DEPARTMENT OF MINES
SOUTH AUSTRALIA

THE RESERVOIR GEOLOGY FOR GAS RESERVE ESTIMATES, MOOMBA AND GIDGEALPA FIELDS, COOPER BASIN

by

R.C.N. THORNTON
GEOLOGIST
PETROLEUM GEOLOGY SECTION

Rept.Bk.No. 774
G.S. No. 5039
SR. No. 27/4/122

9th February, 1973.

CONTENTS

TABLES

FIGURES

MAPS TO ACCOMPANY REPORT

		Scale	Drg. No.
1.	Moomba Field - "P" (top of Permian) Map	1:60 000	73-41 Cb
2.	" - Toolachee Formation: Top of Pay Sand Contour Map	"	73-42 Cb
3.	" - Toolachee Formation: Bottom of Pay Sand Contour Map (for Proven-Probable estimate)	"	73-43 Cb
4.	" - Toolachee Formation: Isopach of Gross Pay Map (for Proven-Probable estimate)	"	73-44 Cb
5.	" - Toolachee Formation: Proven-Probable Pay Sand Isolith Map	"	73-45 Cb
6.	" - Toolachee Formation: Bottom of Pay Sand Contour Map (for Lower Limit Possible estimate)	"	73-46 Cb
7.	" - Toolachee Formation: Lower Limit Possible Pay Sand Isolith Map	"	73-47 Cb
8.	" - Toolachee Formation: Upper Limit Possible Pay Sand Isolith Map	"	73-48 Cb
9.	" - Patchawarra Formation: Proven-Probable Pay Sand Isolith Map	"	S10141 Cb
10.	Gidgealpa Field - "P" (top of Permian) Map	"	73-49 Cb
11.	" - Upper Reservoir: Proven-Probable Pay Sand Isolith Map	"	73-50 Cb
12.	" - Lower Reservoir: Proven-Probable Pay Sand Isolith Map	"	73-51 Cb

DEPARTMENT OF MINES
SOUTH AUSTRALIA

Rept.Bk.No. 774
G.S. No. 5039
S.R. No. 27/4/122

THE RESERVOIR GEOLOGY FOR GAS RESERVE ESTIMATES, GIDGEALPA AND MOOMBA FIELDS, COOPER BASIN

INTRODUCTION

This investigation of the Gidgealpa and Moomba gas fields has been carried out to complete the Petroleum Geology Section's reservoir geology study of all the known economic gas and oil fields in the Cooper Basin at the end of 1972. Townsend and Youngs, (1972) conducted a similar study on the other fourteen fields.

The aim of the study has been to produce pay sand isolith maps for each field (see fig. 1 for location) so that estimates may be obtained of the volume of Proven-Probable gas contained within the sands. From these data (Table 1) the Assistant Petroleum Engineer has calculated the amount of deliverable gas.

Gas has been supplied to the Adelaide market from both the Gidgealpa and Moomba gas fields since 1969. However, for the sake of this study it has been assumed that no depletion has occurred, and therefore where gas water interfaces have subsequently risen, the original depth has been taken.

TABLE 1 : RESERVOIR DATA (PROVEN-PROBABLE)

FIELD	AREA (acres)	PAY VOLUME (acre feet)	HYDRO-CARBON SATURATION (% gas)	WEIGHTED AV. POROSITY (%)	HYDROCARBON PORE VOLUME (acre feet)	TEMPERATURE (°R)	AV. RESERVOIR PRESSURE (PSIA)	GAS DEVIATION FACTOR	INITIAL RESERVOIR FACTOR
GIDGEALPA									
NORTH DOME									
UPPER RESERVOIR	7495.4	348555.4	63.1	16.22	35674.0	685	3083	0.8976	178.00
LOWER RESERVOIR:N.W.	1308.5	25430.3	55.0	13.60	1902.2	685	3261	0.9031	187.11
" " :N.E.	1130.6	23716.2	44.7	11.51	1220.2	685	3343	0.9247	187.33
SOUTH DOME									
UPPER RESERVOIR	705.9	18196.3	69.9	18.11	2303.4	685	3082	0.8910	179.24
LOWER RESERVOIR:N.W.	4103.5	83706.3	57.8	13.10	6338.1	685	3166	0.8686	188.87
" " :S.E.	556.7	13837.8	68.0	15.23	1433.1	685	3309	0.8923	192.16

N.B. For want of better information, 685° was taken as the temperature throughout. In the deeper reservoirs this may be too low by about 10° but the difference in reserve estimate would be insignificant.

FIELD	AREA (acres)	PAY VOLUME (acre feet)	HYDRO-CARBON SATURATION (% gas)	WEIGHTED AV. POROSITY (%)	HYDROCARBON PORE VOLUME (acre feet)	TEMPERATURE (°R)	AV. RESERVOIR PRESSURE (PSIA)	GAS DEVIATION FACTOR	INITIAL RESERVOIR FACTOR
MOOMBA									
TOTAL AREA	103501	3229642	73.2	13.09	309481	755	3485	0.9650	169.78
EXCLUDING S.W. AREA	93549	3078074	73.2	13.09	295222	755	3485	0.9650	169.78

N.B. 1. Gas reserve estimates were carried out only on the Toolachee Formation. The Patchawarra Formation reservoir is insignificantly small.

2. Gas reserve estimates were carried out on Moomba - total area and Moomba - excluding S.W. area, but one additional estimate was made. This third estimate was produced by taking 80% of Moomba - excluding S.W. area due to low confidence in areas remote from existing wells.

The hydrocarbon producing horizons in both fields occur within the Permian Gidgealpa Group (fig. 2). The Gidgealpa field produces from the Toolachee and Patchawarra Formations, and Moomba from these two formations and also the Daralingie Beds.

Because of the very different nature of the two fields, a different technique was used in each case to derive the volume of Proven-Probable gas. The methods and results for each field will be dealt with separately.

MOOMBA FIELD

General

Moomba 1 was drilled in 1966 and flowed gas from DST No. 3 at the rate of 4.37 MMCFD. Since that time, a further ten wells have been drilled, eight of which have been completed as gas producers. One of these, Moomba 7, was shut in after completion, because of low permeability, to await formation fracturing. Moomba 3 and 4 did not produce gas.

The Moomba field comprises two structural highs, each trending in an approximately northwesterly direction, separated by a structurally low area. There are three wells on the northern structure, Moomba 5, 6 and 7, the others being situated on the southern structure. The three formations from which gas has been recovered are the Toolachee Formation, Daralingie Beds and Patchawarra Formation. Table 2 shows which wells were productive from each of these formations.

For the purpose of this study, the pay sands from the Toolachee Formation and Daralingie Beds have been considered together, but pay sand from the Patchawarra Formation has been considered separately.

TABLE 2: Moomba Field-Productive Formations

Formation	Wells										
	Northern Structure			Southern Structure							
	5	6	7	1	2	3	4	8	9	10	11
Toolachee Formation	x	x	x	x	x			x	x	x	x
Daralingie Beds								x	x	x	x
Patchawarra Formation		x									

x: Productive

Map Compilation

The Moomba field extends over a larger area than any other field so far discovered in the Cooper Basin. As a result, although eleven wells have been drilled, the well density is relatively low. Added to this, the pay sands are predominantly thin and thus difficult to correlate with any degree of certainty between wells. It was therefore decided not to use the cross-sectioning technique used by Townsend and Youngs (1972), but to compile pay sand isolith maps in the manner described below.

Toolachee Formation

Three pay sand isolith maps were produced. The Proven-Probable map is the most conservative and is therefore the only one for which Gas-in-Place and Sales Gas Reserves have been calculated. The three categories differ as follows (see fig. 3):

Proven-Probable: pay sand thickness determined from the wells was contoured down to a structural level defined by the base of pay in all eleven wells.

Lower Limit Possible: pay sand thickness determined from the wells was contoured down to a planar surface defined by the base of pay from four wells around the margin of the field. This gave a more optimistic figure than the Proven-Probable category, especially in the centre of the field, because most of the peripheral wells are deeper than the more central ones.

Upper Limit Possible: pay sand thickness determined from the wells was contoured on the assumption that there was no lower limit to the field other than the base of the formation. This gave a very optimistic interpretation, particularly in the low between the northern and southern structures.

These three maps were compiled as follows:

(a) Proven-Probable Pay Sand Isolith Map

1. From logs, and quantitative log evaluation data, the pay sand

thicknesses for each well were calculated and the subsea depths of the top and bottom of pay sands were noted (Table 3).

2. A top of pay sand contour map (Map 2) was compiled, using the "P" (top of Permian) map (Map 1) as a structural control.

3. With the possible exception of Moomba 4, no gas/water interface has been encountered within any Moomba well. A hypothetical gas water interface was therefore constructed using the base of pay sands from each well as limiting control. The surface (Map 3) was drawn by arithmetically grading the depths between each well. It was extended outwards from the wells as far as it was reasonable.

4. Map 2 was superimposed on Map 3, and at points on an arbitrary grid the depths on Map 3 were subtracted from those on Map 2. The result was then contoured to produce an isopach of gross pay (Map 4), i.e. an isopach of that part of the formation which encloses the pay sands. This isopach therefore includes coal, shales and non-pay sands. The limit of the field occurs along the locus of points at which Maps 2 and 3 have the same depth value. This limit was drawn on Map 4. This method produced no limit along the southwestern margin of the field because zero differences between the extrapolated contours on Maps 2 and 3 were not obtained. An approximate limit was drawn through the thinnest part of the isopach in that region.

TABLE 3 : Moomba Field - Pay Sands

Well Name & No (K.B.-ft.)	Formation	Pay Sand Top Depth (ft.)	Pay Sand Top Subsea (ft.)	Pay Sand Bottom Depth (ft.)	Pay Sand Bottom Subsea (ft.)	Pay thickness (ft.)	Average Porosity (%)	Average Sw (%)
Moomba 1 (+123)	Toolachee	7731	-7608	7745	-7622	14	12.9	19.5
	"	7746	-7623	7748	-7625	2	15	15.5
	"	7752	-7629	7759	-7636	7	14.7	17.7
	"	7760.5	-7637.5	7765.5	-7642.5	5	9.2	29
	"	7767	-7644	7768	-7645	1	13	17
	"	7784	-7661	7795	-7672	11	14.9	20
	"	7801	-7678	7811	-7688	10	13.4	15
	"	7816	-7693	7824	-7701	8	12.2	24
	"	7872	-7749	7873.5	-7750.5	1.5	5	38
	"	7876	-7753	7882	-7759	6	14.2	16.2
	"	7890.5	-7767.5	7898	-7775	7.5	13.2	14.8
	"	7912	-7789	7918.5	-7795.5	6.5	13.5	21.2
	"	7928	-7805	7935	-7812	7	16.3	7.0
						Total: 86.5		
Moomba 2 (+109)	Toolachee	7580	-7471	7585	-7476	5	18.0	51.5
	"	7589.5	-7480.5	7599.5	-7490.5	10	16.5	37.3
	"	7607	-7498	7609	-7500	2	) 13.0	65.0
	"	7611	-7502	7616	-7507	5	)	
	"	7623	-7514	7624	-7515	1	)	
	"	7626	-7517	7628	-7519	2	) 15.2	51.0
	"	7630	-7521	7632	-7523	2	)	
	"	7640.5	-7531.5	7641.5	-7532.5	1	) 14.0	55.0
	"	7642.5	-7533.5	7644.5	-7535.5	2	)	
	"	7656.5	-7547.5	7669.5	-7560.5	13	17.0	38.3
	"	7678	-7569	7686	-7577	8	19.5	36.0
	"	7702	-7593	7703	-7594	1	) 16.5	39.8
	"	7709	-7600	7716	-7607	7	)	
	"	7733	-7624	7735	-7626	2	13.5	64.0
						Total: 61		

Well Name & No (K.B.-ft.)	Formation	Pay Sand Top Depth (ft.)	Pay Sand Top Subsea (ft.)	Pay Sand Bottom Depth (ft.)	Pay Sand Bottom Subsea (ft.)	Pay thickness (ft.)	Average Porosity (%)	Average Sw (%)
Moomba 5 (+160)	Toolachee	7976	-7816	7985	-7825	9	-	-
	"	7987	-7827	7997	-7837	10	-	-
	"	8101	-7941	8115	-7955	14	10.9	22.3
	"	8156	-7996	8160	-8000	4	-	-
	"	8187	-8027	8189	-8029	2	-	-
	"	8191	-8031	8193	-8033	2	-	-
	"	8222	-8062	8224	-8064	2	-	-
	"	8236	-8076	8242	-8082	6	4.3	18.6
						Total:49		
Moomba 6 (+135)	Toolachee	8051.5	-7916.5	8053	-7918	1.5	)	
	"	8055.5	-7920.5	8057	-7922	1.5	)	
	"	8058.5	-7923.5	8059	-7924	0.5	)	
	"	8059.5	-7924.5	8060	-7925	0.5	) 12	33
	"	8061.5	-7926.5	8062	-7927	0.5	)	
	"	8063	-7928	8066	-7931	3	)	
	"	8077	-7942	8079	-7944	2	)	
	"	8081.5	-7946.5	8083.5	-7948.5	2	) 12.7	35.2
	"	8129	-7994	8131	-7996	2	)	
	"	8133	-7998	8145.5	-8010.5	12.5	)	
	"	8146.5	-8011.5	8147	-8012	0.5	) 13.3	15.6
	"	8148.5	-8013.5	8159.5	-8024.5	11	)	
	"	8179.5	-8044.5	8190.5	-8055.5	11	13.5	28
	"	8210	-8075	8213	-8078	3	)	
	"	8214	-8079	8215	-8080	1	) 11.5	24
	"	8226	-8091	8234	-8099	8	11.5	13
	"	8245	-8110	8251.5	-8116.5	6.5	)	
	"	8253	-8118	8259	-8124	6	) 14.5	18
						Total:73		
	Patchawarra	9050	-8915	9055	-8920	5	11	6

Well Name & No (K.B.-ft.)	Formation	Pay Sand Top Depth (ft.)	Pay Sand Top Subsea (ft.)	Pay Sand Bottom Depth (ft.)	Pay Sand Bottom Subsea (ft.)	Pay thickness (ft.)	Average Porosity (%)	Average Sw (%)
Moomba 7 (+138)	Toolachee	8055	-7917	8079	-7941	24	12	17
	"	8102	-7964	8106	-7968	4	15	25
	"	8121.5	-7983.5	8125.5	-7987.5	4	13	23
	"	8168	-8030	8173	-8035	5	13	30
						Total:37		
Moomba 8 (+118)	Toolachee	7678	-7560	7694	-7576	16	) 11.5	19.5
	"	7696	-7578	7707	-7589	11	)	
	"	7759	-7641	7768	-7650	9	10	17
	"	7783	-7665	7785	-7667	2	12.4	32
	"	7800	-7682	7804	-7686	4	12.8	34
	"	7816	-7698	7821	-7703	5	-	-
	"	7832	-7714	7840	-7722	8	12	19
	"	7861	-7743	7863	-7745	2	18.3	37
	"	7866	-7748	7869	-7751	3	18.1	24
	"	7883	-7765	7894	-7776	11	13.5	22.5
	"	7903	-7785	7912	-7794	9	16	19.5
	"	7934	-7816	7940	-7822	6	16	22
	Daralingie	7982	-7864	7988	-7870	6		
	"	7995.5	-7877.5	7999	-7881	3.5		
						Total:95.5		
Moomba 9 (+134)	Toolachee	7788	-7654	7800	-7666	12	8.6	29.1
	"	7824	-7690	7834	-7700	10	13.6	25.5
	"	7850	-7716	7856	-7722	6	12.7	31
	"	7861	-7727	7882	-7748	21	12.8	24.9
	"	7888.5	-7754.5	7890.5	-7756.5	2	8.5	45
	"	7892	-7758	7894	-7760	2	12.5	37
	"	7914	-7780	7917	-7783	3	11.7	30
	"	7977.5	-7843.5	7979.5	-7845.5	2	) 12.8	33
	"	7980	-7846	7983	-7849	3	)	
	Daralingie	8074	-7940	8082	-7948	8	14.8	16.5
	"	8094	-7960	8096	-7962	2	9.0	46
						Total:71		

Well Name & No (K.B.-ft.)	Formation	Pay Sand				Pay thickness (ft.)	Average Porosity (%)	Average S_W (%)
		Top		Bottom				
		Depth (ft.)	Subsea (ft.)	Depth (ft.)	Subsea (ft.)			
Moomba 10 (+138)	Toolachee	7590	-7452	7592.5	-7454.5	2.5	9.0	39
	"	7607	-7469	7609	-7471	2	9.7	38
	"	7611	-7473	7613	-7475	2	9.0	42
	"	7615	-7477	7617	-7479	2	8.0	43
	"	7729	-7591	7732	-7594	3	8.5	46
	"	7740	-7602	7743	-7605	3	9.5	43
	"	7757	-7619	7764	-7626	7	16.3	19.5
	"	7769	-7631	7771	-7633	2	14.5	27
	"	7773	-7635	7777	-7639	4	14.5	19.5
	"	7778	-7640	7784	-7646	6	13.5	18
	"	7796	-7658	7798	-7660	2	12	29
	"	7799	-7661	7805	-7667	6	13.8	22.8
	"	7825	-7687	7834	-7696	9	13.4	24.5
	"	7845	-7707	7848	-7710	3	12.7	31
	"	7849	-7711	7850	-7712	1	13.2	30
	Daralingie	8029	-7891	8037	-7899	8	14.8	16
						Total:62.5		
Moomba 11 (+138)	Toolachee	7926	-7788	7930	-7792	4	13.6	35.5
	"	7937	-7799	7939	-7801	2	8.5	55
	"	7940	-7802	7941	-7803	1	9.0	55
	"	7943	-7805	7953	-7815	10	12.2	45.6
	"	7962	-7824	7980	-7842	18	11.9	50.5
	"	7986	-7848	7994	-7856	8	15.3	21.5
	"	8006	-7868	8009	-7871	3	7.8	68
	"	8010	-7872	8015	-7877	5	10.7	48
	"	8117	-7979	8122	-7984	5	10.1	46.5
	Daralingie	8227	-8089	8231	-8093	4	13.5	35
	"	8243	-8105	8247	-8109	4	16.0	-
						Total:64		

5. An isolith of pay sands (Map 5) was then drawn using the isopachs of Map 4 as thickness controls. The field limit derived in Map 4 was retained as the zero isopach. Three Proven-Probable gas reserve estimations were carried out by the Assistant Petroleum Engineer from Map 5 (see Table 1). The first was made from the complete area. For the other two, the southwestern area of pay sands, shown by the dotted line on Map 5, was excluded because of the lack of well control.

(b) <u>Lower limit Possible Pay Sand Isolith Map</u>

Because of the lack of a gas/water interface in the Moomba field, there are a number of ways of defining the base of pay. The technique used to derive the Lower Limit Possible map was the same as that used for the Proven-Probable map, with the one exception that the surface defining the base of pay was constructed differently.

According to normal hydrostatic theories, the bottom limit of a gas field should be a plane surface. If a field contains a gas/water interface, this interface is either horizontal or dipping due to some external force such as water pressure. To obtain a conservative estimate, an undulating surface was constructed for the Proven-Probable isolith. In the case of the Lower Limit Possible map, however, a dipping planar surface was constructed which underlay all gas bearing sands from the eleven wells drilled.

The depths to base of pay from four peripheral wells were used as controls. These four wells were Moomba 4, which is a non-producer but contains water-free sands overlying water-bearing sands, and Moomba 11 on the southern structure, and Moomba 6 and 7 on the northern structure. Plane surfaces were constructed between Moomba 4, 11 and 7 and between Moomba 11, 6 and 7. These two surfaces coincide along the line between Moomba 11 and 7, and together form the bottom of pay sand contour map (Map 6).

The pay sand isolith map (Map 7) was derived from Map 2 and Map 6.

(c) <u>Upper Limit Possible Pay Sand Isolith Map</u>

Moomba 11 contains gas at a depth greater than the deepest closing contour in that area of the structure. The entrapment of gas must, therefore, to a certain extent be due to stratigraphic control. This being the case, there is no reason to suppose that stratigraphic entrapment should cease at the deepest part of a structural low. Topwee 1, on the rising flank of a basement high, is the nearest well to Moomba 11, lying to the southwest of it. Topwee 1 was a dry well. The cut off point for the Moomba field was therefore taken as the halfway point between Topwee 1 and Moomba 11. The limit of the Moomba field, elsewhere around the margin of the structure, was controlled by horizontally projecting outwards the depth of the bottom pay sand of the nearest well. The upper limit pay sand isolith was then drawn, using Map 2 as a thickness control. This isolith (Map 8) is considered to be very optimistic.

Patchawarra Formation Proven-Probable Pay Sand Isolith Map

Only Moomba 6 has intersected economic amounts of gas within the Patchawarra Formation. This gas is contained within one 5 ft. thick pay sand. Moomba 5, the closest well to Moomba 6, was not drilled to sufficient depth to intersect the Patchawarra Formation, and thus test the lateral extent of pay. However, Moomba 7, the only other well on the northern structure, recovered a small amount of gas (82 MCFD). Nevertheless, for the purpose of Proven-Probable estimation only the area immediately surrounding Moomba 6 can be taken to contain pay.

The pay sand isolith map (Map 9) was derived by horizontally extrapolating the base of pay around the Moomba 6 dome. A base of Permian structure contour map was used as a thickness control and a minor fault situated approximately midway between Moomba 5 and 6 was taken as the southeastern limit of the field.

No reserve estimate of this pool has been done because of its very small volume.

Discussion

The three pay sand isolith maps for the Toolachee Formation (Maps 5, 7 and 8) show a wide divergence in field shape and pay sand volume. In particular, the pay sand volume in the low between the north and south structures increases markedly from the least to the most optimistic maps. Only in the Proven-Probable category are the pay sands around Moomba 7 isolated from the rest of the field.

As explained previously, the divergence is due to the different methods used to define the base of the field. Because of the extremely large area (over 100 000 acres on the Proven-Probable map) and the very poor well density, no definitive method has yet been devised for defining the fields limits in either area or depth.

Moomba 3 is a non-producer because of the impermeable nature of its sands. It is reasonable, therefore, to expect that other impermeable areas may occur within the Moomba area. The extent to which stratigraphic factors control gas entrapment within the field, such as around Moomba 11, is uncertain. Only further drilling will throw light on these problems and help clarify the field limits.

Three gas reserve estimates have been produced from the Proven-Probable map (see Table 1). The most optimistic figure was obtained from the whole map area, and a more conservative estimate was derived by excluding the southwestern area in which no well has been drilled. To achieve, as closely as possible, conformity with estimates conducted on other fields a final very conservative value was achieved by removing 20% from the second figure due to low confidence in areas remote from existing wells. The reserve estimates, carried out by the Assistant Petroleum Engineer, are filed in "Natural Gas Reserves - Cooper Basin" (SR. 28/1/15).

GIDGEALPA FIELD

General

Gidgealpa 1 was drilled in 1963 on the eastern flank of the Gidgealpa structure. Although it did not produce economical volumes of gas, testing results were encouraging enough to warrant drillingasecond hole to intersect Permian sediments at a higher elevation, closer to the structural culmination. This well, Gidgealpa 2, recovered gas at the rate of 2.8 MMCFD from DST No. 2 on 31st December, 1963. It was the first successful exploration well in the Cooper Basin.

In all, thirteen wells have been drilled on the Gidgealpa structure, and only Gidgealpa 1 and 6 were non-producers. All the wells, except Gidgealpa 5 and 7, were drilled on the larger, northern, dome of the structure. Table 4 shows which wells were productive from each formations.

TABLE 4: Gidgealpa Field - Productive Formations

Formation	Wells										
	Northern Dome									Southern Dome	
	2	3	4	8	9	10	11	12	13	5	7
Toolachee Formation	x		x	x	x	x	x	x	x		x
Patchawarra Formation		x	x					x		x	x
Tirrawarra Formation											x

x: Productive

Map Compilation

Well density is much higher in Gidgealpa than in Moomba. In addition, two gas/water interfaces, and therefore two gas reservoirs, occur in Gidgealpa. As a result, pay sand isolith maps were derived for these reservoirs by drawing cross-sections, plotting the pay sand thicknesses at regular intervals along the sections, and contouring the result.

Wells drilled around the northern dome have shown that a practically horizontal gas/water interface occurs beneath the upper reservoir. Therefore it has been assumed that all the gas/water interfaces are horizontal. On each cross-section the limit of the field occurs at the point where the gas/water interface cuts the "P" Horizon.

Throughout the field, all the gas held within the sands of the Toolachee Formation occurs in the upper reservoir, and most of the Patchawarra gas lies within the lower reservoir. In a few cases, however, Patchawarra gas entrapment is controlled by the upper gas/water interface and therefore occurs within the upper reservoir. (fig. 4).

From logs, and quantitative log evaluation data, pay sand thicknesses were derived for each well (Table 5) and gas/water interfaces noted (Table 6). After the cross-sections had been drawn (section lines shown on fig. 1 and Map 10 - "P" Map) the pay sand thicknesses for the Upper Reservoir were plotted and contoured, using Map 10 as a thickness control, to produce a Proven-Probable pay sand isolith map (Map 11). The Proven-Probable pay sand isolith map for the Lower Reservoir (Map 12) was produced in a similar manner except that thickness control

TABLE 5: GIDGEALPA FIELD - PAY SANDS

Well Name(K.B.)	Formation	Designation	Pay Sand Top Depth(ft)	Pay Sand Top Subsea(ft)	Pay Sand Bottom Depth(ft)	Pay Sand Bottom Subsea(ft)	Thickness(ft)	Av.Ø (%)	Av. Sw. (%)
Gidgealpa 2	Toolachee	B1	6755	-6577	6779	-6601	24	17.4	26
(+178)	"	(	6790	-6612	6791	-6613	1	)	
	"	B3 (	6792	-6614	6796	-6618	4	)14.6	34
	"	(	6798	-6620	6802	-6624	4	)	
	"	(	6803	-6625	6809	-6631	6	)	
	"	C2	6836	-6658	6843	-6665	7	19.7	20
	"	D1	6857	-6679	6868	-6690	11	15.6	38
							Total:57		
Gidgealpa 3	Patchawarra		7318	-7142	7321	-7145	3	)	40.8
	"		7326	-7150	7328	-7152	2	)13.5	
(+176)	"	M	7414	-7238	7419	-7243	5	8.5	56
	"	N	7452	-7276	7454	-7278	2	8.5	66
	"	(	7475	-7299	7477	-7301	2	)	55
	"	Q (	7479	-7303	7480	-7304	1	)10.4	
	"	(	7480.5	-7304.5	7484	-7308	3.5	)	
All in Lower	"	R (	7524	-7348	7527.5	-7351.5	3.5	)	
Reservoir	"	(	7529	-7353	7537	-7361	8	)12.7	58.5
	"	S	7540	-7364	7544	-7368	4	)	
							Total:34		

Well Name(K.B.)	Formation	Designation	Pay Sand Top Depth(ft)	Pay Sand Top Subsea(ft)	Pay Sand Bottom Depth(ft)	Pay Sand Bottom Subsea(ft)	Thickness(ft)	Av.Ø (%)	Av. Sw. (%)
Gidgealpa 4	Toolachee	B1 (	6879	-6714	6886	-6721	7	)12.5	44
		(	6888	-6723	6889	-6724	1	)	
(+165)	"	B3 (	6897	-6732	6902	-6737	5	)13.7	29
		(	6903	-6738	6906	-6741	3	)	
	"	(	6936.5	-6771.5	6940	-6775	3.5	)	
		C2 (	6941	-6776	6954	-6789	13	)16	33
		(	6955	-6790	6957	-6792	2	)	
	"	D1	6977	-6812	6986	-6821	9	17.7	39
	"	D2 (	6992	-6827	6998	-6833	6	)17.3	36
		(	6999.5	-6834.5	7013	-6848	13.5	)	
							Total:63		
(	Patchawarra		7194	-7029	7196	-7031	2	)	
(	"		7197	-7032	7198	-7033	1	)	
(	"		7201	-7036	7204	-7039	3	)	
Lower (	"		7206	-7041	7210.5	-7045.5	4.5	)	
Reservoir (	"		7214	-7049	7218	-7053	4	)13.6	45
(	"		7219	-7054	7229	-7064	10	)	
(	"		7230.5	-7065.5	7232	-7067	1.5	)	
(	"		7233.5	-7068.5	7238	-7073	4.5	)	
(	"		7240	-7075	7246.5	-7081.5	6.5	)	
							Total:37		
Gidgealpa 5	Patchawarra	S	7090	-6924	7093	-6927	3	12.5	37
(+166)	"	T1	7127	-6961	7130	-6964	3	15.2	34
	"	(	7142	-6976	7151	-6985	9	)	
	"	(	7153	-6987	7155	-6989	2	)13.1	43
	"	T2 (	7156	-6990	7158	-6992	2	)	
All in	"	(	7161	-6995	7163	-6997	2	)	
Lower Reservoir	"	U	7181	-7015	7185	-7019	4	12.0	49
							Total:25		

Well Name(K.B.)	Formation	Designation	Pay Sand Top Depth(ft)	Pay Sand Top Subsea(ft)	Pay Sand Bottom Depth(ft)	Pay Sand Bottom Subsea(ft)	Thickness(ft)	Av.Ø (%)	Av. Sw. (%)
Gidgealpa 7 (+168)	Toolachee	B3	6877	-6709	6901	-6733	24	18.9	26.3
	"	C1 (	6922	-6754	6925	-6757	3	)17.4	33.5
		(	6927.5	-6759.5	6948.5	-6780.5	21	)	
	"	C2	6951	-6783	6954	-6786	3	)	
							Total:51		
Lower (	Patchawarra	V	7238	-7070	7242	-7074	Total: 4	14	35
Reservoir (	Tirrawarra	Ti1	7246	-7078	7248	-7080	Total: 2	17.7	26
Gidgealpa 8 (+198)	Toolachee	B3	6907	-6709	6943	-6745	36	18.2	31
	"	C2	6972	-6774	6996	-6798	24	16.2	42.9
	"	D2	7016	-6818	7029	-6831	13	)18	51
	"	D3	7033	-6835	7036	-6838	3	)	
							Total:76		
Gidgealpa 9 (+191)	Toolachee	B1	6935	-6744	6939	-6748	4	14.5	48
	"	B3	6952	-6761	6972	-6781	20	15.8	38.5
	"	C1	6996	-6805	7004	-6813	8	)13.2	54.5
	"	C2	7006	-6815	7020	-6829	14	)	
							Total:46		

Well Name (K.B.)	Formation	Designation	Pay Sand Top Depth (ft)	Pay Sand Top Subsea (ft)	Pay Sand Bottom Depth (ft)	Pay Sand Bottom Subsea (ft)	Thickness (ft)	Av.Ø (%)	Av.Sw. (%)
Gidgealpa 10 (+176)	Toolachee	B3	6930	-6754	6940	-6764	10	18.1	22.6
	"	C2	6978	-6802	6987	-6811	9	13.5	49
	"	D1	6998.5	-6822.5	7006	-6830	7.5	)18.9	42
	"	D2	7008	-6832	7017	-6841	9	)	
	"	D3	7024	-6848	7031	-6855	7	17.2	48.2
							Total: 42.5		
Gidgealpa 11 (+178)	Toolachee	B3	6775	-6597	6795	-6617	20	19.3	20
	"	C2	6834	-6656	6837	-6659	3	15.0	40
	"	D1	6854	-6676	6859	-6681	5	12.0	58
							Total: 28		
Gidgealpa 12 (+186)	Toolachee	B3	6785	-6599	6821	-6635	36	16.8	29.5
	"	C2	6850	-6664	6865	-6679	15	17.3	28.7
	"	D1	6886	-6700	6903	-6717	17	)15.2	31.5
	"	D2	6905	-6719	6915	-6729	10	)	
							Total: 78		
Upper (	Patchawarra	M (	6938	-6752	6942	-6756	4	)11.6	56
Reservoir (	"	(	6943	-6757	6946	-6760	3	)	
(	"	N	6967.5	-6781.5	6970	-6784	2.5	16	42
							Total: 9.5		

Well Name (K.B.)	Formation	Designation	Pay Sand Top Depth (ft)	Pay Sand Top Subsea (ft)	Pay Sand Bottom Depth (ft)	Pay Sand Bottom Subsea (ft)	Thickness (ft)	Av. Ø (%)	Av. Sw. (%)
Gidgealpa 13 (+198)	Toolachee	A	6884.5	-6686.5	6901.5	-6703.5	17	16.9	36
	"	B2	6925	-6727	6930	-6732	5	)	
		(	6934	-6736	6946	-6748	12	)15.6	29.5
	"	B3 (	6948	-6750	6958	-6760	10	)	
	"	D2 (	7010	-6812	7022	-6824	12	)13.5	58
		(	7026	-6828	7041	-6843	15	)	
							Total: 71		

TABLE 6 : Gidgealpa Field - Gas/Water Interfaces

Well Name & No.	Toolachee Formation		Patchawarra Formation	
	Depth (ft.) or Comments	Subsea (ft.)	Depth (ft.) or Comments	Subsea (ft.)
Gidgealpa 1	Water wet	-	Water wet	-
2	None		Formation Absent	
3	Water wet	-	7544	-7368
4	7013	-6848	None	
5	Water wet	-	7185	-7019
6	Water wet	-	Water wet	-
7	6954	-6786	7248	-7080
8	7033	-6838	Water wet	-
9	7020	-6829	Water wet	-
10	7031	-6855	Water wet	-
11	None		Formation Absent	
12	None		None	
13	approx. 7041	approx. -6843	Water wet	-

was an isopach map of the Gidgealpa Group produced by D.C. Burton, Delhi Australian Petroleum in January, 1969 (lodged in Env. 2171).

The cross-sections compiled during this study are lodged in the security Register of the South Australian Department of Mines (Env. 2171).

Discussion

Only Proven-Probable isolith maps were compiled for the two reservoirs. Lower and Upper Limit Possible maps were not drawn because the field is fairly well defined, except for the following areas. Across the northern dome, although the Upper Reservoir is reasonably well defined, the Lower Reservoir has only been intersected by Gidgealpas 3 and 4. More wells drilled on the eastern and northern flanks of the structure could markedly increase known reserves. On the southern dome, Gidgealpa 5 and 7 do not conclusively delimit the two reservoirs.

The area of the Upper Reservoir is slightly larger (8,200 acres) than that of the Lower Reservoir (7,100 acres), but its pay volume is nearly three times as great. The other important difference between the two reservoirs is that on the northern dome the Upper Reservoir consists of one continuous pool, whereas the Lower Reservoir appears to comprise two unconnected fault controlled pools. On the southern dome the Lower Reservoir seems to consist of two non-communicating pools separated by a major fault.

For the purpose of obtaining the data required to derive a gas reserve estimate, the four separate pools of the Lower Reservoir have been considered separately (Table 1). These pools are named on Map 12. The reserve estimate is filed in "Natural Gas Reserves - Cooper Basin" (SR. 28/1/15).

REFERENCE

Townsend, I.J. and Youngs, B.C., 1972. The reservoir geology of gas reserve estimates, Cooper Basin. Dept. Mines unpublished report RB.772 (Confidential).

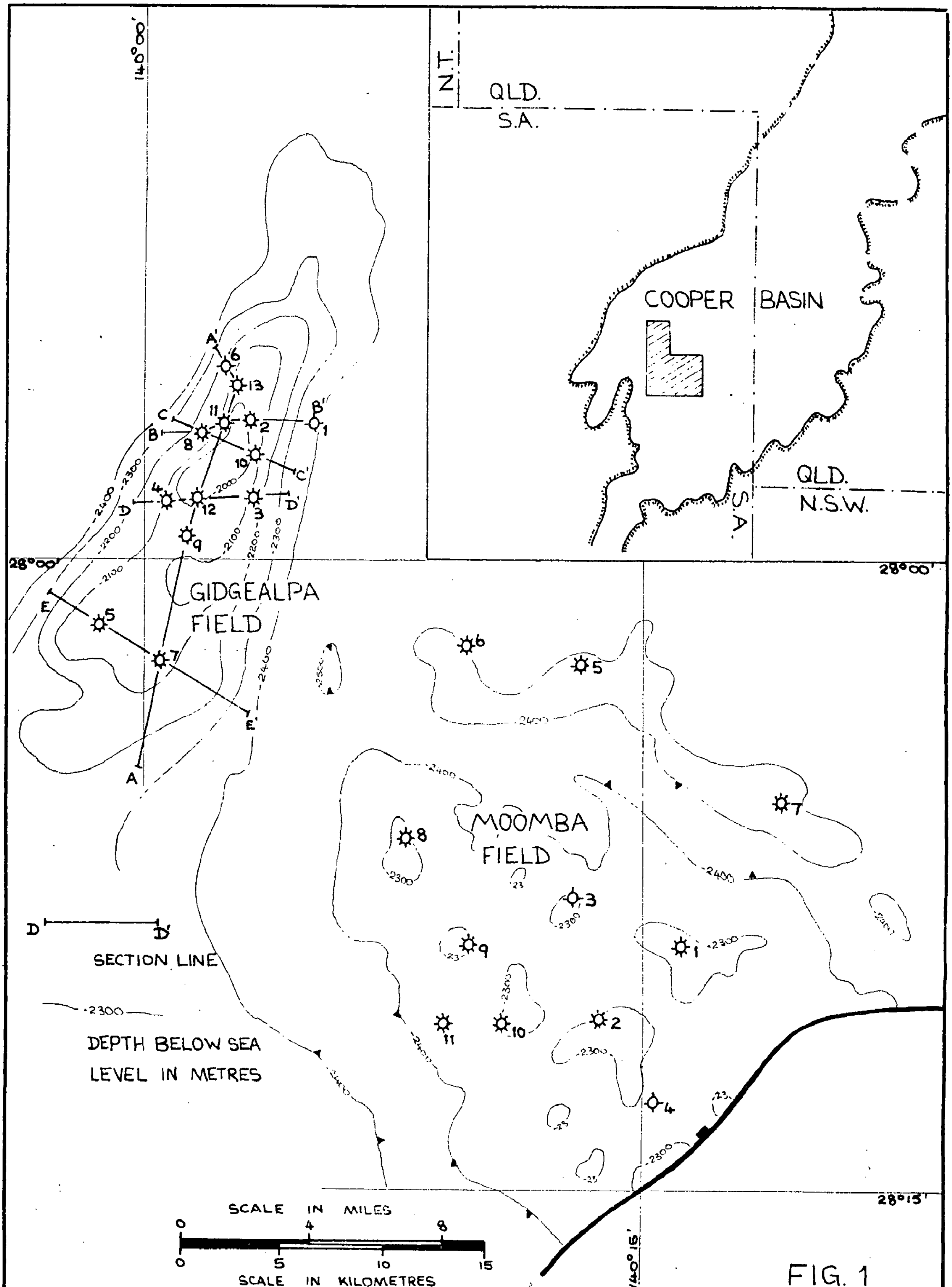


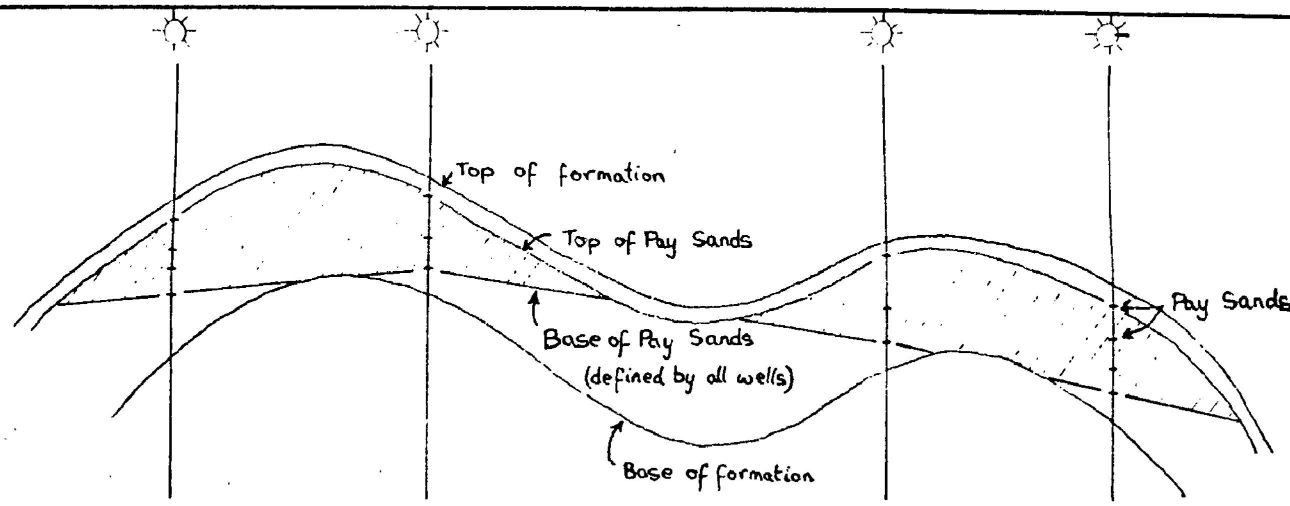
FIG. 1

DEPARTMENT OF MINES – SOUTH AUSTRALIA	Scale: 1:250 000
Compiled: R.C.N.T.	GIDGEALPA AND MOOMBA GAS FIELDS LOCALITY MAP SHOWING TOP OF PERMIAN STRUCTURE CONTOURS	Date: 7 FEB. 1973
Drn. R.T. Ckd. R.T.		Drg. No. S10138 Cb

1M–2.70 A1810

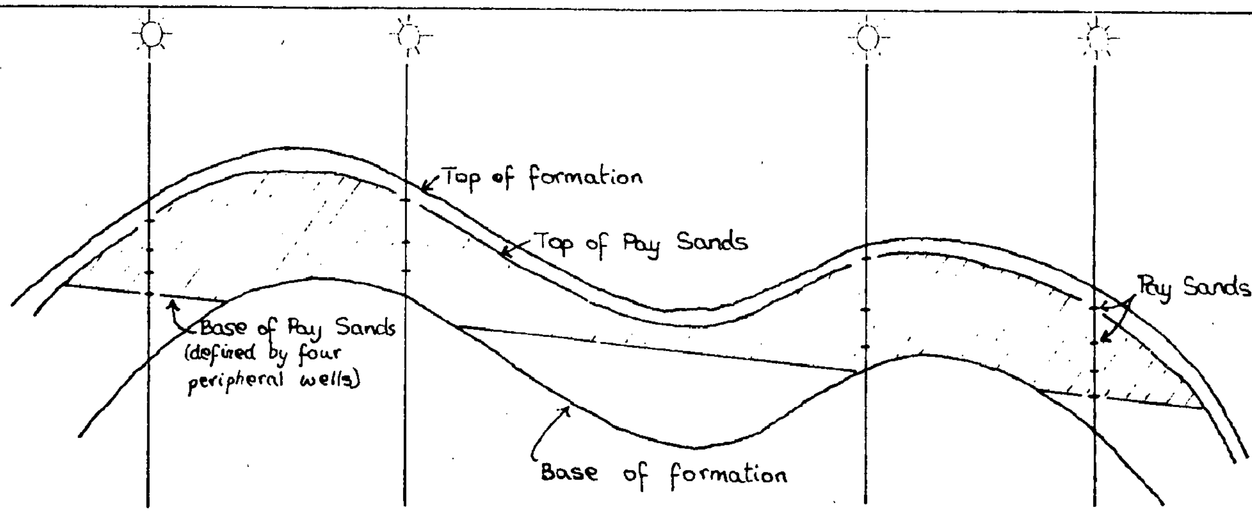
<table>
<tr><th colspan="2">NEW TERMINOLOGY
(Kapel, 1972; Gatehouse, 1972)</th><th>AGE</th><th colspan="3">OLD TERMINOLOGY
(Martin, 1967)</th></tr>
<tr><td colspan="2">NAPPAMERRIE FORMATION</td><td>TRIASSIC</td><td colspan="3">NAPPAMERRIE FORMATION</td></tr>
<tr><td rowspan="8">GIDGEALPA GROUP</td><td>TOOLACHEE FORMATION</td><td>TARTARIAN-KUNGURIAN</td><td colspan="2">UPPER MEMBER</td><td rowspan="8">GIDGEALPA FORMATION</td></tr>
<tr><td>DARALINGIE BEDS</td><td rowspan="5">ARTINSKIAN</td><td rowspan="4">MIDDLE MEMBER</td><td rowspan="2">UPPER PART</td></tr>
<tr><td>ROSENEATH SHALE</td></tr>
<tr><td>EPSILON FORMATION</td><td>MIDDLE PART</td></tr>
<tr><td>MURTEREE SHALE</td><td>LOWER PART</td></tr>
<tr><td rowspan="2">PATCHAWARRA FORMATION</td><td colspan="2" rowspan="3">LOWER MEMBER</td></tr>
<tr><td rowspan="2">ARTINSKIAN-SAKMARIAN</td></tr>
<tr><td>MOORARI BEDS
TIRRAWARRA SANDSTONE</td></tr>
<tr><td colspan="2">MERRIMELIA FORMATION</td><td>SAKMARIAN-(?) CARBONIFEROUS</td><td colspan="3">MERRIMELIA FORMATION</td></tr>
</table>

FIG 2



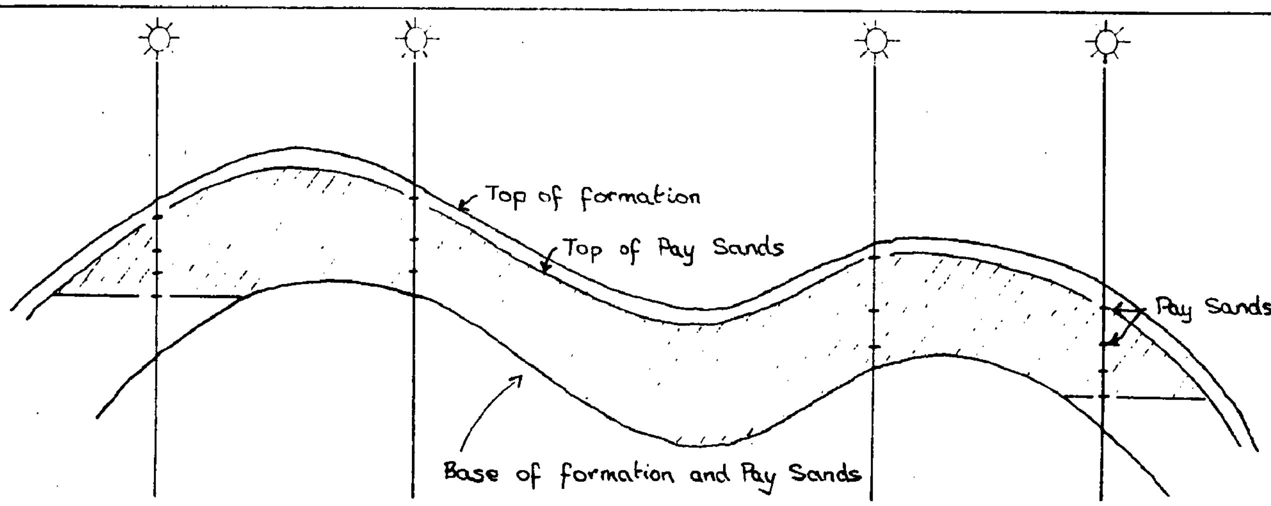
PROVEN-PROBABLE

PART CONTAINING PAY SANDS



LOWER LIMIT POSSIBLE

PART CONTAINING PAY SANDS



UPPER LIMIT POSSIBLE

PART CONTAINING PAY SANDS

FIG. 3

DEPARTMENT OF MINES – SOUTH AUSTRALIA

Compiled: R.C.N.T.

Drn. R.T. Ckd. R.T.

MOOMBA GAS FIELD

DIAGRAMMATIC CROSS SECTIONS

SHOWING DIFFERENCES BETWEEN PROVEN-PROBABLE, LOWER LIMIT POSSIBLE & UPPER LIMIT POSSIBLE

Scale: Diagrammatic

Date: 5 Feb. 1973

Drg. No. S10139 Cb

1M–2.70 A1810

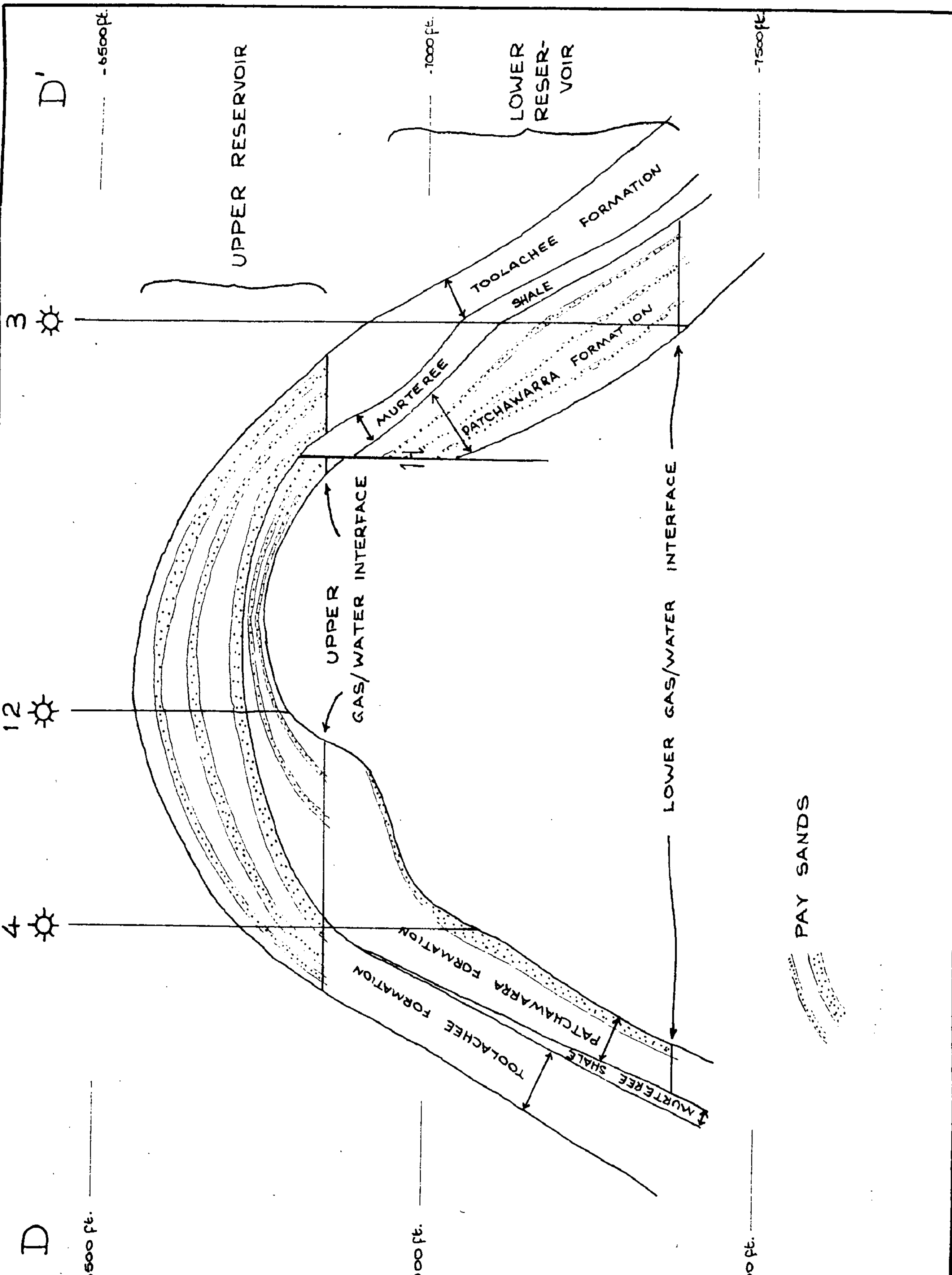
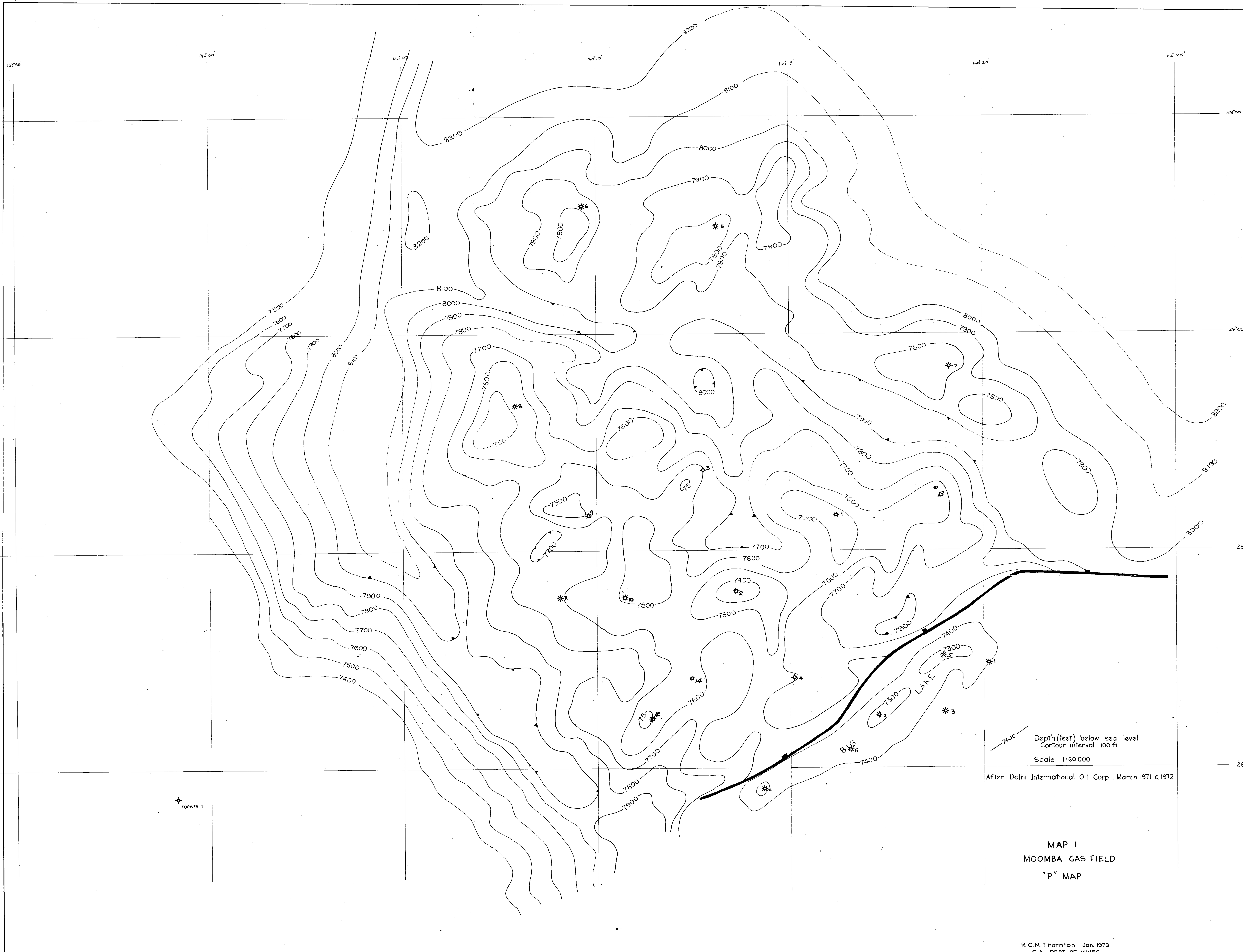
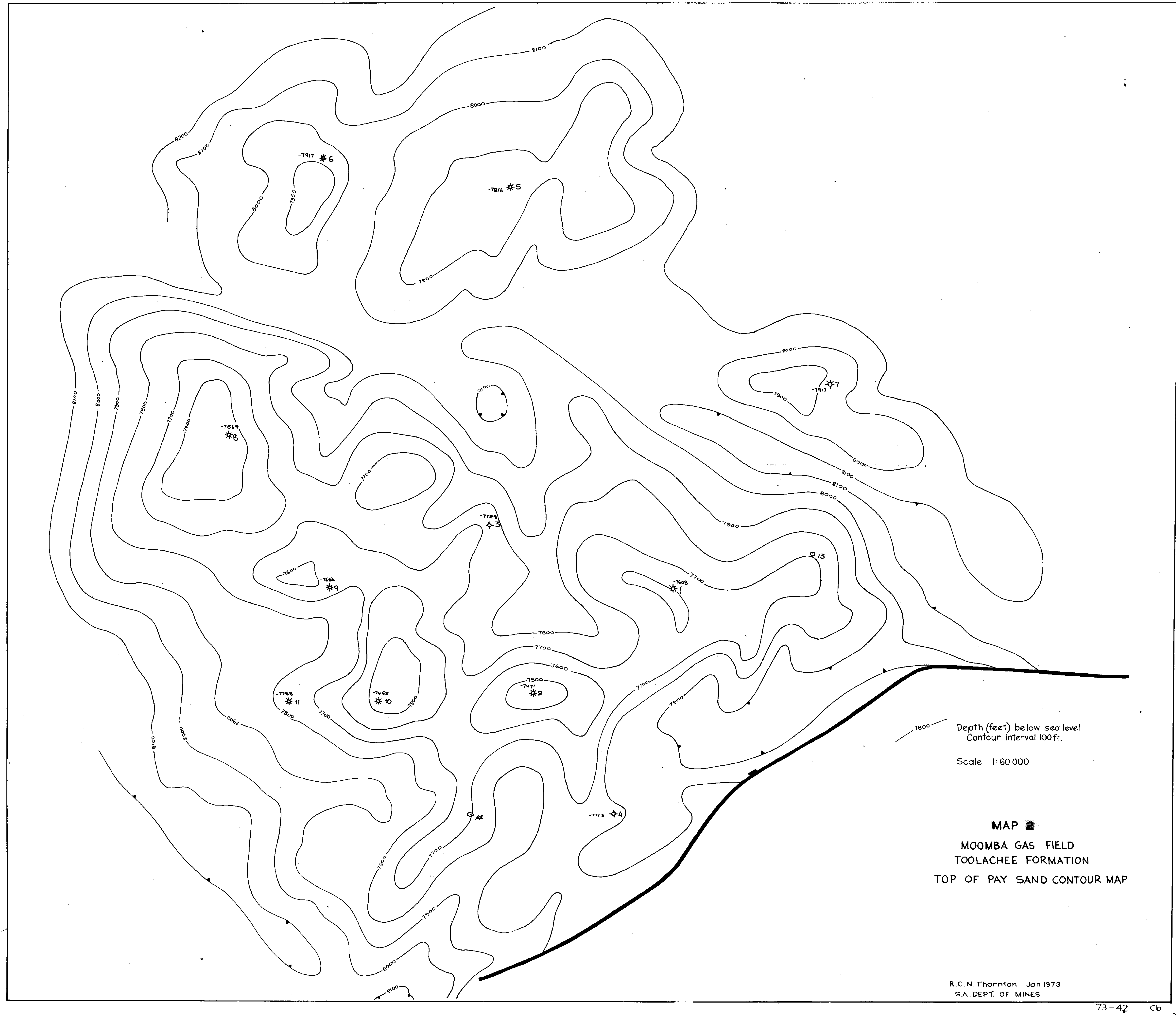


FIG. 4

	DEPARTMENT OF MINES – SOUTH AUSTRALIA	Scale: Diagrammatic
Compiled: R.C.N.T.	GIDGEALPA GAS FIELD	Date: 7 FEB. 1973
Drn. R.T. | Ckd. R.T.	DIAGRAMMATIC CROSS SECTION D-D'	Drg. No. S10140 Cb

1M–2.70 A1810


139°55'
140°00'
140°05'
140°10'
140°15'
140°20'
140°25'
28°00'
28°05'
28°10'
28°15'
8200
8100
8000
7900
7800
7700
7600
7500
7400
7300
TOPWEE 1
BIG LAKE
Depth (feet) below sea level
Contour interval 100 ft.
Scale 1:60 000
After Delhi International Oil Corp., March 1971 & 1972
MAP 1
MOOMBA GAS FIELD
"P" MAP
R.C.N. Thornton Jan 1973
S.A. DEPT OF MINES
73-41



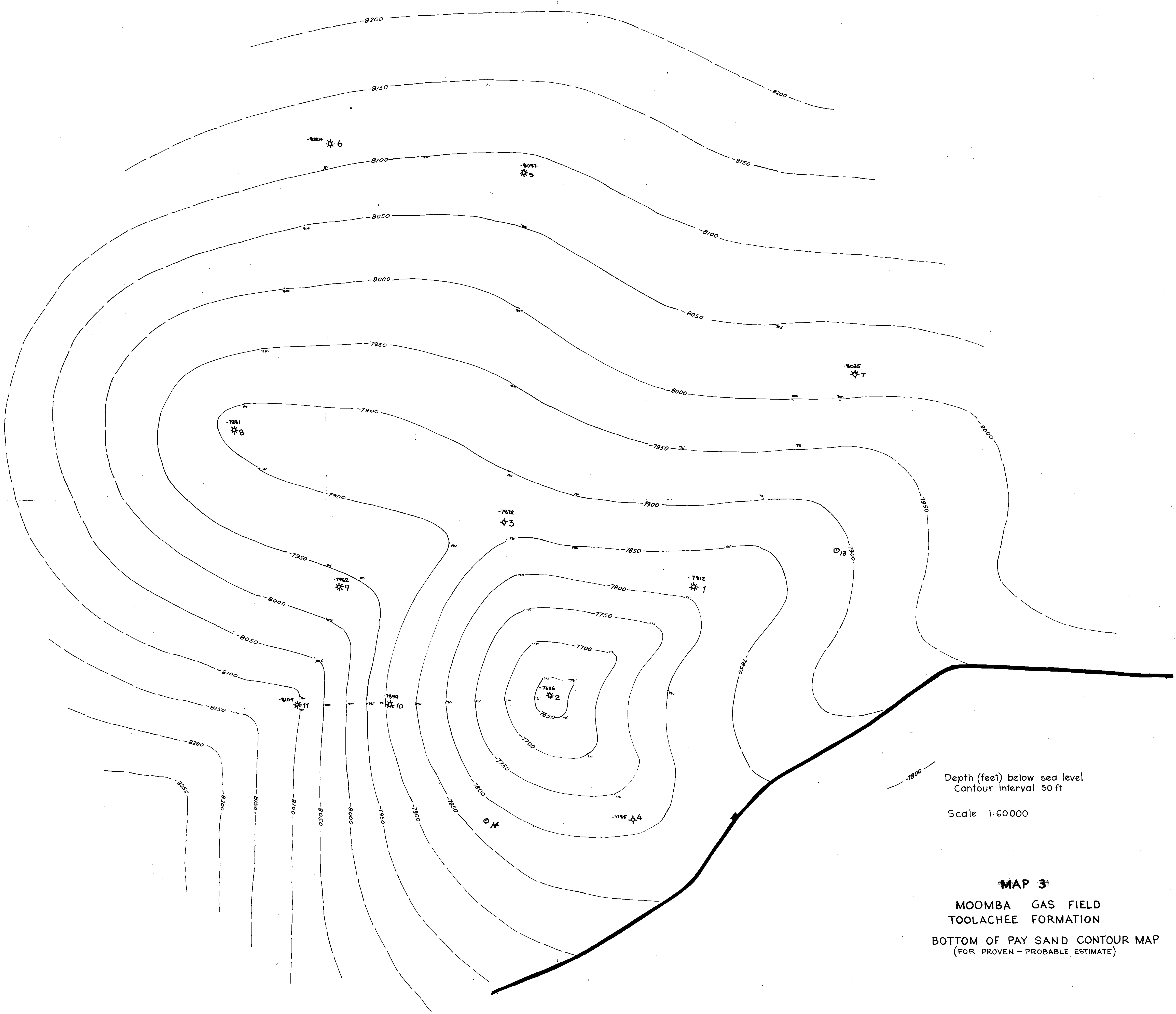
MAP 2

MOOMBA GAS FIELD
TOOLACHEE FORMATION

TOP OF PAY SAND CONTOUR MAP

R.C.N. Thornton Jan 1973
S.A. DEPT. OF MINES

73-42 Cb



Depth (feet) below sea level
Contour interval 50 ft.

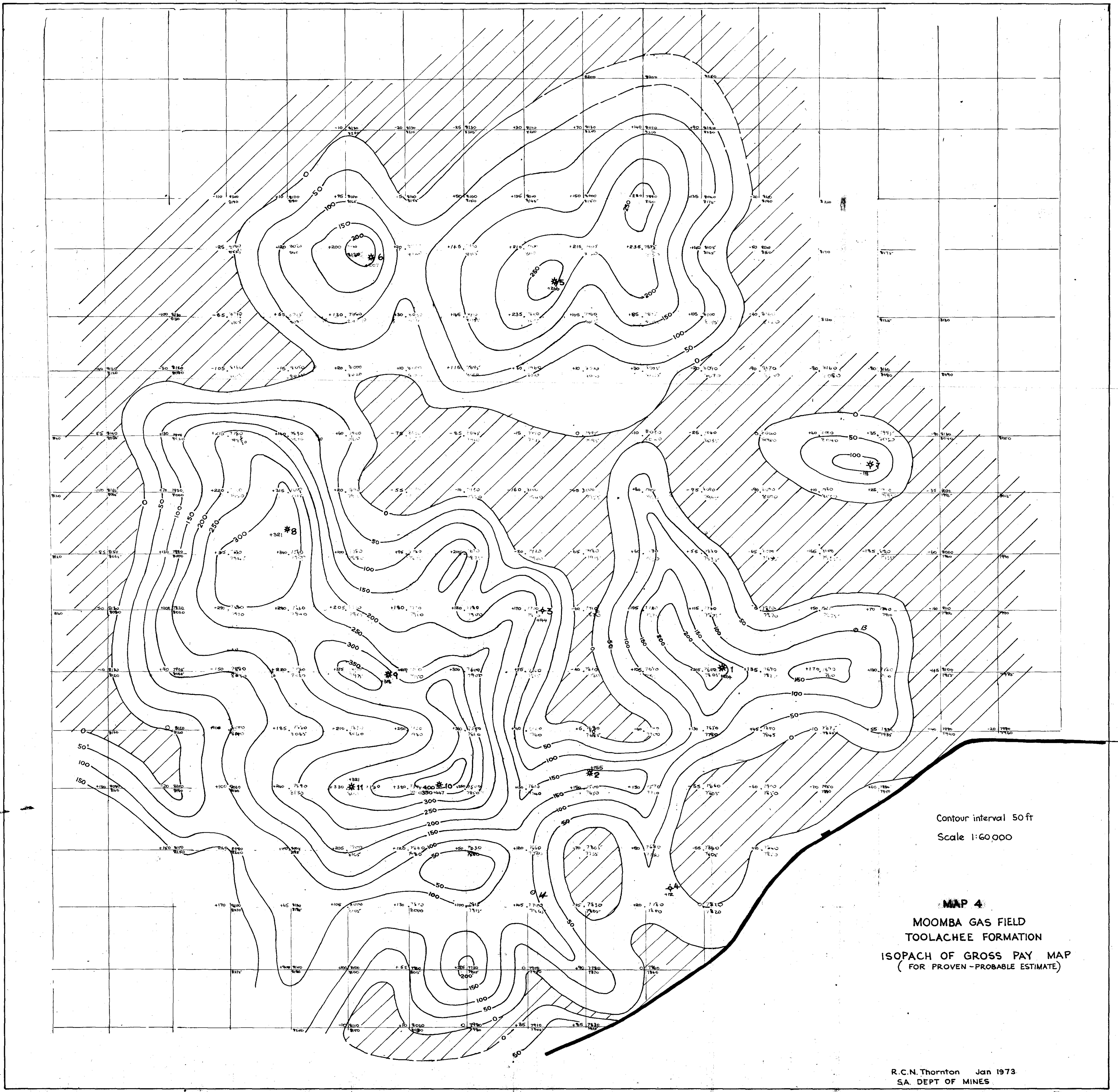
Scale 1:60000

MAP 3

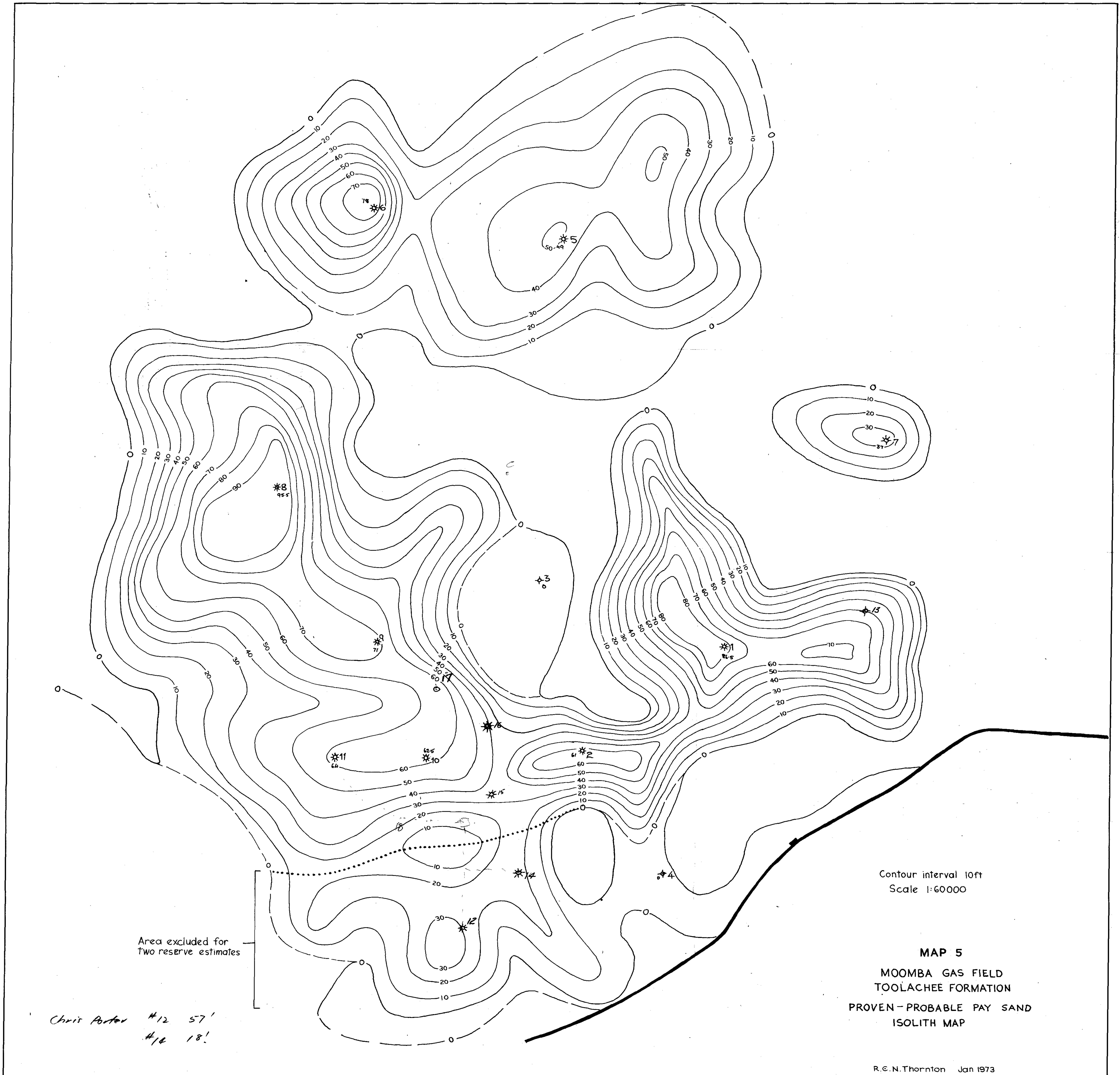
MOOMBA GAS FIELD
TOOLACHEE FORMATION

BOTTOM OF PAY SAND CONTOUR MAP
(FOR PROVEN – PROBABLE ESTIMATE)

R.C.N. Thornton Jan 1973
S.A. DEPT OF MINES



Contour interval 50 ft
Scale 1:60,000
MAP 4
MOOMBA GAS FIELD
TOOLACHEE FORMATION
ISOPACH OF GROSS PAY MAP
(FOR PROVEN - PROBABLE ESTIMATE)
R.C.N. Thornton Jan 1973
S.A. DEPT OF MINES
73-44
Cb



MAP 5

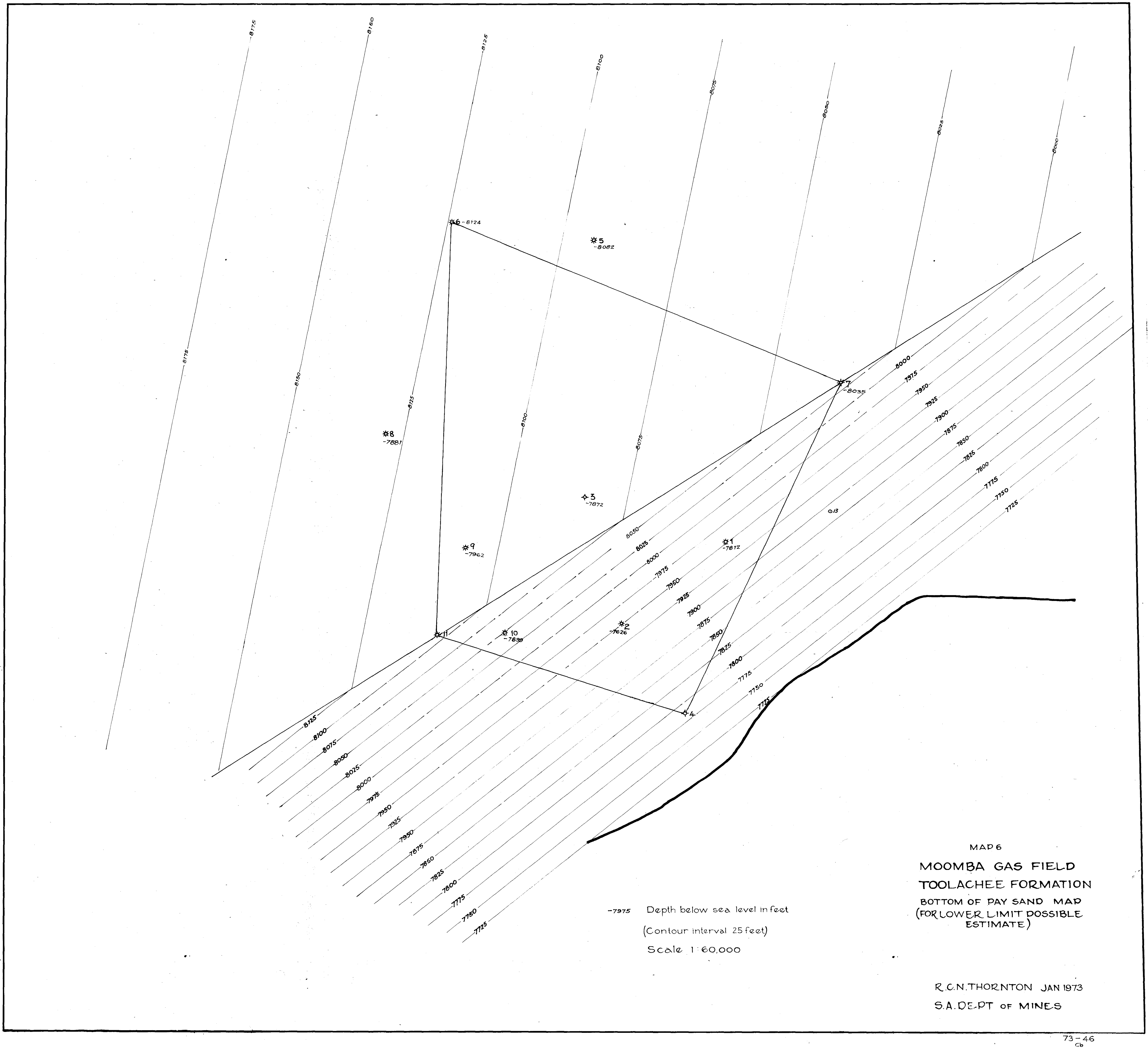
MOOMBA GAS FIELD
TOOLACHEE FORMATION

PROVEN – PROBABLE PAY SAND
ISOLITH MAP

R.C.N. Thornton Jan 1973
S.A. DEPT. OF MINES

Chris Porter #12 57'
#14 18!

73-45
Cb



MAP 6

MOOMBA GAS FIELD
TOOLACHEE FORMATION
BOTTOM OF PAY SAND MAP
(FOR LOWER LIMIT POSSIBLE ESTIMATE)

R.C.N. THORNTON JAN 1973
S.A. DEPT of MINES

73-46

Contour interval 10ft
Scale 1:60 000

MAP 7
MOOMBA GAS FIELD
TOOLACHEE FORMATION
LOWER LIMIT POSSIBLE PAY SAND
ISOLITH MAP

R.C.N. Thornton Jan 1973
S.A. DEPT. OF MINES

73-47
Cb

MAP 8

MOOMBA GAS FIELD

TOOLACHEE FORMATION

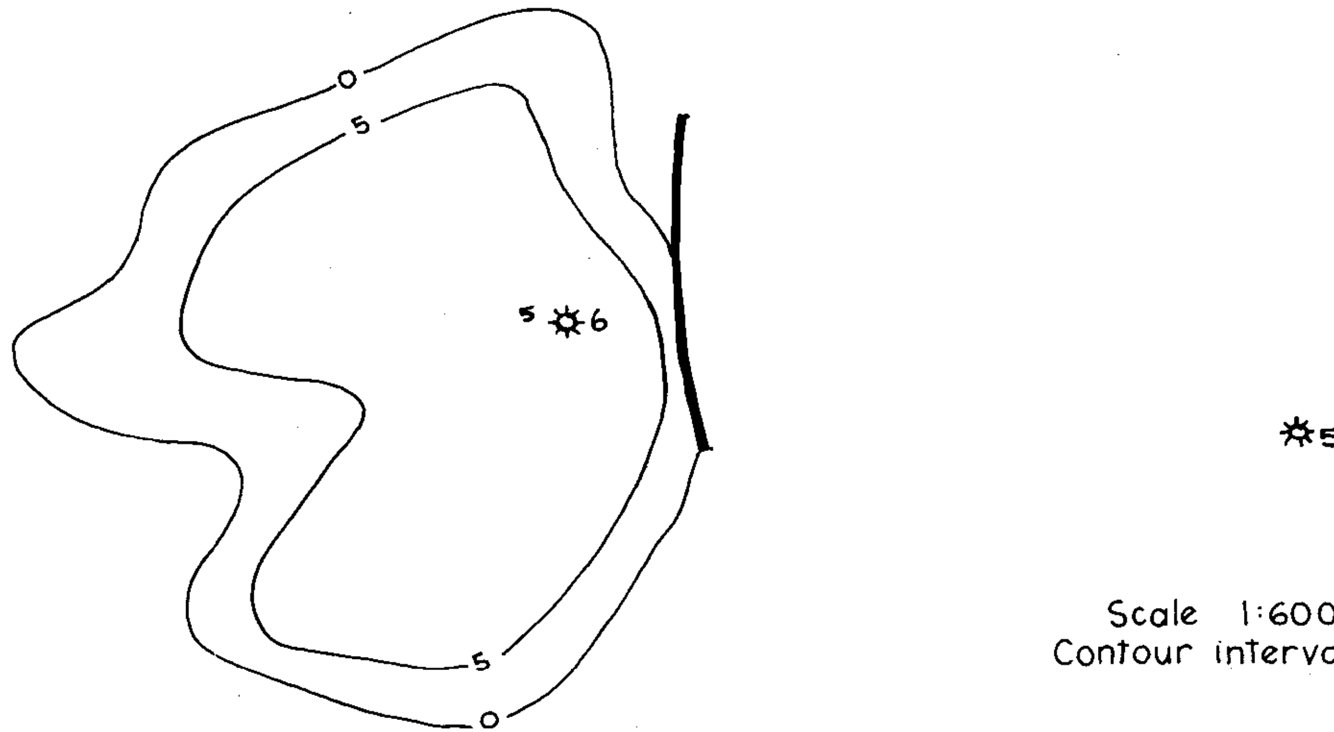
UPPER LIMIT POSSIBLE PAY SAND
ISOLITH MAP

Contour interval 10ft
Scale 1:60,000

R.C.N.THORNTON Jan. 1973

S.A. Dept. of Mines

73-48
Cb

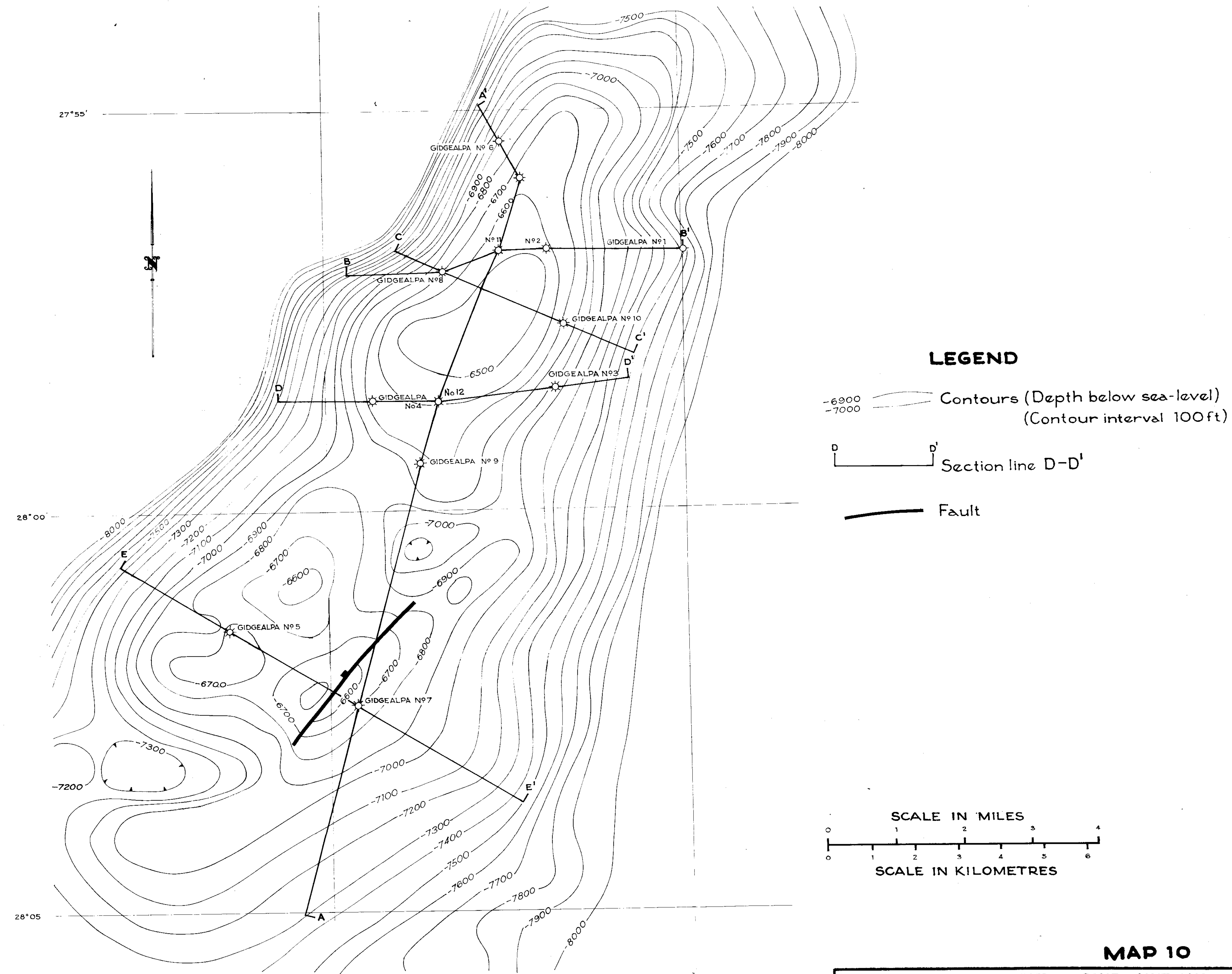


Scale 1:60000
Contour interval 5ft

MAP 9

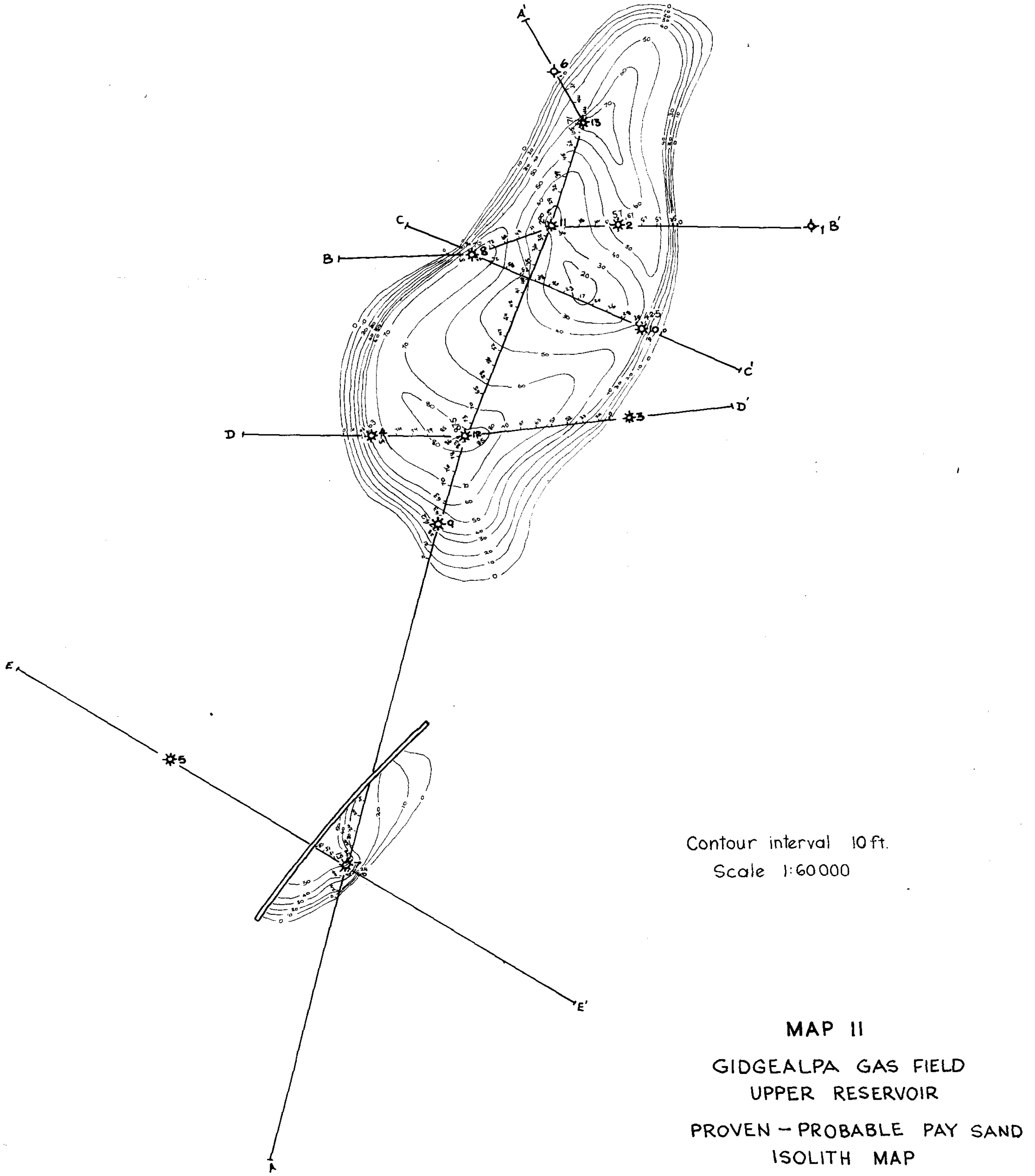
MOOMBA GAS FIELD
PATCHAWARRA FORMATION
PROVEN-PROBABLE PAY SAND ISOLITH MAP

R.C.N. Thornton Jan 1973 S.A. DEPT OF MINES



MAP 10

DEPARTMENT OF MINES — SOUTH AUSTRALIA			
GIDGEALPA GAS FIELD "P" (TOP OF PERMIAN) MAP			
	R.C.N. Thornton GEOLOGIST	Drn. R. T.	SCALE: 1 : 60,000
		Tcd. G. M.	73-49
		Ckd.	Cb
Director of Mines		Exd.	DATE: 3rd Feb. 1973



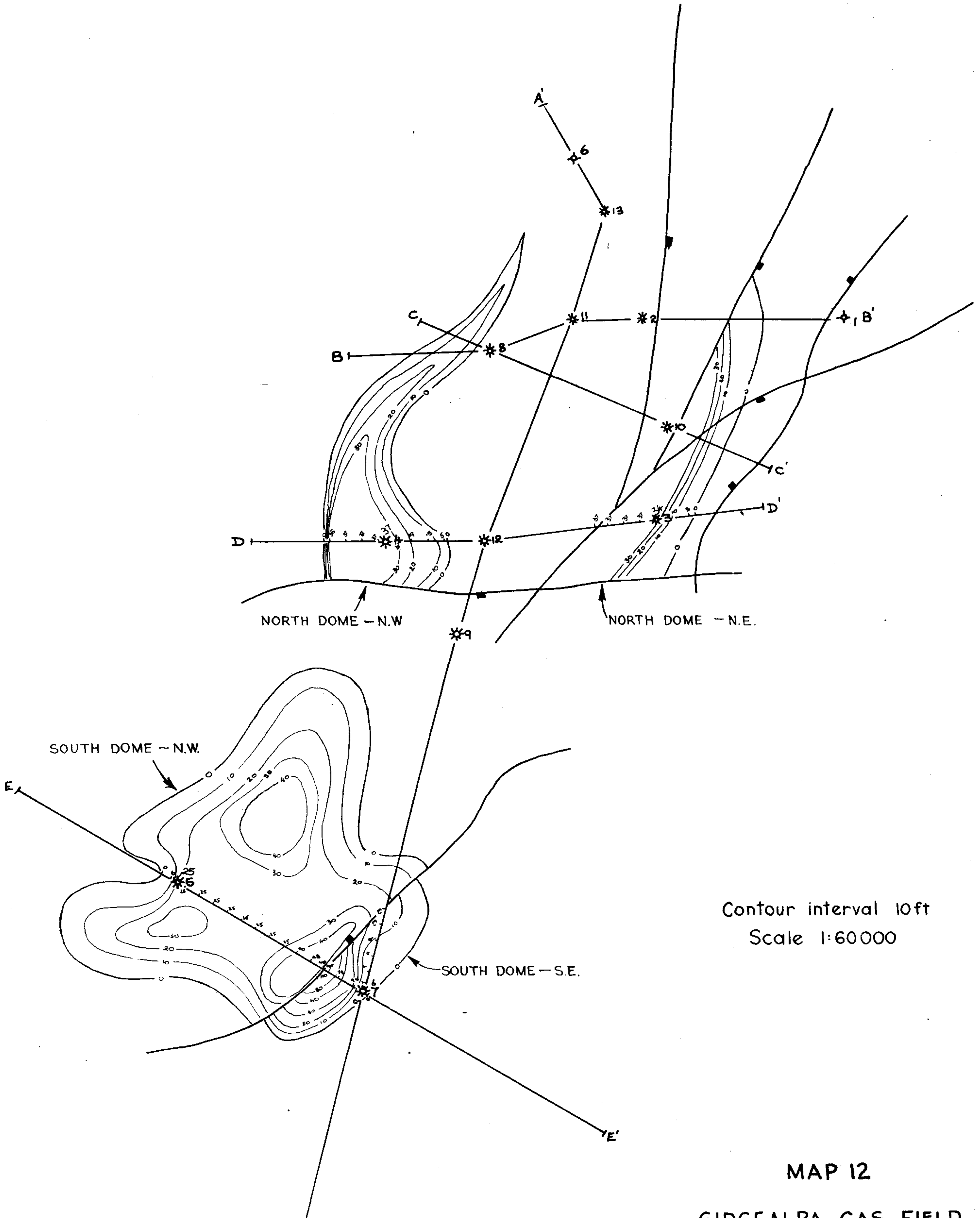
MAP 11

GIDGEALPA GAS FIELD
UPPER RESERVOIR

PROVEN – PROBABLE PAY SAND
ISOLITH MAP

R.C.N. Thornton Jan 1973
S.A. DEPT. OF MINES

73–50
Cb



Contour interval 10ft
Scale 1:60000

MAP 12

GIDGEALPA GAS FIELD
LOWER RESERVOIR

PROVEN - PROBABLE PAY SAND
ISOLITH MAP

R.C.N. Thornton Jan 1973
S.A. DEPT. OF MINES

73 – 51
Cb