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THE OCCURRENCE OF A SHALLOW GROUNDWATER HORIZON AND ITS NATURAL OUTLETS IN NORTH-EASTERNMOST SOUTH AUSTRALIA.

by

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REGIONAL MAPPING SECTION

GEOLOGICAL SURVEY

CONTENTS

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SUMMARY

Shallow groundwater occurs on the limbs of anticlines in north-easternmost South Australia. The water, which usually is of good quality is derived from local intakes and occurs immediately above or at the duricrust horizon. Laterites and lateritic sands overlying the duricrust act as water bearing strata.

Natural springs or seepages are occasionally developed where the contact between duricrust and laterite is exposed down dip on large fold structures. Two such occurrences are described. The Milyie Springs, situated 20 miles east of Cordillo Downs on the south limb of Cordillo uplift deliver approximately 6,000 gallons of water per day into Milyie water hole and the Callamurra Seepages, 16 miles east of Innamincka Station, on the southern limb of Innamincka Dome, discharge an estimated 1,000 gallons per day into Callamurra water hole.

The importance of this shallow groundwater horizon as a source of good quality water and as an additional feeder for some permanent water holes is emphasised.

INTRODUCTION

The area discussed in this paper concerns approximately 2,000 square miles in the far north-eastern corner of South Australia between Cooper Creek and Haddon corner. It comprises some of the most prominent and best developed surface structures in the geological unit known as the Great Australian Artesian Basin. Domes and anticlines greatly influence the occurrence and the distribution of shallow groundwaters whose sources are largely derived from local intake areas. Some of the characteristics of the uppermost water bearing stratum are subject of the present paper.

The observations were made while the author was engaged in exploration work in the Cordillo area on behalf of Santos Ltd., in 1957-58 and during subsequent visits to the area.

GEOLOGY OF THE "LATERITE" WATER HORIZON

The structures which govern the shallow aquifers are developed in Cretaceous sediments, the exposed strata being members of the Winton formation (Cenomanian) which, in most parts of the area are overlain by Tertiary grits and sands. The top-members of the sequence are invariably silicified and altered to a very hard and tough crust usually referred to as "duricrust". The amplitudes of the fold structures are up to 700 feet with limb dips ranging from 2° to 20°. The tectonic movements responsible for formation of these structures post dated the development of the duricrust (Wopfner, 1960).

R. L. Jack (1925) who gave a comprehensive account of the occurrence of shallow groundwater in the north-east of South Australia (particularly the area around Cordillo Downs), placed the aquifers of all the shallow wells e.g. Nada etc., within the "upper third of the Desert Sandstone Formation", and consequently, his cross-sections show these aquifers well below the hard, silicified "duricrust".

However, recent investigations by the author have shown that many of these shallow wells are fed by a water-bearing horizon occurring above the duricrust.

Due to the development of the broad domal and anticlinal structures which characterise the area, the duricrust frequently forms extensive dip slopes, with prominent erosional remnants forming flat topped hills in the structural "highs". The dip slopes are covered with younger outwash deposits, commonly made up largely of "gibber" gravels formed from the break down of the duricrust itself. The amount of dip of the duricrust on the southern limb of the Cordillo uplift is shown on Map A in Fig. 1.

Approximately half way down the dip slopes a lateritic formation can be observed overlying the duricrust, extending down dip into the synclinal areas. (See geological cross section in Fig. 1). It is a dark brick-red, nodular (pisolitic) laterite varying in thickness from a thin veneer of a few feet to 120 feet thick and more in the centres of the synclines.

Thin layers and wedges of a red, highly ferruginous, laterised sand and some stringers and lenses of red clay are quite common throughout the laterite sequence. The base is commonly clayey.

The position of the laterite above the duricrust and the continuity of the latter underneath the laterite has been established in several localities in the Cordillo area, and extending into Queensland. It was particularly clearly demonstrated in seismic shot holes across the Haddon Syncline which were drilled in the course of a seismic survey carried out by the Bureau of Mineral Resources in 1957. (Wopfner, 1960). A distinct increase of thickness of the laterite towards the synclines is evident.

The contact between the laterite and the duricrust is either conformable or in form of an erosional disconformity. On structures with steeper limb-dips, the contact is unconformable. In some places a thin pebble horizon composed of well rounded duricrust pebbles occurs between duricrust and laterite. The occurrence of these pebble beds, which might be interpreted as traces of a consequent drainage pattern "in statu nascendi" suggests that the laterite is formed on top of and is younger than the duricrust and therefore is not directly related to the formation of the latter. The author considers that the laterisation process affected late Tertiary to early Pleistocene soils, developed on "post-duricrust" sands and silts.

These laterites, which are extremely porous (15-25% porosity) and permeable, generally carry a considerable amount of groundwater. The water occurs near the bottom of the laterite, a few feet above the top of the duricrust. The duricrust acts as an impermeable horizon preventing the water from entering deeper strata (See geological cross section in Fig. 1).

The source of the water is the local intake area situated in the upper parts of the anticlinal limbs, mainly along the contact between duricrust and laterite. The most effective intake conditions exist where consequent streams with a lesser gradient than the existing duricrust dip-slope flow across large exposures of laterite. Water may also enter the laterite anywhere along the dip-slope, but the clayey "gibber-soils" which extensively cover these slopes may tend to reduce the effective intake. (See geological cross section in Fig. 1).

The quality of the water is very good, provided the horizon is tapped on the structural slopes, where the total salinity very rarely exceeds 50 grains per gallon. Towards the synclines the total salinity increases rapidly. Tables 1 and 2 show the change of the quality of the water in relation to the structural position of the individual well. In both cases the increase of total salinity towards the synclines is evident. (Refer to Map A in Fig. 1 for position of wells mentioned in table 2. Analyses of Nada and Horseshoe Well are taken from R. L. Jack's paper, 1925).

Table 1

Name of well	Position of well	Total salinity Grains per gallon
Coppacunda	Westlimb, Curallie-Dome, Qld.	36
Tobo	South-west-limb Curallie Dome, Qld.	46
Terrietcha	Madden Syncline, S.A.	80

Table 2

Well or spring	Hada Well	Milpie Springs	Horseshoe Well
Date of analysis	19-7-34	29-1-59	19-7-34
Chlorine, Cl	2.10	14.0	65.94
Sulphuric acid (rad) SO_4	7.91	4.2	37.49
Carbonic acid (rad) CO_3	5.10	11.0	11.05
Nitric acid (rad) NO_3	-	trace	-
Sodium, Na	2.96	16.2	53.18
Potassium, K		-	
Calcium, Ca	3.56	1.8	7.78
Magnesium, Mg	1.16	0.7	4.02
Iron, Fe	-	-	-
Silica, SiO_2	5.90	-	5.00
Total saline matter Grains per gallon	28.49	47.9	186.08
	Assumed composition of salts		
Calcium carbonate	8.40	4.5	19.20
Calcium sulphate	-	-	-
Calcium chloride	-	-	-
Magnesium carbonate	0.08	2.4	0.38
Magnesium sulphate	5.70	-	19.55
Magnesium chloride	-	-	-
Sodium carbonate	-	11.7	-
Sodium sulphate	4.95	6.2	32.32
Sodium chloride	3.46	23.1	108.65
Potassium chloride		-	
Sodium nitrate		Trace	
Silica	5.90	-	5.00
	Hardness (English Degrees)		
Total	13.24	7.4	36.08
Temporary	8.48	7.4	19.76
Permanent	4.76	nil	16.32
Due to Calcium	8.40	4.5	19.30
Due to Magnesium	4.84	2.9	16.78

The water bearing strata are always tapped by means of shallow well-shafts ranging in depth from approximately 50 to 100 feet. This form of development appears to be the most suitable and gives very good pumping supplies.

Unfortunately, there are no exact figures available, regarding the supplies of these wells but as far as the author could gather in conversation with local pastoralists, none of them produces less than 3,000 to 4,000 gallons per day. Most of them are stated to have never been pumped dry by continuous windmill operation. (In 1957, while SANTOS drilling operations were in progress, a daily average of 4,000 gallons was obtained from Turrietcha Well without lowering the water level).

NATURAL OUTLETS

In two places, the "laterite" groundwater finds a natural outlet, forming springs or seepages. This is significant, when one considers that the area only registers an average annual rainfall of approximately 6 inches.

One such natural outlet, the Nilpie Springs, is situated on the southern limb of the Cordillo Uplift, (See Map A in Fig. 1) and another, the Callamurra seeps occurs on the eastern end of Callamurra Water hole which is situated on the south-side of Innamincka Dome (See Map B in Fig. 1).

Nilpie Springs

The Nilpie Springs are situated 20 miles ENE of Cordillo Downs homestead on the north eastern embankment of Nilpie Water hole in the course of Nilpie Nilpie Creek (See Map A in Fig. 1).

The Nilpie Nilpie Creek is a consequent stream originating on the southern limb of the Cordillo Dome. At the location where the springs occur, the creek has cut deep into the laterite down to the level of the duricrust, forming steep laterite cliffs on its north-eastern side, and exposing the water bearing horizon. At the base of the cliff face an intricate system of springs occurs over a distance of 200 to 250 feet. There are at least 30 to 40 separate outlets each one showing a small, but free flow of clear water, which finally collects in the deepest part of Nilpie Water hole. (Plate 1, Fig. 1). The water is discharged from small cavities at the base of the laterite, underlain by a red silty clay (Plate 1, Fig. 2). The layer of clay which attains a thickness of 2 to 3 feet rests directly on top of the duricrust. The cross section in Fig. 1 illustrates the geological conditions, which govern the Nilpie Springs.

The temperature of the spring-water immediately at the outlet was measured. It registered 74°F at an air temperature (shade temperature) of 102.5°F. An analysis of the water is given in table 2.

It would be extremely difficult to obtain an exact figure on the total supply of the springs but the following indirect deduction gives an approximate figure. The author was told by the manager of Cordillo Downs Station, Mr. R. B. Beckwith, that the supply of the springs is sufficient to water a herd of 600 heads of cattle for 12 months. At a daily average consumption of 10 gallons per head and neglecting evaporation, the total supply of the springs would be at least 6,000 gallons per day of excellent water. The supply of the springs remains fairly consistent under drought conditions. The springs themselves can only be observed, when the Nilpie Water hole has reached a very low level, so exposing the lower cliff-face.

<u>Callamurra Seepages</u>

The Callamurra Seepages occur at the northern embankment of Callamurra Waterhole on the Cooper Creek, about 16 miles east of Innamincka Station (See Map B in Fig. 1). There, the Cooper Creek which in this region usually consists of a multitude of channels, has only one single, narrow channel, cut deep into the duricrust. Being part of the Southern limb of the Innamincka dome (Sprigg, 1959), the duricrust slopes slightly to the south. Fracturing and subsequent block-weathering has dissected the duricrust extensively, forming deep, narrow cracks, which protrude down to the underlying clays (See Plate 1, Fig. 3).

The water of the seeps extrudes at the base of the duricrust into recent river silts which are deposited against the duricrust. Immediately at the seepages themselves, the laterite has been eroded but is still preserved about 300 feet north.

It appears that the water is carried in the laterite and also in the duricrust where the latter is fractured. The final transport to the seeps takes place within the fractured duricrust.

The seepages occur over a distance of 150 feet and nine individual outlets were observed. The amount of supply of the visible discharge is rather small and was estimated to be about 500 to 1,000 gallons per day. The actual quantity may be considerably larger, as a great amount of the seeping water disappears immediately into the recent river silts.

The intake area is along the southern limb of the Innamincka Dome. As with the Nilpia Springs the groundwater is hydrodynamically controlled by the structural dip. The seeps can only be observed at times of low water level in the Cooper Creek.

CONCLUSIONS

It can be concluded that wherever the duricrusted limbs of prominent structures are blanketed by a reasonable thickness of laterites good pumping supplies of water can usually be obtained. The likelihood of obtaining good supplies of fresh-water will be increased when the location of a new well is positioned down dip from the major intake area. The quality of the water, which is excellent along the slopes, rapidly deteriorates towards the structural "lows". Shallow wells appear to be the most suitable method of developing this groundwater horizon.

Several of the large permanent waterholes in this area occur at a position which is identical to the one described for the natural outlets of the shallow groundwater. It seems highly probable that these waterholes receive additional water via springs and seeps from the laterite groundwater, which could balance the loss incurred by evaporation. The permanency of these water holes could well be due therefore, to the additional supply which they obtain from groundwater sources.

BIBLIOGRAPHY:

JACK, R.L. 1925. Some Developments in Shallow Water Areas in the North-East of South Australia. Geol. Survey. S.A. Bulletin No. 11

JACK, R.L. 1930. Geological structure and other Factors in Relation to Underground Water Supply in Portions Of South Australia. Geol. Survey. S.A. Bulletin No. 14.

PRESCOTT, J.A. & PENDLETON, R.L. 1952 Laterite and Lateritic Soils. Commonwealth Bureau of Soil Science, Technical Commun. No. 47.

SPRIGG, R.C. 1958. Petroleum Prospects of Western Parts of Great Australian Artesian Basin, Bull. Amer. Assoc. Pet. Geol. Vol. 42.

WOPFNER, H. 1960. On Some Structural Development in the Central Part of the Great Australian Artesian Basin. Transact. Roy. Soc. S.A. Vol. 83.

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<u>TEXT TO PHOTOGRAPHS</u>

Fig. 1. The northern embankment of Nilpie Water-hole showing the occurrence of the springs along the base of the laterite cliff (left centre of picture) and the spring-water draining down the creek-bed to the water hole. In the foreground the duricrust is covered by recent silt and gravel but is exposed at the far end of the water hole. Height of laterite cliff approximately 15 to 18 feet.

(authors photograph)

Fig. 2. Two of the individual outlets (points of arrows) of the Nilpie Springs at the base of the laterite. The pisolitic nature of the laterite is illustrated between the two arrows.

(authors photograph)

Fig. 3 The surface of the duricrust at the eastern end of Callamurra Water hole with typical development of open joints. The seep occurs to the far left of picture.

(authors photograph)

Fig 1

Fig 2

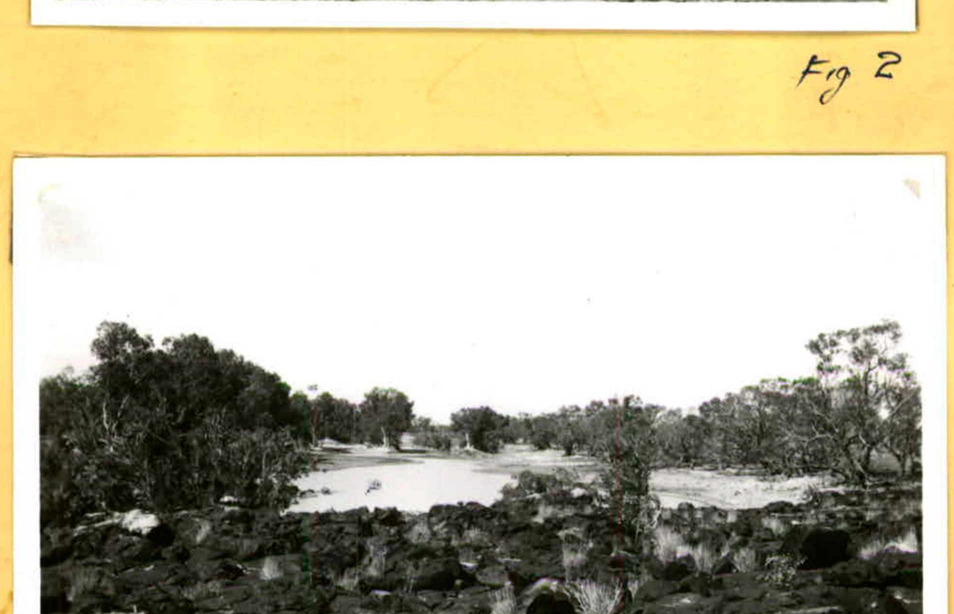
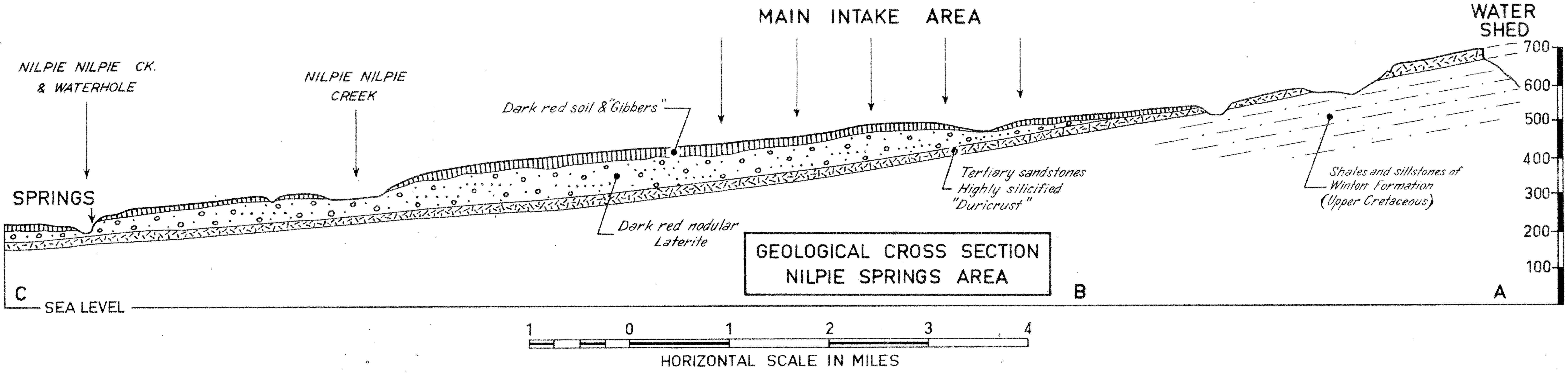
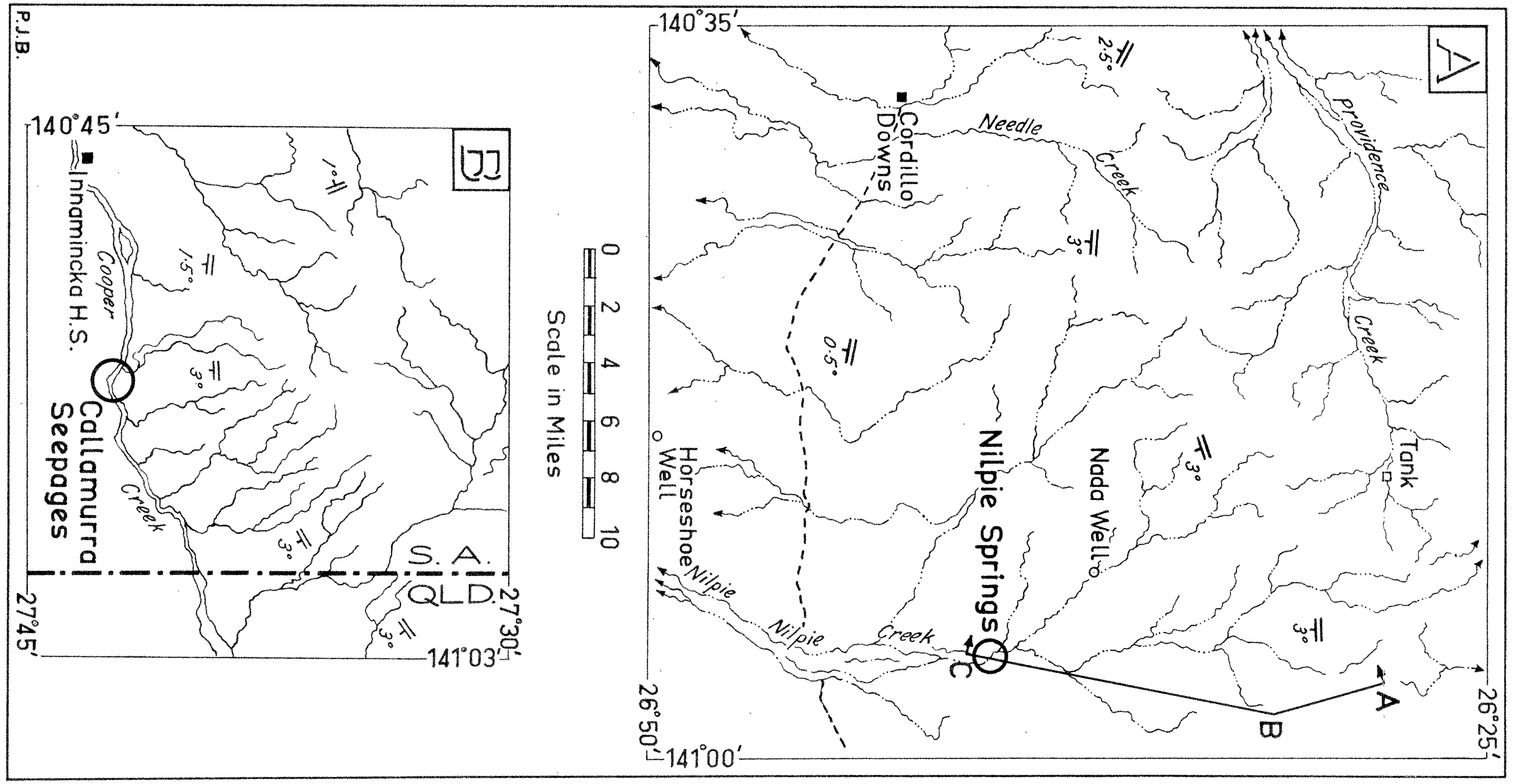
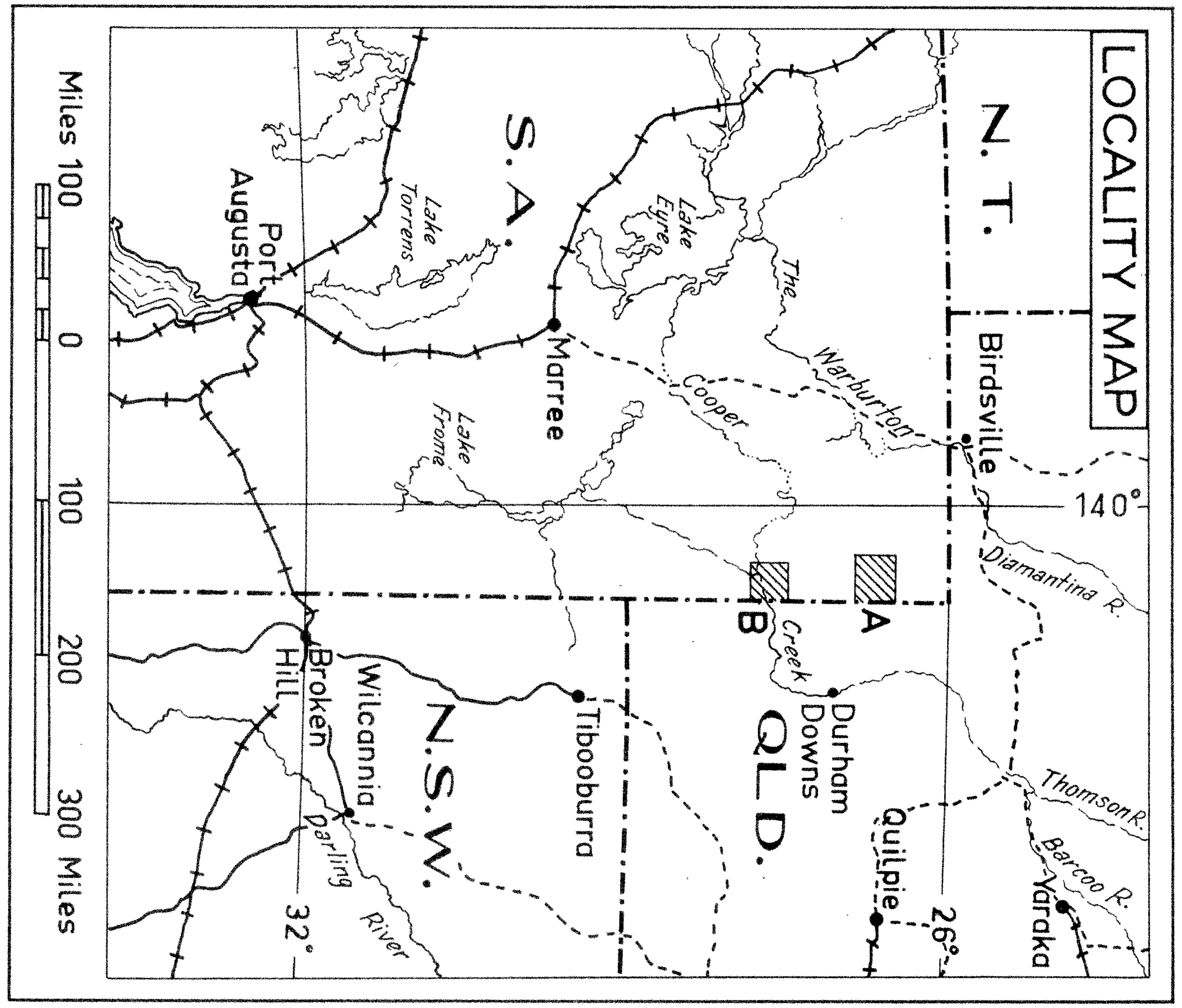


Fig 3

Plate 1


MAIN INTAKE AREA
WATER SHED
NILPIE NILPIE CK. & WATERHOLE
NILPIE NILPIE CREEK
SPRINGS
Dark red soil & "Gibbers"
Dark red nodular Laterite
Tertiary sandstones Highly silicified "Duricrust"
Shales and siltstones of Winton Formation (Upper Cretaceous)
GEOLOGICAL CROSS SECTION
NILPIE SPRINGS AREA
C
B
A
SEA LEVEL
700
600
500
400
300
200
100
VERTICAL SCALE IN FEET
1 0 1 2 3 4
HORIZONTAL SCALE IN MILES


P.J.B.
B
140°45'
Innamincka H.S.
Cooper
Creek
Callamurra Seepages
S.A.
QLD.
27°45'
141°03'
27°30'
Scale in Miles
0 2 4 6 8 10
A
140°35'
Cordillo Downs
Needle Creek
Providence Creek
Tank
Nada Well
Horseshoe Well
Nilpie Springs
Nilpie Nilpie Creek
C
B
A
26°50'
141°00'
26°25'


LOCALITY MAP
N.T.
S.A.
Port Augusta
Lake Torrens
Lake Eyre
Marree
The Warburton
Cooper
Birdsville
Lake Frome
Diamantina R.
140°
B
A
Creek
Durham Downs
QLD.
Broken Hill
Wilcannia
Tibooburra
N.S.W.
Darling River
Quilpie
Thomson R.
Barcoo R.
Yaraka
32°
26°
Miles 100 0 100 200 300 Miles