REGOLITH GEOLOGY AND GROUNDWATER CHARACTERISTICS OF THE PINJARRA LAKES, NORTH WEST EYRE PENINSULA, SOUTH AUSTRALIA

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INTRODUCTION

The Pinjarra Lakes are a system of continental playa lakes covering an area of approximately 60 km^2 in the northwestern Eyre Peninsula, South Australia. The field area of this study is located in the margin of the eastern Eucla Basin and takes in the Pinjarra playa lake complex, the surrounding quartz sief dunefield and part of the adjacent Gawler Ranges, a hinterland of stripped Archaean and Proterozoic crystalline rocks.

A local property owner, Mr James Tremaine, first noticed a small sediment mound on lake surface that appeared to be gradually growing in size and active groundwater discharge springs on the surface of the Pinjarra Lakes some 40 years ago. These springs are identified by water-filled channel features radiating away from a small vent and dark red staining developing into ferruginous induration of sediments in the immediate vicinity. The springs range in size from half a metre to several metres in diameter and commonly occur in clusters close together, sometimes forming a rough lineation across the playa lake surface.

The project aims to understand the geochemical evolution of and the relationship between regolith and groundwater in the Pinjarra Lakes field area, including the history and development of groundwater discharge springs and the potential pathways for fluid movement. The Pinjarra lakes are at the northwestern end of a long chain of salt lakes, which have formed in a topographic low known as the Corrobinnie Depression on the surface of the pre-Tertiary Narlaby Palaeovalley (Bourne 1974). Large amounts of aeolian cover have been deposited in the form of longitudinal sief sand dunes which run southeast to northwest through the field area and are imprinted upon by the salt lakes. The sediments filling the palaeovalley are unconsolidated to semi-consolidated fluviatile and marine transgressive sands silts and clays, including the Miocene to Pliocene Garford and Mid to Late Eocene Pidinga formations, the latter also containing the abundantly sponge spicular Late Eocene Khasta formation. The palaeovalley fill sediments are underlain by variably weathered late Archaean and Proterozoic Hiltaba Suit granites of the Gawler Craton (Rankin 1991).

The Pinjarra Lakes are analogous in their mode of formation to the 'boinkas' of the Murray Basin mallee country, which are nested groundwater recharge and discharge complexes that form in topographic lows in response to the land surface interacting with the groundwater table (Macumber 1991). Previous work in the Pinjarra Lakes area on nearby salt lakes located on the surface of the Narlaby Palaeovalley by Lock (1988) has shown that groundwaters are acidic, with measured pH values ranging from approx 2.8 to 3.7. The source of this groundwater acidity may be from oxidative weathering of sulfide minerals within the granite bedrock below. The acid sulfate minerals alunite and jarosite are also common in sediments of ephemeral lakes on the Eyre Peninsula suggesting a history of acidic and sulfate rich groundwaters in the region (Lock 1988). However, initial XRD analysis of sediments from the Pinjarra Lakes active groundwater discharge springs show alunite and jarosite are not present.

IMPORTANCE OF STUDY

The NW Eyre Peninsula is semi-arid mallee country and marginal grazing land with virtually no surface runoff and an average rainfall of approximately 250 mm per year (Sheldon 1999). Current information shows that groundwater resources are highly saline, generally measuring over 12,000 mg/L in dissolved solids (Sheldon 1999). However, little is known about the possible occurrence and distribution of perched fresh water aquifers in the region. Groundwater discharge springs of this type may be evidence for the presence of artesian water supplies and the springs are a rare natural phenomenon that are of great environmental importance, worthy of scientific description and documentation.

This project will contribute to an increased understanding of groundwater resources present in the Narlaby Palaeovalley and the processes that lead to groundwater salinisation, by comparing detailed major ion chemistry and stable isotope data from groundwater collected in deep windmill bores with water sampled from the groundwater discharge springs present on the surface of the Pinjarra Lakes.

The Narlaby Palaeovalley is prospective for heavy mineral sands and several drilling programs have also revealed extensive but low-grade 'roll front' uranium deposits that are associated with groundwater redox conditions in the Eocene Pidinga Formation in the area to the west and north of Pinjarra Dam (Binks 1984). An area 10 km to the east of Pinjarra Dam has also been drilled for the purposes of calcrete gold exploration but turned up only trace amounts of gold (Homestake Gold 1998). Study of the geochemical and physical characteristics of natural groundwater discharge in this system may also help to provide valuable information on the processes affecting mineralisation in the Narlaby Palaeovalley.

METHODS

The project aims will be investigated by a fieldwork program to measure and sample groundwater and surface water, to conduct regolith mapping and to sample sediments from the active groundwater discharge zones and playa lake sediments from areas without active groundwater discharge. The water samples are analysed for physical parameters in the field including: pH; Eh; Electrical Conductivity; temperature; and alkalinity in HCO_3^-. Water samples are then analysed in the laboratory for major and minor ion chemistry using Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES) and Ion Chromatography (IC) and for stable isotopes of oxygen and hydrogen using a mass spectrometer. The mineralogy of sediment samples is analysed using X-ray diffraction (XRD), and sediment grain size distribution is determined using Low Angle Light Scattering. Evaporite minerals are analysed for major element composition using Scanning Electron Microscopy (SEM-EDS).

RESULTS

Regolith mapping of the field area has revealed various landforms resulting partially from groundwater-surface interactions. The irregular dunefield areas have lower relief and more sparse vegetation than the longitudinal dunefield areas, and the irregular outlines are typical of groundwater influenced landforms Macumber (1991).

A correlation between depth of sampled groundwater and overall salinity has been established between lake surface waters and piezometers inserted in the playa lake surface, with screened intervals at 1.5 m, sampling the Pinjarra Lakes shallow groundwaters (PLSGs). Electrical conductivity of lake surface water was measured in a range between 137 and 144 mS/cm and field observations showed lake surface waters commonly approaching dissolved solid concentrations sufficient for halite saturation. In comparison the PLSGs were relatively less salty than the lake surface waters but still hyper-saline, ranging from 115 to 133 mS/cm. A piezometer (CS1) was located in the centre of a groundwater discharge spring sampling groundwater from a screened interval at the same depth as other piezometers. However, the electrical conductivity of the groundwater sample collected from the CS1 piezometer is the lowest of all the PLSGs at 115 mS/cm, which is 13 mS/cm lower than the WC1 piezometer, which sampled water from the same depth only 50 m away. The anomalously low EC value of the spring discharge suggests a conduit exists allowing movement of deeper palaeovalley groundwater to the surface in the spring zone.

Results from analysis for the stable isotope ratios δ D (SMOW) and δ^{18}O (SMOW) show the PLSGs lie along an evaporation and water-rock interaction trend from the deeper groundwaters collected in Toondullya and Jessey windmill wells (Figure 1). Water collected from the CS1 shallow piezometer, sampling an active groundwater discharge spring at 1.5m depth, was measured at –12 δ D and 1.1 δ^{18}O. Five other piezometers sampling shallow groundwaters at the same depth in the outlying playa lakes, where groundwater discharge was not active at the time of sampling, all showed more positive values ranging from 0 to 5 δ D and 3 to 3.8 δ^{18}O. Therefore the CS1 piezometer indicates a similar signature to the measured values for deeper groundwater upwelling at the CS1 site.

Ratios of major dissolved ions such as SO_4^-/Cl^- and Na^+/Mg^{2+} in the Pinjarra Lakes shallow groundwaters have been compared to deeper groundwater from the Toondullya and Jessey windmill wells and to local rainfall. Assuming that local rainfall composition controls the initial ratio of major ions in solution, the data show that the PLSGs have enriched Na^+ relative to Mg^{2+} and enriched Cl^- relative to SO_4^-. The CS1 piezometer sample shows the least deviation from the rainfall initial ratio, suggesting that it has undergone a combination of less evaporite mineral dissolution and evaporation relative to the other PLSGs, and may be a result of mixing with fresher waters.

CONCLUSIONS

These results indicate that the Pinjarra Lakes springs are discharging water that is closer in composition to the deeper groundwaters sampled in the Jessey and Toondullya Wells than any of the other PLSGs. Brine discharge from the active groundwater springs is less evolved than brines at the same depth in areas not actively discharging groundwater. It is possible that the pathways for groundwater migration to the surface are different for the groundwater discharge springs as opposed to the other PLSGs, which allows the deeper groundwater to interact with less previously deposited saline evaporite minerals mainly halite and gypsum, on its way to the surface. The groundwater discharge springs may also be receiving a more constant flow of deeper groundwater, which will result in a shorter residence time in the near surface brine pool, therefore reducing the effect of evaporative concentration. A more constant and greater volume of flow will also flush some salts from the near surface sediments, resulting in a less saline sediment environment along the localised fluid pathway.

Further work will concentrate on the regolith architecture as it affects the hydrogeology of the groundwater flow system and a comparison of the mineralogy of the near surface sediments in the groundwater discharge spring zones with near surface playa lake sediments where groundwater discharge is not currently active.

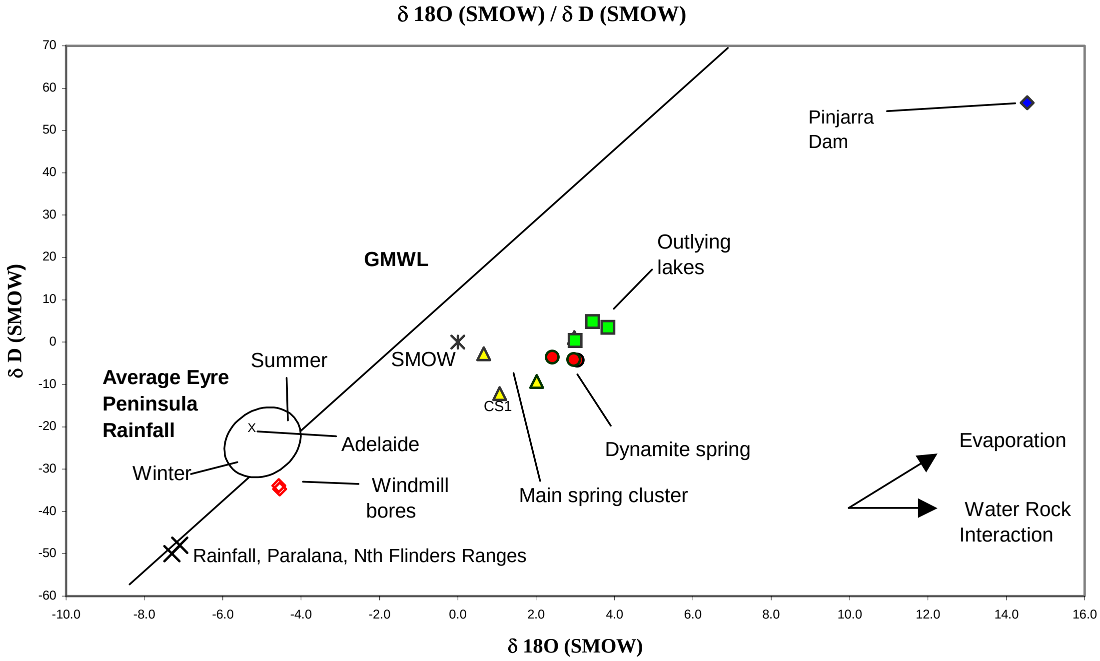

Figure 1: $^{18}O/^{16}O$ versus $^{2}H/H$ relative to Standard Mean Ocean Water (SMOW), stable isotope plot of Pinjarra Lakes shallow groundwaters, surface water and local rainfall.

REFERENCES

BINKS P.J. & G.J. HOOPER. 1984. Uranium in Tertiary palaeochannels "West Coast Area" South Australia. *Proceedings of the Australasian Institute of Mining and Metallurgy* No 289, Nov/Dec 1984.

BOURNE J.A., TWIDALE C.R. & SMITH D.M. 1974. The Corrobinnie Depression, Eyre Peninsula, South Australia. *Transactions of the Royal Society of South Australia* **98(3)**, 139-150.

CLARKE J.D.A., GAMMON P.R., HOU B. & GALLAGHER S.J. in press. Middle to Late Eocene stratigraphic nomenclature and deposition in the Eucla basin.

HOMESTAKE GOLD 1988. *PIRSA Open File Envelope No. 9200 EL 2183 Yardea Annual Reports for the period 7/6/96 to 6/6/98, submitted by Homestake Gold of Australia*. Department of Primary Industries and Resources South Australia.

LOCK D.E. 1988. Alunite and jarosite formation in evaporative lake of South Australia. *SLEADS Conference 1-16 Aug 1988, Lake Eyre, Arkaroola, Lake Frome, South Australia*. Australian National University.

MACUMBER P.G. 1991. *Interactions between groundwater and surface systems in Northern Victoria*. Department of Conservation and Environment.

RANKIN L.R. & FLINT R.B.F. 1991. *Streaky Bay 1:250,000 Geological Series – Explanatory Notes*. Department of Mines and Energy South Australia.

RANKIN L.R. & FLINT R.B.F. 1991. *Streaky Bay 1:250,000 Geological Map*. Department of Mines and Energy South Australia.

SHELDON F. 1999. *Spencer regions water management study: Environmental flow criteria*. Cooperative Research Center for Freshwater Ecology, Adelaide, Canberra **Technical Report 90**.