples suggest values aren't that different.
- MA10 has a lower grade upper layer – probably related to a lens of fresher water at surface associated with the island it is drilled on the side of.
- There is a NW to SE trend from higher to lower grades overall – but very influenced by NW corner of property and MA04, MA24, MA25. This is possibly due to less seasonal freshwater input and dilution there.
- There is likely to be seasonal dilution of the brine in the upper unconfined layer, based on RUM jungle sample results from 2011-2014 and our observations that brine grades do not change significantly with depth.
    - A lot of the RUM aircore holes were only 12 m deep and didn't necessarily intersect the deeper gypsum layers at around 16 m in the east of the lake – so most of their flow was probably from the surficial brine.
- The observation that rainfall dilutes the brine grades seasonally, before they increase through evaporation following rain and inundation, suggests that there may be potential to recharge the sandy parts of the aquifers and flush potassium out of the sediments. The results of the attrition testing conducted at Lake Mackay by Reward Minerals should be revisited, to understand this possibility better.
- Lake Mackay is unlikely to be related to recycling of salts from a buried salt dome or directly related to the Bitter Springs Formation.
    - This is because all the Central Australian salt Lakes – including those in the eastern Yilgarn, like Lake Wells, appear to have developed similar concentrations and geochemical ratios, suggesting they form in response to general environmental conditions.
    - If Lake Mackay was produced by evaporite salt recycling one would expect to see a lot more halite/salt present and potentially a salt dominated salt lake, such as Salar de Atacama – which is thought to recycle salt from earlier evaporite basins.

12 DATA CONTROL

12.1 Assay data

Assays were originally provided by ALS laboratories. A small program of inter-laboratory checks was planned to accompany these samples. However, upon notification that the laboratory analyses were expected to be 10-20% too high Agrimin had all remaining samples re-analysed at by Intertek laboratories, with additional checks conducted by the Bureau Veritas laboratory (formerly Ultratrace Laboratories). These laboratories used the ICP-MS method of analysis. It is known that calibration of ICP equipment for brines is a specialist activity and results can vary considerably due to interference in the spectra between elements. ICP setup. The axial view is ideal for the reading of minor elements because the optical path is higher, while the radial view is appropriate for major elements. The ALS Environmental ICP is configured in an axial view, which is less suited for analysis of major elements.

Additional check samples have been analysed at the University of Antofagasta laboratory in Chile, with atomic absorption equipment, as a check on the results.

12.2 Geological data

Attempts were made to minimize the variation in geological descriptions between personnel. To this end the chip trays were revised by principal author Murray Brooker, to aid correlation between drill holes.

12.3 Survey data

Hand held Garmin GPS units were used to collect the location of drill holes. In the salt lake setting the GPS signal is typically strong and a minimum horizontal precision is expected to be ±5 m. Data was collected in the GDA94 coordinate system, in Zone 52.

13 MINERAL RESOURCES ESTIMATES

13.1 Background to the resource estimate

Aircore and power auger drilling at Lake Mackay has been used to estimate an in-situ resource for the project. The power auger results were used in addition to aircore drilling as there does not appear to be significant vertical difference in brine concentrations in data collected from aircore holes, based on the quite limited vertical sampling information from aircore drilling. The principal difference in grade appears to be laterally across the lake, with power auger brine samples consistent with the geochemical zoning observed in the aircore samples. Twinning of aircore holes with power auger holes was not carried out and is something that should be considered in the future.

Drilling shows that brine is continuous throughout the sediments from surface to the contact with underlying basement (with numerous intervals where no sample was recovered). The sediments are likely to continue to >30 m in the centre and east of the lake, but probably not significantly exceeding this depth, and probably shallowing in the eastern part of the lake within the Northern Territory, depending on the characteristics of the paleochannel which is interpreted to occur there.

Drilling to date has not intersected any coarse deeper sediments (sand, gravel) which relate to a paleochannel or basal sediment package in the lake. Lake Mackay and other Central Australian salt lakes are characterized by clays and slow sedimentation. Drilling by Rum Jungle in the south of the lake reportedly intersected artesian flows of brackish water, and these may represent water from a paleochannel inflow into the lake basin. These holes are thought to be located close to the southeastern margin of the lake. The relationship with the thick unconsolidated sediments intersected by Toro Energy is unknown at this stage.

13.2 Area covered by the resource

The area containing the resource is defined on the basis of:

- The property boundaries (**2,268.6 km^2** of granted licences), as the mineralised brine underlies all of the lake, based on observations to date. The application area in the NT is not included in the resource, but has been estimated as an exploration target;
- The limits of the lake (67.2 km^2 are off the lake, **reducing the resource area to 2200.8 km^2);**
- The salar morphology, with the more porous coarse upper sand having distinct physical characteristics from the clays. The gypsum islands being excluded from the upper layer area, due to their lower brine concentrations (which have not been quantified at this early stage). The **islands cover an area of 222 km^2**, **reducing the resource area in the upper resource units (to 6 m) to 1979 km^2**. The resource of the lower unit does not have the area of the islands excluded.

13.3 Resource thickness

The resource has been estimated in three different layers:

- An upper layer to 2.7 m depth,
- An underlying extension of this upper zone to 6 m potential maximum trenching depth; and
- A lower layer that extends to the base of the lake sediments or 30 m, where the base was not intersected.

The thickness is based on:

- The distribution of the upper sandy material. This was broken into a sandier western sub-unit, corresponding to the western extent of the gypsum islands, with a less sandy upper unit extending to the west. This was extended to 2.7 m, based on observations from auger sampling and historical vibracore sampling, with observations of sand zones.
- The underlying unit from 2.7 m to 6 m was defined on the basis of the potential to trench this deep, with the potential for some sand and gypsum beds to this depth, but a predominance of clay.
- The lower unit to the base of the sediments is dominated by clay, with some layers of crystalline gypsum that provide enhanced flow.
- The resource is open at depth in the east. There is the possibility of some coarser sediment at the base of the lake in this area.

13.4 Resource volume

- Different total porosity and values have been applied to each unit, based on averaging and applying proportions of the sand, sandy and clay sample measurements from Corelabs. There is insufficient data to apply laterally variable porosity values, with the exception of distinguishing between the western and eastern sub-units of the upper layer.
- The porosity values applied to the resource were of two types:
    - Total porosity – used to determine total contained brine, for no other reason than to compare with the volumes estimated by competitors
    - Specific yield, the appropriate value to estimate the volume of brine, of which a portion could be extracted.

13.5 Resource grade

- Average (non-weighted) brine results from 27 aircore holes and 34 power auger holes. These include of airlift samples, pump testing and top of hole pit samples.
- No cutoff grade has been used internal or external to the resource. The fluid nature of the resource does not allow low grades to be excluded from the resource and the lower grade areas are in the east and the south west of the lake.
- However, the gypsum islands have been excluded from the upper resource layer to 6 metres, as they contain brackish to lower grade brine. This hard boundary does not allow for the likely mixing of brine from these areas with higher grade brine when pumping from trenches occurs.
- The mg/l hole for each hole was converted to g/l, which was is equivalent to kg/m3 of brine volume (multiplying grams and litres each by a factor of 1000).

13.6 Hole spacing and data density

The hole spacing between MA hoes is 7.9 km, and with the PA holes included the spacing between holes is 7.2 km. This corresponds to a hole density of a hole per 84 km^2 for the MA holes or 36.6 km^2 including the power auger holes over the combined 2268.6 m of properties within Western Australia.

13.7 Resource estimation methodology

As there are a limited number of holes in the project area and there is considerable variation in the hole depths the resource maximized the use of drilling and used all the aircore and power auger holes, with assay data combined in one file and the thickness of the sediments at the power auger locations interpolated from the aircore drilling – which was used to create a base of drilling surface.

The resource estimation was undertaken in Micromine software, with a check of the estimate conducted in Mapinfo software and in a simple tablular estimate in Mapinfo. The Micromine estimate involved:

- A grid with 1km square cells used for gridding. The resource thickness has been estimated by gridding the thickness of the lake sediments across the lake.
    - A constant thickness of 6m (and 2.7m) depth was applied to the upper resource zone, which is the target for development using trenches.
    - The Lower Zone extends to the base of the lake sediments.
    - Blocks that did not report entirely within the lake tenements were assigned a block factor (i.e. % of block within the property salt lake boundary), to remove material outside the lake outline, rather than using sub-blocking.

- Potassium concentration was estimated across the cells using an inverse distance squared methodology.
    - Three passes with search expansion were used in the estimation. The first pass used radii of 5 x 5 km whereas the second used 7.5 x 7.5 km and the third used 30 x 30 km in order to estimate all the points. All three passes used a four sector search. Passes one and two required a minimum of three and a maximum of 16 data points with a maximum per sector of four. Pass three required a minimum of one and a maximum of 12 data points with a maximum per sector of three.
    - The maximum extrapolation of estimates is 25 km – into the northeast corner, where there is no drilling.
    - The passes produced material in the Upper Zone to 2.7m classified as Indicated, with small areas around the edge of the lake classified as Inferred, due to the sample distribution. Material in the Lower Zone is classified as Inferred.

- Uniform total porosity data was applied to grid cells, based on an average of samples, as differences between sandy and clay samples are slight. Differences in specific yield (drainable porosity) are more significant and different values are applied to the Upper and Lower Zones.
    - A different value is also applied in the Upper Zone to a depth of 2.7m, where the eastern part of the lake sediments has a higher sand content.
    - The Upper Zone has a higher specific yield and contains sand, silt and sandy clay; while the lower layer is clay-dominated with intermixed sand and silt, and interbedded gypsum and sand layers.
    - Porosities vary between samples and without having an extensive database of spatially disperse samples averaged values were applied for estimation.

- A fixed surface elevation was applied to the surface of the lake, as detailed topographic data is not yet available over the area.
- The product of the concentration and volume grids and specific yield (or total porosity) data was summed to produce the estimate of contained potassium and SOP using both the specific yield and total porosity. SOP from potassium was calculated using a conversion of 2.23, accounting for the sulphate and oxygen in the K2SO4 formula.
- No grade cut-off was applied to the resource. However, islands totaling 222km^2 were excluded from the Upper Zone, as they were not specifically systematically sampled or evaluated in the field program.
    - The islands are considered to host lower brine grades than the surrounding sandy sediments based on sampling at Lake Mackay. Despite the exclusion of the islands from the shallow resource (effectively applying a hard boundary

around the island perimeters) during brine extraction there would be a degree of mixing of brine from islands and surrounding areas of extraction, as groundwater is in dynamic equilibrium. For this reason it is not considered realistic to apply internal cut-offs to brine resources.
    - The area beneath the islands was included in the Lower Zone, as aircore drilling shows brine is present in sediments below the islands.

13.8 Resource estimation outputs and classification

The resource is categorized by the author based on the JORC criteria taking into account best practice documents from other reporting jurisdictions, such as The Evaluation of Brine Prospects and the Requirement for Modifications to Filing Standards (Houston, 2011) the Ontario Securities Commission CIM Best Practice Guidelines for Resource and Reserve Estimation for Lithium Brines and Brine Resources and Reserves (Kunasz, 2013).

The document by Houston and co-authors (including consultant Peter Ehren) suggests that for immature (clastic sediment dominated) salt lakes of this type a spacing of 7-10 km for drill holes is required for inferred classification, increasing to 5 and 2.5 km for indicated and measured classification.

For sediments above 2.7m, for which more drilling and sampling information is available from power auger and vibracore sampling, 89% of the resource has been classified as Indicated, with the remaining 11% Inferred in the corners of the tenements, where fewer samples were involved in estimation. The Indicated classification was based on the search parameters and available samples.

The part of the Upper Zone from 2.7m to 6m is classified as Inferred, due to the lower drilling density to this depth. Limited push tube sampling by Agrimin confirms sandy material within clay and silt continues to 6m below surface.

In the Upper Zone of the Mineral Resource there has been:

- Core drilling techniques including vibracore and direct push tube.
- Physical properties measurements completed on the sediments.
- Additional data points present from auger sampling and trenching.
- Mapping of the sediment distribution across the surface of the lake area.

The Lower Zone and areas outside the Indicated portion above 2.7m have been classified as Inferred on the basis of the available data, the aircore drilling method and broad spacing of the holes.

The new Mineral Resource Estimate of December 2015 supersedes the Mineral Resource Estimate and Exploration Target reported in November 2014.

Although drilled at a density of $36km^2$ per drill hole (aircore and power auger holes) the lake sediments and brine concentrations display a high level of lateral continuity across the lake and between the Upper and Lower Zones. This reflects the slow deposition of sediments in the lake basin. Trenches could be used to extract brine, potentially down to a depth of approximately 6m. Below this depth wells would be required to pump out brine. Trenches allow inflow of groundwater as the sediments are drained.

As mentioned, no cut-off has been applied to the resource, which is relatively homogeneous. Internal cut-offs in brine resources are not applicable, as brine migrates over time, in response to pumping of the host sediments.

The output of the resource estimation is shown in Figures 15.1 and Figure 15.2, and Table 15.1, with the distribution of resource blocks and grades, and the resource classification in the upper 2.7 m zone.

*The resource grade distribution in the block model is shown in **Figure 15.1** and the classification of the blocks in the upper layer to 2.7 m in **Figure 15.3,** with the 2014 resource to 2.7 m shown as **Figure 15.2** for comparison. The resource below 2.7 m is all classified as inferred.*

Resource Category	Zone	Depth (m)	Volume (million m³)	Average Total Porosity	SOP Grade (K_2SO_4 kg/m³)	Contained SOP (Mt)
Indicated	Upper	0.4 – 2.7	4,036	45.0%	8.41	15
Inferred		0.4 – 6.0	7,047	45.0%	8.25	26
Inferred	Lower	6.0 – 24.7	33,004	45.0%	8.23	122
Total	**Upper & Lower**	**0.4 – 24.7**	**44,088**	**45.0%**	**8.25**	**164**

Resource Category	Zone	Depth (m)	Volume (million m³)	Average Specific Yield	SOP Grade (K_2SO_4 kg/m³)	Contained SOP (Mt)
Indicated	**Upper**	0.4 – 2.7	1,993	10.0%	8.79	1.8
Indicated		0.4 – 2.7	2,043	15.0%	8.04	2.5
Inferred		0.4 – 2.7	89	10.0%	8.26	0.1
Inferred		0.4 – 2.7	427	15.0%	7.39	0.5
Inferred		2.7 – 6.0	6,531	9.0%	8.31	4.9
Total		**0.4 – 6.0**	**11,083**	**10.5%**	**8.31**	**9.7**
Inferred	**Lower**	6.0 – 24.7	33,004	5.0%	8.23	13.6
Total	**Upper & Lower**	**0.0 – 24.7**	**44,088**	**6.4%**	**8.25**	**23.2**

Notes:

- Average depth of drilling was 24.7m, however the estimation extends to 30.0m where drilling reached this depth
- Water table is at 0.4m below surface
- Potassium grades are converted to K_2SO_4 using a conversion factor of 2.23
- The resource to 2.7 m depth is 89% Indicated. The remaining 11% to 2.7 m is included in the upper zone total inferred that includes material 2.7 - 6m deep
- The resource in this table supersedes the previous resource and exploration target announced in November 2014

Table 13.1: Summary of the Lake Mackay resource

13.9 Comparison to previous resource and exploration target

The previous resource estimated for the project by Simon Coxhell in 2014 is summarized in the table provided in that report (Figure 15.2 below). *The total porosity of 62.8% used for this estimate is likely to be at the extreme high end of possible porosities.* Further this porosity is not considered relevant in the context of resource estimation, as it is the Specific Yield which indicates the portion of brine which could be extracted. The total porosity value in fine grained sediments does not meet reasonable expectations for reasonable economic extraction. The historically estimate

The new 2015 (indicated) resource to 2.7 metres using specific yield data is 4.3 mt SOP, or 15 mt using the total porosity, compared to the 22.2 Mt estimated by Coxrocks using total porosity data.

The exploration target (including the previous resource) provided by Coxrocks in 2014 is presented in the table provided in Figure 15.3 below. This used a low and high range of 30% and 40% total porosity and brine concentrations between 3000 and 4000 mg/l potassium.

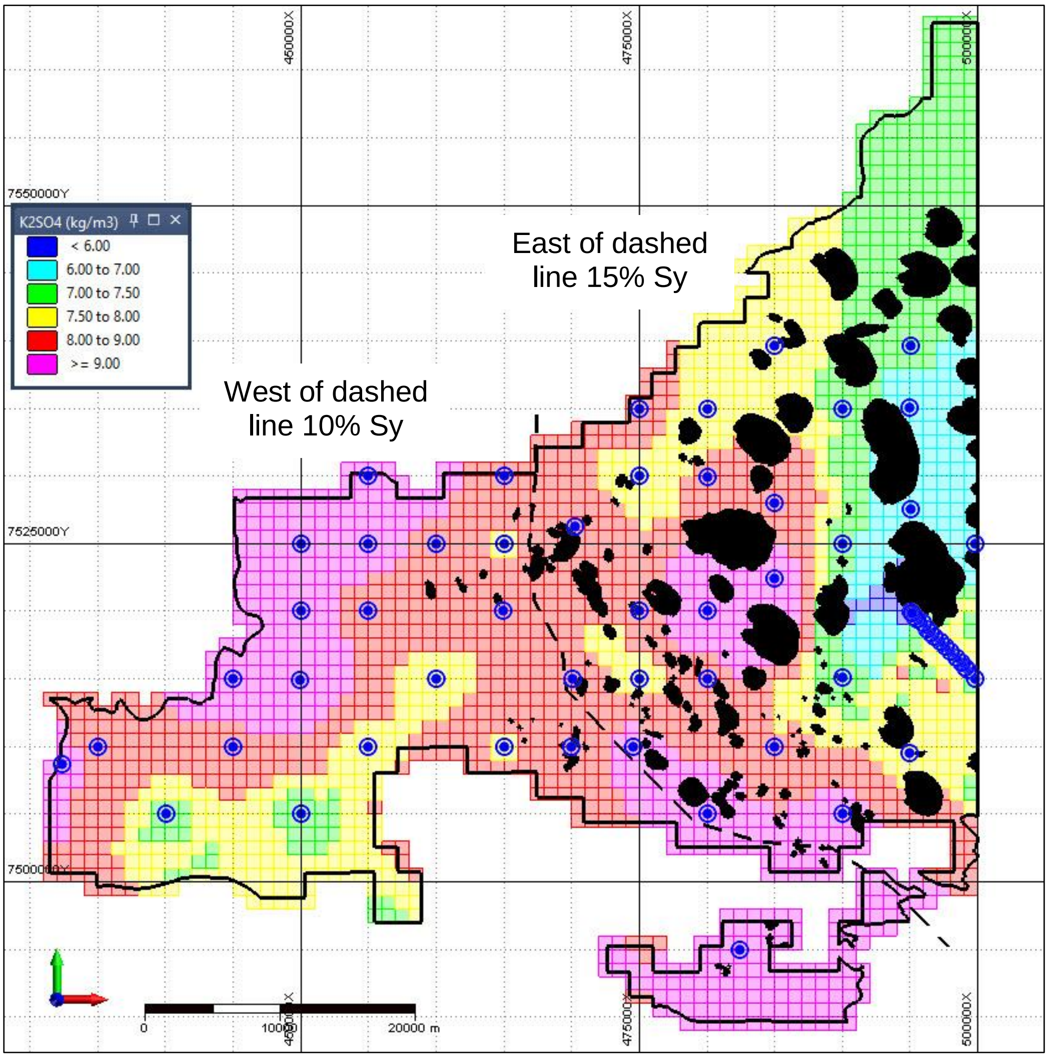

Figure 13.1: Distribution of SOP in resource blocks to 2.7 m deep

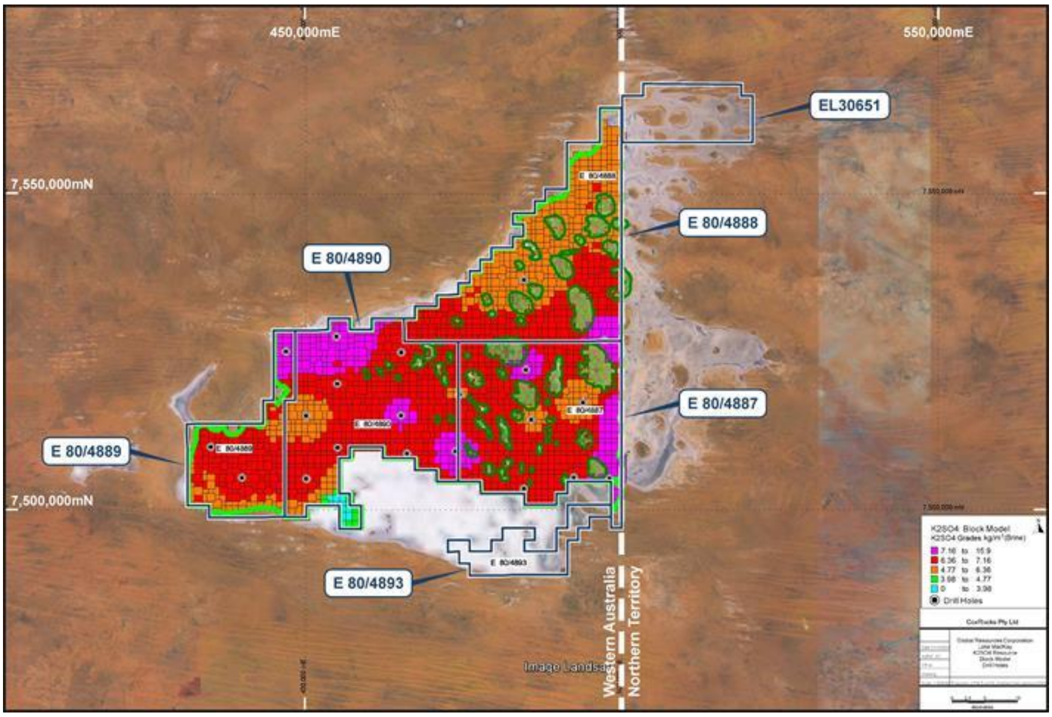

Figure 13.2: Distribution of SOP in 2014 estimate

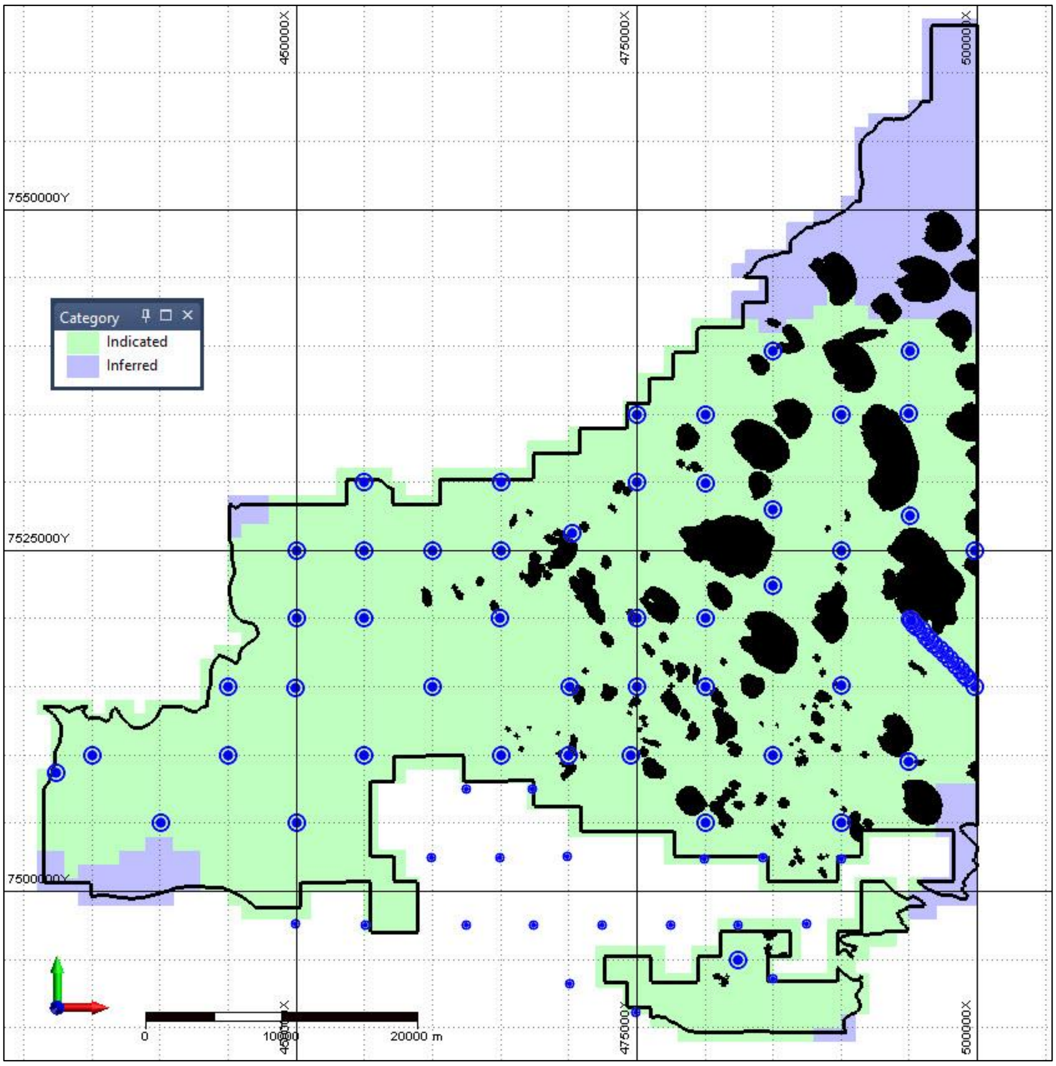

Figure 13.3: Classification of the resource to 2.7 m

The contained brine inventory of the 2015 total porosity "resource" is 164 mt, to an average drilling depth of 24.7 m (open at depth in the east, where it extends below 30 metres). This compares to the Coxrocks exploration target upside of 110mt potassium, to a depth of 16 metres. If the Coxrocks exploration target was extrapolated to an average depth of 24.7 m it would be very similar to the 2015 total porosity resource.

14 ENVIRONMENTAL STUDIES

It is noted that Lake Mackay, while often appearing barren of vegetation and wildlife actually supports a number of ecosystems within the outline of the lake. Provided the project advances further to a full feasibility study and permitting it will be necessary to conduct baseline environmental surveys.

The following observations are of a general nature, based on very limited observations but should be considered in the planning of future environmental monitoring. Refer to the conceptual model Figure 10.2 for additional details.

- The islands on the lake (Figure 18.1, Figures 18.4 and 18.5) are composed of gypsum sand, which is porous in places and allows for infiltration of rainwater
- An important portion of the annual rainfall is likely to infiltrate into the gypsum sand, forming a lens of fresh water grading deeper to brackish water and overlying the principal brine body underlying the lake.
- Vegetation has developed on the islands (Figures 18.2&18.3) based on the presence of this fresh to brackish water lens and could be considered as groundwater dependent ecosystems – which is likely to be the case for all the Australian salt lakes
- The groundwater lens is in a dynamic equilibrium with the rainfall and evaporation, and the groundwater level of the brine body
- Pumping from the brine body will potentially influence and possibly destabilize the fresh to brackish water lenses on islands (which are topographically higher than the lake brine) where the gypsiferous sands hosting brine are hydraulically connected to the brine underlying the islands – which is likely to be the case.

Consequently it is recommended than in the next field program piezometers are installed at different distances and different depths around some of the sand islands to assess the groundwater connectivity and impacts of pumping from a trench established near one of the islands.

Other evaluations of flora and fauna will of course be needed as part of EIS studies to support a full project feasibility study.

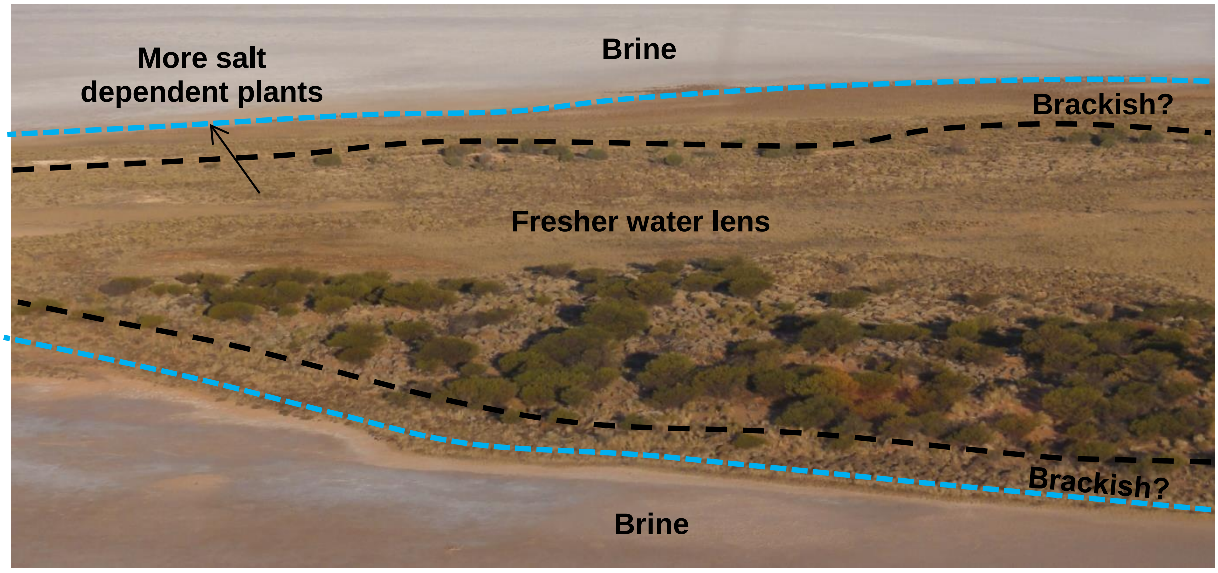

Figure 14.1: Vegetation developed in an asymmetric distribution on an island


Figure 14.2: Vegetation developed on the margin of the island closest to MA10


Figure 14.3: Vegetation developed on the closest island to drill site MA08


Figure 14.4: Porous gypsum sand and some crusting on the top of the island near MA08

Figure 14.5: Cemented gypsum in 2 m cliff on the side of an island

15 INTERPRETATION AND CONCLUSIONS

The following are major observations, interpretations and conclusions of work conducted on Lake Mackay during 2015.

Rainfall and inundation

- Landsat imagery suggests the wet season from December to March/April can cause significant inundation of the lake surface.
- The western and northwestern parts of the lake are probably topographically higher, but this needs to be confirmed
- Rainfall is dominated by brief intense rainstorms, which have the potential to damage infrastructure and cause rapid runoff onto the lake
- Rainfall captured by direct infiltration into the gypsum lake islands supports lenses of probably fresh to brackish water, which support vegetation on the islands – modification of the hydrology by brine extraction near the islands could affect these ecosystems
- Relatively fresh water is probably available in dunes near the lake, but an investigation with drilling and possibly electrical geophysics would be required to prove up a water resource

Geomorphology

- The lake has a number of geomorphologically distinct zones. These consist of:
    - Channel systems, where the surface halite coating is absent to thin
    - Areas of rippled gypsum-halite crust, which resemble an estuarine type environment and were subject to periodic inundation. This crust is dominant in the east of the lake around the area of gypsum islands and marks an area of underlying thicker gypsum sand.
    - Areas of polygonal halite crust (maximum a couple of cm thick) that reflect areas that were not redissolved with such frequency
    - Thin halite crust (5 mm) – present in much of the east of the lake
- Paleochannels which have not been intersected in drilling, but which are interpreted by Geoscience Australia to enter the east of the lake. Drilling by Rum Jungle may have intersected this unit on the south of the lake. Drilling by Toro Energy may have intersected a more major channel of this type further south of the lake.

Lithology

- Drilling has intersected a loose gypsum sand in the east of the lake that can be mapped in satellite imagery. This unit thins to the east and is essentially absent in the eastern half of the lake, where islands are absent. A similar unit appears to be present in other major Central Australian salt lakes like Lake Amadeus and Lake Disappointment and in Lake Wells.
- The dominant lithology is a red-brown clay that extends to the base of the salt lake, which deepens form the west (around 16 m) to the east (>30 m). However, the lake sediments are unlikely to be significantly >30 m in the central part of the lake and in the Northern Territory they may be thinner than 30 m or continue deepening gradually to intersect the paleochannel on the eastern lake margin.
- Crystalline gypsum layers may be correlated over 10's of kilometres within the lake and provide higher porosity and permeability layers. These units are more common in the east of the lake.
- Saprolite and ferruginous weathering forms on top of the basement – which is probably of Proterozoic age. Sandstone and pebbly sandstone was identified as the basement lithology in some holes. Other holes intersected fine grained material which may be siltstone or metasediment. One or more holes intersected more granular material which is possibly intrusive.

Drilling and augering

- A total of 27 aircore and 39 auger holes were drilled in the program, the former to a maximum of 30 m and the latter 1.5 m (5 of the auger holes were hand augers).
- Aircore drilling proved an effective way of exploring the lake sediments. The lithology sample provided was low quality, by the nature of the drilling, but appears to have been sufficient to characterize the lake sediments – suggesting they are quite homogeneous, although they contain thin layers of gypsum.
- Power auger sampling proved to be an effective means of recovering sampling in the upper 1.5 metres, to characterize the sediments and obtain lithology samples where there was insufficient time and budget to drill aircore holes. However, vibracore sampling or push tube sampling would provide higher quality lithology samples.
- Although drilling was generally accomplished without injecting water it was sometimes necessary to add small volumes of brine from a surface pit. However, these should not have affected brine sample results, as the volumes added were small (litres) and were most likely to have been absorbed by the clays, which extrude as stiff clay.
- Similar clays look to have been intersected in other Australian salt lakes.

Brine sampling and results

- The clay units are low yielding and generally did not provide brine samples at the end of every 3 m drill rod. If drilling was stopped to wait for brine inflows then conceivably it would have been possible to obtain samples every 3 metres (which appears to be the case with Goldphyre at Lake Wells). However, experience in clays in other salt lakes, using less disruptive drilling (diamond coring), suggests this is not necessarily possible.
- The area of porous gypsum sand extending from surface up to 1.5-2 m below surface predominantly coincides with lower grade brine of <3500 mg/l K, probably due to rainfall dilution in this porous unit.
- Brine samples show different grade zones across the lake that may reflect the amount of recharge, and the evolution of brine.
- Potassium values in auger holes vary from 1953 to 6520 mg/l K, with values in aircore holes from 2691 to 4548 mg/l K (average of hole values).
- Average values are very similar between the aircore and auger datasets, with respective averages of 3603 and 3690 mg/l K, medians of 3560 and 3533 mg/l K. The standard deviation of the aircore dataset is 452 mg/l, lower than the Auger data at 813 mg/l – which reflects some lower grade samples in the area around the eastern islands.
- The highest K brine grades are in the NW of the lake (up to 6520 mg/l in Auger sample PA33) and in the SE corner (MA27 at 4395 mg/l), adjacent to Rum Jungle samples which showed the highest results in their adjacent property to the south. Agrimin brine samples appear consistent across the property boundary with the Vibracore results of Rum Jungle. This hole showed significant brine flows, and at this stage it is uncertain how this relates to flows and local artesian conditions observed by Rum Jungle Resources to the south.
- The lowest brine grades are in the east of the lake, which appears to be an area of major surface water and probable paleochannel inflows.
- The islands have brackish zones associated with them, with lower densities and brine grades.

Brine zoning

- There is a high grade zone of >4000 mg/l K near the centre of the lake, and the reason for this is not clear. The higher grades in the west probably reflect the more quiescent condition of the lake there, with less freshwater inundation and dilution, and the lack of an upper gypsum layer to capture seasonal rainfall for recharge.

- The reasons for the high grade zone on the centre of the southern margin of the lake (including MA27) is unclear at this stage. This is where seasonal inundation is noted to be most pronounced, so dilution of brine would be expected from this. It is possible that a paleochannel enters the lake in this area, with rainfall throughout the catchment migrating through the channel and discharging through into the lake in response, but it is unlikely transmissivity/permeability in the channel sediments is sufficiently high to explain most of the inundation and it is more likely to relate to rainfall runoff.
- Sulphate concentrations in brine increase east to west across the lake, as does magnesium, sodium, chloride, brine density and Total Dissolved Solids – all with a higher concentration central area that is higher in these elements and K but lower in Ca.
- The K/Mg ratio decreases west across the lake, with the SO4/K ratio highest in the south of the lake and the SO4/Mg ratio highest in the east and decreasing to the west.

Laboratory analyses and QA/QC

- It appears the different analytical laboratories have distinct biases in their reporting of elements, particularly potassium, using ICP-MS. ALS reported the highest results, with Bureau Veritas the lowest and Intertek in the middle. These biases appear to be consistent over time for each laboratory, based on comparison of different data sets (i.e. ALS checking of 2009 Reward Mackay vibracore samples and 2015 assays; Intertek 2015 assays and RUM vibracore assays; Bureau Veritas 2015 results and the original analyses of the Reward 2009 vibracore brine samples).
- The check samples sent to the University of Antofagasta returned slightly lower K than most of Intertek samples and suggest more similarity with the Bureau Veritas samples.
- Ionic balances by Intertek, Bureau Veritas and the University of Antofagasta (UA) were all satisfactory, with the UA showing consistently low balance differences.
- Analysis by other methods like atomic absorption are preferable, to avoid issues related to ICP calibration, configuration and the interference of elements in brines – particularly related to high sodium concentrations.
- Extensive use of inter-laboratory sampling, standards and duplicates is necessary for all future sampling.
- New standards are needed for future work, with certification of the standards by Atomic Absorption analysis.
- The axial ICP view is ideal for the reading of minor elements because the optical path is higher, while the radial view is appropriate for major elements. The ICP Environmental lab
- This suggests a problem for all the Australian potential potash development companies, as results received depend on the laboratory used and ICP is likely to bias the K results on all projects high. This is particularly a problem as all these projects are low grade when compared to operating overseas projects (Salar de Atacama, Lubopo).

Infrastructure development

- One of the major costs of brine development projects is the construction of ponds, and a significant part of this cost is the application of impermeable HDPE (or similar) liners. The presence of the low permeability red-brown clay at Lake Mackay, while a negative factor for brine pumping rates, provides a suitable material for pond construction using materials that can be sourced from the lake bed.
- Geotechnical studies on the lake bed will be needed in addition to laboratory test work and infiltration modelling to assess the relevant construction of ponds
- Utilising the natural gradient of the site to minimize pumping is an important consideration for potential development of the project canals to transport brine to ponds.

- Diversion canals may be necessary to divert inundation waters away from ponds, trenches and canals and possibly divert this to recharge areas. Similarly brine capture trenches may be required around the margins of the gypsum sand area, to prevent brine draining into low lying channels and evaporating.
- Obtaining high resolution topographic data over the lake will be important for infrastructure assessment. This will need to be acquired specifically for the project, as existing public data sets are of insufficient resolution.

Resource estimation

- The limits of the lake limited the resource area to 2200.8 km2; with the gypsum islands not included in the upper 6 m of the resource, reducing the area to 1979 km2. The resource of the lower unit does not have the area of the islands excluded.
- The resource has been estimated in three different layers; an upper layer to 2.7 m depth; an underlying extension of this upper zone to 6 m potential maximum trenching depth; and a lower layer that extends to the base of the lake sediments or 30 m, where the base was not intersected.
- Different total porosity and values have been applied to each unit, based on averaging proportions of sand, sandy and clay sample measurements. There is insufficient data to apply laterally variable porosity values, with the exception of distinguishing between the western and eastern sub-units of the upper layer. The porosity values applied included total porosity (to compare with competitors projects) and specific yield.
- Average brine results from 27 aircore holes and 34 power auger holes were used for estimation. No cutoff grade has been used internal or external to the resource.
- Three passes with search expansion were used in the estimation. The first pass used radii of 5 x 5 km whereas the second used 7.5 x 7.5 km and the third used 30 x 30 km in order to estimate all the points. All three passes used a four sector search.
- The maximum extrapolation of estimates is 25 km – into the northeast corner, where there is no drilling.
- The passes produced material in the Upper Zone to 2.7m classified as Indicated, with small areas around the edge of the lake classified as Inferred, due to the sample distribution. Material in the Lower Zone is classified as Inferred.
- A fixed surface elevation was applied to the surface of the lake, as detailed topographic data is not yet available over the area.
- The total porosity resource in the upper and lower layers is 164 mt SOP, with the specific yield resource to 6 m comprising 9.7 mt SOP indicated and inferred, and an additional 13.6 mt of inferred resource to an average depth of 24.7 m.

Further exploration and investigation

- Detailed evaluation of the gypsum sand unit is necessary with vibracore sampling and/or auger drilling, to characterize this unit in more detail – which would allow an upgrade in the resource category of this unit.
- Commercial scale trench pump tests and evaluations of recharge are necessary to evaluate the potential for potash extraction.

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22 LIST OF ABREVIATIONS AND DEFINITIONS

°C :	Temperature in degrees Celsius
AAS :	Atomic absorption spectrometry
Aquifer :	An aquifer is a wet underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, or silt) from which groundwater can be extracted using a well or bore.
ASTM:	American Society for Testing and Materials
Bailer:	A tube with a non-return valve at the base, which is used to collect water from within a drill hole, with the bailer being winched to the surface to recover the water (fluid) sample
Brine:	Brine is water saturated or nearly saturated with salts (i.e. sea water, water in salars), whereas fluid refers to freshwater, brackish water and brine
B:	Boron
Ca:	Calcium
CaCO3:	Calcium carbonate
Cl:	Chloride
CO3:	Carbonate
Fluid:	Liquid substance (i.e. brine) which flows when subject to a gradient
GPS:	Global positioning system
ha:	Hectare
HCO_3:	Bicarbonate
ICPMS:	Inductively Coupled Plasma spectrometry – used for chemical analysis
JORC :	Joint Ore Reserve Committee code for reporting of mineral resources
K:	Potassium
K:	Not to be confused with the element potassium – this term refers to the hydraulic conductivity ("permeability") of a geological unit, as determined by pump or permeability testing
L:	Litre (liter) of volume
Li:	Lithium
SOP:	Potassium sulphate K2SO4 – common saleable higher value potassium product, with a conversion of 2.23 from contained potassium mass to potassium sulphate mass
m asl:	Metres above sea level
mg/L:	Milligrams per litre
Mg:	Magnesium
Mmol/L :	Millimoles per litre
mS/cm^2:	Millisiemens/centimeter squared – a measure of electrical conductivity of a fluid
Na:	Sodium
pH :	Measure of hydrogen ion activity and the relative acidic or basic character of a fluid
ppm:	Parts per million
Pe	Effective porosity – the porosity that corresponds to interconnected pores
Pt	Total porosity. This relates to the volume of pores within a unit volume of aquifer material. Except in well sorted sands some of the pores are isolated from others and only pores in mutual contact can be drained. The interconnected porosity is referred to as effective porosity (Pe). If

	the effective porosity is totally saturated only part of this will drain under gravity during pumping. This part of the Pe is referred to as the specific yield (Sy). A portion of the fluid is retained in the pores due to capillary forces and adsorption, and this portion is referred to as specific retention (Sr). Pt > Pe and Pe = Sy + Sr
QA/QC:	Quality assurance/quality control
Reserve:	Mineral reserves are resources known to be economically feasible for extraction. Reserves are either Probable Reserves or Proven Reserves. Generally the conversion of resources into reserves requires the application of various modifying factors. Definition of reserves in salar projects is problematic, due to the fluid nature of brine. The reader is referred to Houston et. al., (2011) for a more detailed discussion of this issue
Resource:	Mineral resources are those potentially economic mineral concentrations that have undergone enough scrutiny to quantify their contained metal to a certain degree. None of these resources are ore (economically extractable mineral material), because the economics of the mineral deposit may not have been fully evaluated. Resources consist of inferred, indicated and measured categories, with increasing associated confidence regarding the conditions of the resource.
Salt lake:	Salt flat, salt pan. Other similar terms include playa and salt lake (note lagoons of brine or fresh water may be present adjacent to salt flats and together these constitute salars in the general usage of the term).
SO_4 :	Sulphate, part of the chemical composition of Gypsum. $CaSO_4 \cdot 2H_2O$
Sy:	See Pt section above
T:	This refers to the transmissivity of a unit, a hydrogeological term which is defined as T=Kb, where K is the hydraulic conductivity of the unit and b is the saturated thickness of the unit
TDS:	Total dissolved solids, generally measured in mg/L
Tenement:	An exploration or mining license granted to a company or individual or applied for and not yet granted
TM :	Transverse Mercator coordinate system
uS/cm^2:	Microsiemens/centimeter squared – a measure of electrical conductivity of a fluid
WGS:	World Geodetic System. WGS84 is the geodetic system used with GPS systems
wt%:	Weight percent