DEPARTMENT OF MINES AND ENERGY
GEOLOGICAL SURVEY
SOUTH AUSTRALIA

REPORT BOOK 93/15

SOIL AIR CO_2/O_2 PROJECT
PROGRESS REPORT VI
OLARY AREA

by

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Soil Air CO_2/O_2 Project: Progress Report VI Olary Area

Dr I G WATMUFF and
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INTRODUCTION

Soil air carbon dioxide (CO_2) and oxygen (O_2) measurements as a guide to oxidising sulphide have been assessed by several researchers and government geological surveys in the United States, Ireland, Africa and Saudi Arabia (Lovell et al 1983; Hinkle and Dilbert, 1984; Reid and Rasmussen, 1990; Ball et al, 1990 and McCarthy, Jr and Bigelow, 1990). The rationale is that sulphide oxidation in the presence of water and oxygen will produce sulphuric acid which in turn will attack any carbonates present to produce CO_2. Oxygen is consumed in the process. Both CO_2 and O_2 are easily measured to an acceptable accuracy in the field with portable equipment.

The soil air CO_2/O_2 project is being conducted jointly between Dr I G Watmuff and the South Australian Department of Mines and Energy (SADME). The aim of the project is to test the technique over areas of known mineralisation in a variety of geological and geographical settings. Progress Reports I, II, III, IV and V detailed testing in the Mount Lofty Ranges (Watmuff, 1992), Moonta District (Watmuff and Morris, 1992a) Mt Gunson area (Watmuff and Morris, 1992b), Wirrda Well Prospect, Stuart Shelf (Watmuff and Morris, 1992c) and Curnamona area (Watmuff and Morris, 1992d).

The cooperation of MIM Exploration Pty. Ltd (MIM. in allowing access to mineralised areas is greatly appreciated.

CASE HISTORY

Olary Area

Prospecting in the Olary area is hampered by transported sandy and clayey sediments a few m to over 50 metres thick. Lead - zinc mineralisation has been sought in the area along what are possibly stratigraphic equivalents of the Broken Hill mineralised sequence within Early Proterozoic Willyama Supergroup rocks. Several localities under exploration licence by MIM were tested to see if drill hole and soil air CO_2/O_2 analysis could define zones of known and unknown mineralisation (Figure 1). Drill hole analysis was introduced here because of the possibility that the clayey cover may be preventing a significant gas flux from the base of oxidation to the surface soils. The holes, which are usually loosely backfilled, puncture this cover and may therefore be expected to channel escaping gas to the surface from any oxidising sulphide in the basement.

Cottage Dam Prospect

Weak stratiform zinc sulphide mineralisation has been found in the rocks of the Willyama Supergroup on the Cottage Dam Prospect about 10 km west of Cockburn on the SA/NSW border (Figure 1). The geology as interpreted by MIM consists of a major shear along the axis of an overturned synform. Several ?layered suites are recognised, but the target horizon (suite 16) is a zone of graphitic metasediments locally containing garnet and sulphide.

A transported cover of sand 6-10 m thick over clayey sediments with minor silicrete 30 to 45 m thick rests on weathered bedrock. Oxidation extends to about 70 to 80 m below ground surface.

The terrain is gently undulating and covered with salt and blue bush up to 0.5 m high but generally less than 0.3 m high. At the time of soil air sampling in the early spring, the ground was generally bare or showing only weak new green germination of annual species a few centimetres high. Surface soil depressions up to 1 m or so across, some with open fissures and holes due to the "gilgai phenomenon" are developed over at least half of the soil surface.

Soil air CO_2/O_2 measurements were made in the early spring 1992 along five parallel lines 800 m apart and normal to the strike of suite 16. Sample interval was 20 m and sample depth was 75 cm. The line positions are shown in Figure 1 and detailed below:

Line No.	Northings
19	800-1600N
	3700-4100N
53	140-940N
54	140-940N
55	540-1040N
67	800-1595N

The data are tabulated in Appendix A.

Rotary Air Blast (RAB) drill hole CO_2/O_2 measurements were made in the early summer along some of the above lines and others. The holes had been loosely backfilled immediately after drilling several months prior to the gas sampling. Sample interval was 40 m and the sampling probes could be pushed to a depth of 150 cm down the backfilled holes. The line positions are also shown in Figure 1 and detailed below:

Line No.	Northings or Eastings
53	140-940N
54	20-940N
56	400-720N
58	1560-2200E
59	1400-1840E

The data are tabulated in Appendix B.

About 100 mm of rain fell between the early spring and early summer samplings.

The results are discussed for each line below.

Line 19

No anomalous soil air CO_2/O_2 response was detected along this line between 800N and 1600N. Soil air CO_2 levels were found to be mostly <0.10% (Figure 2). The slight rise between 1350N and 1500N is probably vegetation related but also coincides with the major shear zone. The oxygen deficit (ΔO_2) is also typically <0.1%. Some anomalous Zn rock geochemistry, coincident with a weak IP anomaly, had been detected by RAB drilling between 3700N and 4100N but no anomalous soil air CO_2/O_2 response was detected.

Line 53

Slightly elevated soil air CO_2 values (0.15% and 0.16%) were detected at two adjacent sites on line 53 at 500N and 520N respectively (Figure 3). A single value of 0.15% CO_2 was detected at 800N. Carbon dioxide levels are generally <0.10% and the oxygen deficit is similar, following the pattern of line 19. A weakly mineralised zone was intersected by diamond drilling (DM4) beneath a RAB drill hole that showed a Zn anomaly of 1770 ppm at 500N (Figure 3). The diamond drillhole contained a total sulphide content of 0.5-2% over a 150 m intersection. Pyrite occurs along joint surfaces, pyrrhotite and sphalerite are disseminated or in thin bands.

The later RAB hole air sampling yielded higher CO_2 levels, but the general correlation with the earlier soil air CO_2 levels is maintained (Figure 3). Air inside diamond hole DM4 which was capped, measured 0.36% CO_2 with an oxygen deficit of 0.8%. The highest RAB hole CO_2 value was obtained at 740N and it is interesting to speculate what might have been detected had diamond hole DM3 been drilled with a northerly declination.

Soil air and drill hole CO_2 is slightly elevated between 500N and 800N, corresponding to the approximate position of the major shear zone.

Line 54

The soil air CO_2/O_2 values measured in the early spring were close to atmospheric levels with the exception of one relatively high $CO_2/\Delta O_2$ pair of 0.23%/0.3% at 860N (Figure 4). In-fill sampling about this anomaly showed it to be very localised (Appendix A). Two metres NW of this point, the $CO_2/\Delta O_2$ values were also relatively elevated (0.14%/0.2%). No visible contamination was present and the vegetation did not appear to be unusual.

The early summer soil sampling at the southern end of the line (0-120N) suggests the $CO_2/\Delta O_2$ background has risen, probably in response to the recent heavy rains.

The RAB drill hole measurements generally reflect the earlier soil air trend with the exception of the strong CO_2 peaks at 660N and 900N (Figure 4). The peak at 660N occurs in a hole backfilled only two days before sampling. The hole had been capped with a veneer of drill cuttings hence it is unlikely this high CO_2 value could be related to a faunal or vegetative cause. The high oxygen deficit is a concern however and some form of contamination cannot be ruled out. Twin oxygen deficit peaks at 740N and 820N occur in wet holes with clayey backfill. Water logging is therefore the probable cause of this and CO_2 values are therefore probably higher than if the holes were dry.

The RAB drill hole CO_2 peak at 900N may be related to oxidising sulphide at depth, the oxygen deficit is also encouragingly low (Figure 4). The adjacent RAB hole CO_2 value at 860N, site of the soil anomaly, is also one of the higher values on the line.

The major shear zone lies approximately between 700N and 900N.

Line 55

The early spring soil air $CO_2/\Delta O_2$ values are low and close to atmospheric levels. No apparently anomalous values were detected (Appendix A). No RAB drill holes were measured along this traverse during the early summer follow-up programme.

Lines 56, 58 and 59

Anomalous Pb and Zn geochemistry obtained from the RAB drilling programme was followed up by RAB hole CO_2/O_2 measurement in the early summer. No anomalous sites were detected (Appendix B). No soil air CO_2/O_2 determination had been made along these lines during the earlier spring sampling.

Line 67

As for line 55.

West Mingary Area

West Mingary Dam occurs about 4 km southwest of the intersection of the Adelaide-Broken Hill road and Mingary Creek (Figure 1). The country is slightly undulating and weathered Willyama Supergroup rocks occur in suboutcrop. RAB drilling had detected some weak sulphide mineralization and geochemical anomalies. The holes were shallower than at Cottage Dam and typically reached only 10 to 15 m depth. RAB hole CO_2/O_2 measurements were made in early summer along lines 33 (160E to 320E) and 35 (640N to 880N). Some soil air measurements were made on line 35 at the same time. The results are tabled in Appendix B.

Line 33

High Ba values (1.2-1.4%) had been detected by RAB drilling at 80, 120 and 160E. No clearly anomalous RAB hole CO_2/O_2 values were noted. The RAB hole CO_2/O_2 values correlate more with the physical ground conditions than the geochemistry. The three highest CO_2 values (0.22 - 0.31%) coincide with high oxygen deficits (1.1-2.1%) and in two cases with wet ground (Appendix B).

Line 35

No clearly anomalous CO_2/O_2 values were noted. Less than 1% pyrite had been observed in RAB drill cuttings at 720N. Only background CO_2/O_2 values were detected in the RAB holes. The higher values at 640N appear to relate to a concentration of green vegetation and rain water ponding about this hole. Soil air CO_2/O_2 measurements tended to confirm this (Appendix B). One soil air sample at 640N

could not be extracted below 50 cm due to wet ground conditions.

Tepco Prospect

The Tepco Prospect occurs less than 1 km south of the Adelaide-Broken Hill road and just east of the road to Tepco homestead. Pyritic horizons in Willyama Supergroup rocks with up to 10% pyrite had been intersected by percussion drilling (Figure 5). The base of oxidation varies from 45 to 60 m below surface and the weathered Willyama Supergroup rocks almost suboutcrop. A broad zone of <2% pyrite appears to intersect the base of oxidation (b.o.x.) south of 450N. A narrow band of 2-8% pyrite, 2-4 m wide intersects the b.o.x. at about 400N and 50 m below surface. A wider band of 5-10% pyrite may intersect the b.o.x. north of the water bore between about 480N and 500N, however the structure may be much more complex than assumed.

Soil air CO_2 values measured during the early summer were relatively high over much of the traverse (Figure 5 - note same vertical scale as figures 2-4). The oxygen deficits were also high to very high. Some correlation between the $CO_2/\Delta O_2$ values and the location of sulphide at the b.o.x. is suggested, but it is not entirely consistent. The high oxygen deficits compared to the CO_2 levels probably reflect significant biological activity rendering any interpretation suspect. Sampling after the summer when the ground has dried out may reveal a clearer correlation. The current water table level should also be determined.

Interestingly, the percussion hole with the highest CO_2 gas level (PM20) intersects the band of 2-8% pyrite near the b.o.x. (Figure 5 and Appendix B).

Ballara Prospect

Ballara Prospect lies just north of Roundhill Dam, about 6 km SW of Ballara homestead (Figure 1). Depth of soil over weathered Willyama Supergroup rocks is less than 1 m. The terrain is gently undulating and vegetation consists of sparse salt and blue bush with grasses and other green annuals in the open spaces. Soil air CO_2/O_2 measurements were made at Ballara Prospect in early summer alongside some earlier percussion holes drilled by Seltrust and along a traverse over a TEM geophysical anomaly (see data Appendix B).

Up to 5% total sulphide had been detected in some of the percussion holes when drilled, but no apparently anomalous CO_2/O_2 response was obtained (Appendix B). It is considered unlikely that sampling outside drill hole collars will ever be very useful because of site contamination during drilling and the uncertainty of gas pathways.

Sampling inside capped holes should be more useful but this was not possible at this site.

The traverse along TEM grid line 6550N yielded generally increasing CO_2 values going eastward (Appendix B). The highest values were obtained at 5015E and 5035E, 40 to 60 m east of the TEM anomaly centre at 4975E. The cause of the rising values is uncertain. Vegetation may be the cause, but this is not clear.

South Dam Area

South Dam is located about 10 km SSW of Ballara homestead (Figure 1). The terrain and vegetation are similar to Ballara Prospect. The Willyama Supergroup suboutcrop is covered by a thin veneer of sand about 2 m thick and had been tested by RAB drilling to 10 to 15 m depth over one year ago. A 1650 ppm Zn anomaly was detected in RAB drill cuttings at 3060E on RAB drill line 28 and 710 ppm Pb had been detected at 600E on RAB drill line 29 against a background of about 10 ppm Pb.

No anomalous CO_2/O_2 responses were obtained when the RAB holes were measured in early summer along lines 28 and 29 (Appendix B). The one high value on line 28 at 3140E is attributed to recent rain water ponding at this site and is therefore not considered significant. The CO_2 background is generally higher here than the other prospects in the area, probably reflecting more lush vegetation or recent rainfall variation.

CONCLUSIONS

Known mineralization is relatively weak in the Cottage Dam area and at most sites tested to the south. No very strong CO_2/O_2 responses were found to correlate with known mineralization,

however some of the results at Cottage Dam were encouraging - especially on lines 53 and 54.

The moisture from recent rain (about 50 mm fell as little as two weeks prior to the sampling in early summer) is probably still causing significant biological activity in the soil at sampling depth, particularly about some of the sites south of the Adelaide-Broken Hill highway. Oxygen deficits are commonly high compared to the CO_2 levels indicating biogenic activity, and it is difficult to interpret these results with confidence.

Heavy rain has continued to fall since the early summer sampling and this may eventually stimulate sulphide oxidation at depth. A clearer result may therefore be obtained later when the surface soil has dried out completely.

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APPENDIX A

SOIL AIR CO_2/O_2 DATA, COTTAGE DAM PROSPECT

SEPTEMBER 1992

Soil air CO_2/O_2 data, Cottage Dam prospect, Olary 1:250 000 sheet, S.A.

Traverse line 19 29-9-92

Coordinates	CO_2%	O_2%	Depth (cm)	Comments
Line 19				
800N	0.05	20.85	75	Bare ground
20	0.04	20.9	"	Bare ground. V. sparse salt bush to 0.25m.
40	0.04	20.9	"	Bare ground.
60	0.03	20.9	"	Bare ground.
80	0.06	20.85	"	tr green cover to 8 cm. Sparse salt bush to 0.35 m high.
900	0.05	20.9	"	tr green cover to 10 cm high.
20	0.05	20.9	"	Bare ground.
40	0.05	20.9	"	tr green cover to 6 cm.
60	0.05	20.9	"	Bare ground.
80	0.04	20.9	"	Bare ground.
1000	0.04	20.85	"	Bare ground.
20	0.05	20.85	"	Bare ground.
40	0.03	20.9	"	Bare ground. V. sparse salt bush to 0.25m.
60	0.03	20.9	"	Bare ground.
80	0.05	20.85	"	tr green cover to 2 cm.
1100	0.05	20.8	"	". V. sparse salt bush to 0.2 m.
20	0.06	20.9	"	". V. sparse salt + blue bush to 0.2 m.
40	0.05	20.8	"	Bare ground. Sparse salt bush to 0.25m.
60	0.07	20.8	"	". ".
80	0.05	20.8	"	". " + blue bush to 0.3 m.
1200	0.03	20.8	"	Bare ground.
20	0.04	20.8	"	". Sparse salt bush to 0.3 m.
40	0.05	20.8	"	tr green cover to 3 cm. Sp salt b to 0.25m.
60	0.04	20.8	"	Bare ground.
80	0.06	20.8	"	15% green cover to 6 cm high. Sp salt bush to 0.4 m.
1300	0.07	20.8	72	1% ". Sparse salt bush to 0.4 m.
20	0.03	20.9	75	Bare ground.
40	0.05	20.8	"	". Sparse salt bush to 0.35 m.

Atmospheric oxygen = 20.9%

Soil air CO_2/O_2 data, Cottage Dam prospect, Olary 1:250 000 sheet, S.A.

Traverse line 19 29-9-92

Coordinates	CO_2%	O_2%	Depth (cm)	Comments
Line 19				
1360N	0.11	20.8	75	10% green cover to 6 cm. Sparse salt & blue bush to 0.4 m high.
80	0.11	20.8	"	2% " 8 cm ".
1400	0.10	20.75	"	tr " 6 cm. " to 0.35 m.
20	0.05	20.8	"	1% " 4 cm. " to 0.25 m.
40	0.07	20.8	"	tr " 2 cm. V. sparse salt bush to 0.2 m.
60	0.12	20.75	"	1% " 10 cm. Sparse blue, salt b to 0.4 m.
80	0.10	20.8	"	5% " 3 cm. " 0.5 m.
1500	0.09	20.8	"	40% " 6 cm. " 0.35 m.
20	0.06	20.9	"	Bare ground. V. sparse blue, salt bush to 0.4 m.
40	0.04	20.8	"	Bare ground.
60	0.04	20.9	"	Bare ground.
80	0.10	20.8	"	tr green cover to 10 cm. Sparse blue, salt bush to 0.4 m.
1600N	0.07	20.8	"	tr green cover to 5 cm. Sparse blue, salt bush to 0.5 m.
3700N	0.04	20.8	"	Bare ground.
20	0.04	20.8	"	".
40	0.04	20.8	"	".
60	0.04	20.8	"	".
80	0.05	20.8	"	". Sparse salt bush to 0.25 m.
3800	0.04	20.8	"	".
20	0.05	20.8	"	tr green cover to 3 cm.
40	0.05	20.8	"	Bare ground. V. sparse salt bush to 0.25m.
60	0.04	20.8	"	".
80	0.05	20.8	"	".
3900	0.03	20.8	"	".
20	0.04	20.8	"	tr green cover to 6 cm. V. sparse salt bush to 0.25 m high.
40	0.04	20.8	"	tr green cover.
60	0.05	20.8	"	Bare ground.

Atmospheric oxygen = 20.9%

Soil air CO_2/O_2 data, Cottage Dam prospect, Olary 1:250 000 sheet, S.A.

Traverse lines 19 and 53. 28, 29-9-92

Coordinates	CO_2%	O_2%	Depth (cm)	Comments
Line 19				
3980N	0.04	20.85	75	tr green cover.
4000	0.06	20.8	"	" to 6 cm. Sparse salt bush to 0.3 m.
20	0.05	20.8	"	Bare ground. ".
40	0.04	20.8	"	tr green cover to 1 cm. V. " to 0.2 m.
60	0.06	20.8	"	tr " to 8 cm. Sparse salt b to 0.25 m.
80	0.04	20.9	"	tr " to 8 cm.
4100	0.03	20.8	"	Bare ground.
Line 53				
140N	0.05	20.8	"	Bare ground. Sparse salt b to 0.3 m.
60	0.05	20.8	"	1% green cover to 4 cm.
80	0.08	20.8	"	1% " to 2 cm. Sparse blue bush.
200	0.05	20.8	"	2% " to 8 cm.
20	0.05	20.8	"	Bare ground. Sparse salt bush to 0.3 m.
40	0.06	20.8	"	5% green cover to 8 cm. Sparse salt bush to 0.2 m.
60	0.06	20.8	"	2% ". Sparse salt bush to 0.25 m.
80	0.05	20.9	"	tr " to 8 cm. " to 0.4 m.
300	0.04	20.9	"	Bare ground. Sparse salt bush to 0.3 m.
20	0.05	20.9	"	".
40	0.06	20.9	"	tr green cover to 8 cm.
60	0.06	20.9	"	tr " to 8 cm. Sparse salt bush to 0.3 m.
80	0.05	20.9	"	Bare ground.
400	0.06	20.9	"	tr grass cover to 4 cm high.
20	0.03	20.9	"	Bare ground.
40	0.04	20.9	"	tr grass to 6 cm.
60	0.04	20.9	"	Bare ground.
80	0.08	20.85	"	tr green cover to 4 cm. Sparse salt, blue bush to 0.5 m.
500	0.15	20.8	"	tr " to 8 cm. " to 0.3 m.
20	0.16	20.75	"	5% " to 10 cm. Sparse salt b to 0.3 m.
40	0.08	20.75	"	tr " to 4 cm. " + blue b to 0.3 m.

Atmospheric oxygen = 20.9%

Soil air CO_2/O_2 data, Cottage Dam prospect, Olary 1:250 000 sheet, S.A.

Traverse line 53 28-9-92

Coordinates	CO_2%	O_2%	Depth (cm)	Comments
Line 53				
560N	0.09	20.9	75	2% green cover to 8 cm. Sparse blue, salt bush to 0.3 m.
80	0.07	20.9	"	2% green cover to 6 cm. Sparse blue, salt bush to 0.3 m.
600	0.12	20.8	"	5% " to 8 cm. V. sparse blue, salt b to 0.3 m.
20	0.09	20.9	"	20% " to 6 cm.
40	0.09	20.9	"	tr " to 8 cm. V. sparse salt b to 0.2 m.
60	0.08	20.9	"	2% " to 5 cm. " + blue bush to 0.2 m.
80	0.10	20.9	"	5% " to 6 cm. + " to 0.3 m.
700	0.09	20.85	"	15% " to 6 cm. Sparse salt + blue b to 0.35 m.
20	0.11	20.8	"	Bare ground. Sparse blue and salt b to 0.35 m.
40	0.12	20.8	"	35% green cover to 6 cm.
60	0.08	20.9	"	tr " to 4 cm. V. sparse blue + salt bush to 0.3 m.
80	0.07	20.9	"	Bare ground. V. sparse blue b to 0.3 m.
800	0.15	20.8	"	1% green cover to 4 cm. Sparse blue + salt bush to 0.3 m.
20	0.07	20.9	"	1% " to 6 cm. V. sparse salt b to 0.2 m.
40	0.04	20.9	"	Bare ground.
60	0.06	20.8	"	tr green cover to 6 cm. V. sparse salt bush to 0.3 m.
80	0.03	20.9	"	Bare ground.
900	0.08	20.85	"	5% green cover to 4 cm. Sparse salt b to 0.25 m.
20	0.07	20.8	"	30% " to 4 cm. Sparse salt b to 0.2 m.
940N	0.04	20.8	"	Bare ground.

Atmospheric oxygen = 20.9%

Soil air CO_2/O_2 data, Cottage Dam prospect, Olary 1:250 000 sheet, S.A.

Traverse line 54 28-9-92

Coordinates	CO_2%	O_2%	Depth (cm)	Comments
Line 54				
140N	0.04	20.8	75	2% green cover to 8 cm high.
60	0.05	20.8	"	".
80	0.05	20.9	"	Bare ground.
200	0.04	20.9	"	".
20	0.05	20.9	"	". V. sparse salt bush to 0.3 m.
40	0.04	20.85	"	tr green cover.
60	0.05	20.9	"	Bare ground.
80	0.03	20.9	"	tr green cover to 4 cm high.
300	0.04	20.9	"	Bare ground. Sparse salt bush to 0.3 m.
20	0.03	20.9	"	". Sparse salt bush to 0.3 m high.
40	0.05	20.9	"	". V. sparse salt bush to 0.2 m.
60	0.05	20.9	"	". " to 0.3 m.
80	0.05	20.9	"	".
400	0.05	20.9	"	".
20	0.05	20.9	"	". V. sparse salt bush to 0.2 m.
40	0.05	20.9	"	tr green cover to 8 cm.
60	0.06	20.9	"	Bare ground. V. sparse blue, salt bush to 0.25 m high.
80	0.07	20.9	"	1% green cover. Sparse blue b to 0.4 m.
500	0.04	20.9	"	Bare ground. V. sparse salt b to 0.2 m.
20	0.03	20.9	"	".
40	0.05	20.9	"	tr green cover to 10 cm.
60	0.06	20.9	"	tr " to 4 cm. Sparse salt, blue b to 0.25 m high.
80	0.05	20.9	"	tr green cover. V. sparse salt b to 0.2 m.
600	0.04	20.9	"	tr green cover to 4 cm.
20	0.04	20.9	"	Bare ground.
40	0.06	20.9	"	". Sparse salt bush to 0.35 m.
60	0.06	20.85	"	tr green cover to 6 cm.
80	0.07	20.85	"	15% " to 5 cm. Sparse blue, salt bush to 0.25m.
700	0.05	20.8	"	Bare ground.
20	0.05	20.9	"	". V. sparse blue, salt bush to 0.3 m.

Atmospheric oxygen = 20.9%

Soil air CO_2/O_2 data, Cottage Dam prospect, Olary 1:250 000 sheet, S.A.

Traverse line 54 and 55 28-9-92

Coordinates	CO_2%	O_2%	Depth (cm)	Comments
Line 54,				
740N	0.05	20.9	75	Trace green cover to 8cm high.
60	0.04	20.9	"	Trace green to 4cm high.
80	0.04	20.9	"	Bare ground.
800	0.05	20.9	"	". Sparse salt bush to 0.35m high.
20	0.05	20.8	"	".
40	0.05	20.8	"	Trace grass to 4cm high.
50	0.05	20.9	"	Bare ground. V. sparse salt bush to 0.3m.
60	0.23	20.6	"	". Sparse salt, blue bush to 0.25m.
70	0.05	20.9	"	T4ace green cover to 4cm high.
80	0.05	20.9	"	Bare ground. V. sparse salt, blue bush to 0.2m high.
900	0.04	20.8	"	Bare ground. V. sparse salt, blue bush to 0.15m high.
20	0.04	20.9	"	Bare ground.
40N	0.04	20.9	"	". Sparse salt bush to 0.3m.
2m NW of				
860n	0.14	20.7	"	". v. Sparse salt bush to 0.3m.
15m E of				
860n	0.05	20.9	"	
Line 55				
540N	0.05	20.8	75	Bare ground.
60	0.05	20.8	"	".
80	0.05	20.8	"	".
600	0.06	20.8	"	".
20	0.05	20.85	"	". Sparse salt bush to 0.3m.
40	0.05	20.8	"	".
60	0.06	20.8	"	Trace grass to 10cm. Sparse salt bush to 0.3m high.
80	0.05	20.8	"	Bare ground.
700	0.04	20.8	"	". V. sparse salt bush to 0.25m.
20	0.05	20.8	"	".
40	0.05	20.8	"	Trace grass to 6cm high. Very sparse salt bush to 0.25m high.

Atmospheric oxygen = 20.9%

Soil air CO_2/O_2 data, Cottage Dam prospect, Olary 1:250 000 sheet, S.A.

Traverse line 55 and 67 28-9-92

Coordinates	CO_2%	O_2%	Depth (cm)	Comments
Line 55,				
760N	0.05	20.8	75	Trace green cover to 6cm high. Sparse salt bush to 0.2m high.
80	0.04	20.75	"	Trace green cover to 6cm high.
800	0.04	20.8	"	Trace ".
20	0.04	20.8	"	Bare ground. V. sparse salt bush to 0.25m.
40	0.04	20.8	"	". " to 0.2m high.
60	0.05	20.9	"	". " to 0.2m high.
80	0.04	20.8	"	".
900	0.05	20.8	"	Trace green cover to 2cm high.
20	0.05	20.8	"	Bare ground.
40	0.05	20.8	"	Trace green cover to 3cm. Sparse salt bush to 0.3m.
60	0.05	20.8	"	Trace green cover to 2cm. Sparse salt bush to 0.35m high.
80	0.05	20.9	"	Trace green cover to 10cm. Sparse salt bush to 0.25m high.
1000	0.06	20.8	"	Bare ground.
20	?0.05	20.9	"	Bare ground.
1040N	0.04	20.9	"	Bare ground.
Line 67,				
800N	0.04	20.8	75	Bare ground.
20	0.04	20.8	70	Trace green cover.
40	0.06	20.75	75	Trace green cover to 4cm high.
60	0.05	20.8	"	Trace green cover to 6cm high.
80	0.06	20.8	"	Trace green cover to 8cm. Sparse blue and salt bush to 0.5m.
900	0.05	20.8	"	Trace green cover to 2cm.
20	0.04	20.8	"	Bare ground.
40	0.04	20.9	"	Trace green cover to 6cm high.
60	0.06	20.8	"	".
80	0.05	20.8	"	".
1000	0.05	20.8	"	5% green cover to 6cm high.

Atmospheric oxygen = 20.9%

Soil air CO_2/O_2 data, Cottage Dam prospect, Olary 1:250 000 sheet, S.A.

Traverse line 67 — 26, 28-9-92

Coordinates	CO_2%	O_2%	Depth (cm)	Comments
				28-9-92
1020N	0.05	20.8	75	Trace green cover to 6cm high.
40	0.06	20.8	"	Bare ground.
60	0.05	20.8	"	".
80	0.05	20.85	"	".
1100	0.04	20.9	"	Trace green cover to 4cm high.
20	0.04	20.9	"	Trace green cover to 6cm high.
40	0.05	20.9	"	Bare ground.
60	0.05	20.9	"	Trace green cover to 8cm high. Sparse blue bush to 0.2m high.
				26-9-92
75	0.04	20.9	"	Trace green cover to 6cm high.
95	0.05	20.9	"	Bare ground.
1215	0.05	20.9	"	Trace green cover to 6cm high. Sparse salt bush to 0.3m high.
35	0.05	20.9	"	Trace green cover to 6cm high.
55	0.05	20.9	"	Bare ground.
75	0.05	20.9	"	". Sparse salt bush to 0.25m.
95	0.05	20.85	"	Trace green cover to 6cm high.
1315	0.05	20.9	"	Bare ground. Sparse salt bush to 0.3m.
35	0.06	20.8	"	Trace green cover to 6cm high.
55	0.04	20.9	"	Bare ground.
75	0.05	20.9	"	".
95	0.05	20.9	"	".
1415	0.05	20.9	"	Trace green cover to 6cm high.
35	0.06	20.9	"	Trace green cover to 6cm high. Sparse salt bush to 0.3m.
55	0.06	20.9	"	Trace green cover to 8cm high. Sparse salt bush to 0.3m.
75	0.05	20.9	"	Trace green cover to 8cm high. Sparse salt bush to 0.3m.
95	0.05	20.9	"	Trace green cover to 6cm high.
1515	0.04	20.9	"	Trace green cover to 3cm high.
35	0.06	20.9	"	Bare ground. Sparse salt bush to 0.3m.
55	0.05	20.8	"	Trace green cover to 4cm. Sparse salt bush to 0.2m.
75	0.05	20.9	"	Trace green cover to 3cm high. V sparse salt bush to 0.3m
1595N	0.04	20.8	"	Bare ground.

Atmospheric oxygen = 20.9%

APPENDIX B

DRILL HOLE AND SOIL AIR CO_2/O_2 DATA

OLARY 1:250,000 SHEET

DECEMBER 1992

Drill Hole CO_2/O_2 data, Cottage Dam prospect, Olary 1:250 000 sheet, S.A.

Traverse line 53 7-12-92

Coordinates	CO_2%	O_2%	Depth (cm)	Comments
Line 53,				
140N	0.12	20.7	150	Bare ground. RAB hole (filled).
180	0.12	20.5	"	Bare ground. RAB hole (open -filled 7-12-92, measured 10-12-92).
220	0.10	20.8	"	Bare ground. RAB hole (open, but surface capped).
260	0.10	20.7	"	Bare ground. RAB hole (filled).
300	0.09	20.7	"	". " (").
340	0.12	20.7	"	". " ("). Probe wet.
380	0.09	20.8	"	". " (").
400	0.15	20.5	100	". Diamond hole DM4 (capped). Outside casing.
400	0.36	20.1	150	Bare ground. Diamond hole DM4 (capped). Inside casing.
420	0.04	20.7	"	Bare ground. RAB hole (filled).
460	0.09	20.7	"	". " (").
500	0.19	20.4	"	". " (").
540	0.18	20.7	"	". " (").
580	0.16	20.6	"	". " (open - filled 7-12-92, measured 10-12-92).
620	0.21	20.6	"	Bare ground. Diamond hole DM3 (open). Outside casing.
620	0.03	20.8	"	Bare ground. Diamond Hole DM3 (open). Inside casing.
660	0.13	20.7	"	Bare ground. RAB hole (filled).
700	0.22	20.7	"	". " (open - filled 7-12-92, measured 10-12-92).
740	0.32	20.6	"	Bare ground. RAB hole (filled).
780	0.16	20.8	"	". " (").
820	0.14	20.8	"	". " (").
860	0.09	20.8	"	". " (").
900	0.13	20.8	"	". " (").
940N	0.09	20.7	"	". " (").

Atmospheric oxygen = 20.9%

Drill Hole CO_2/O_2 data, Cottage Dam prospect, Olary 1:250 000 sheet, S.A.

Traverse line 54 8-12-92

Coordinates	CO_2%	O_2%	Depth (cm)	Comments
20N	0.12	20.8	150	Bare ground. RAB hole (filled).
60	0.12	20.8	"	". RAB hole (filled).
100	0.25	20.7	"	". " (").
140	0.11	20.7	"	". " (") filled 8-12-92, measured 10-12-92).
180	0.11	20.7	"	". " (filled).
220	0.09	20.7	"	". " (").
260	0.18	20.6	"	". " (").
300	0.10	20.6	"	". " (open - filled 8-12-92), measured 10-12-92).
340	0.16	20.8	"	". " (filled).
380	0.10	20.6	"	". " (").
420	0.10	20.7	"	". " (").
460	0.20	20.7	"	". " (").
500	0.11	20.7	"	". " (").
540	0.13	20.7	"	". " (").
580	0.10	20.7	"	". " (").
620	0.15	20.6	"	". " (open - filled 8-12-92, measured 10-12-92).
660	0.66	19.6	"	". " (")
700	0.22	20.7	"	". " (filled).
740	0.17	20.1	"	". " (filled). Wet clay - hole collapsed.
780	0.07	20.7	"	". " (open, but surface capped).
820	0.19	19.3	"	". " (filled). Wet clay - hole collapsed.
860	0.25	20.6	"	". " (filled).
900	0.49	20.7	"	". " (").
940	0.11	20.4	"	". " (").

Atmospheric Oxygen = 20.9%

Drill Hole CO_2/O_2 data, Cottage Dam prospect, Olary 1:250 000 sheet, S.A.

Traverse line 56 and 58 8-12-92

Coordinates	CO_2%	O_2%	Depth (cm)	Comments
Line 56,				
400N	0.11	20.7	150	Bare ground. RAB hole (filled).
440	0.11	20.8	"	". RAB hole (filled).
480	0.12	20.8	"	". " (").
520	0.10	20.7	"	". " (").
560	0.10	20.7	"	". " (").
600	0.14	20.7	"	". " (").
640	0.14	20.7	"	". " (").
680	0.13	20.7	"	". " (").
720N	0.09	20.7	"	" " (").
Line 58,				
1560E	0.09	20.8	150	Bare ground. RAB hole (filled).
1600	0.09	20.6	"	". RAB hole (filled).
1640	0.15	20.7	"	". " (").
1680	0.16	20.9	"	". " (").
1720	0.07	20.9	"	". " (").
1760	0.11	20.7	"	". " (").
1800	0.08	20.8	"	". " (").
1840	0.08	20.8	"	". " (").
1880	0.11	20.7	"	". " (").
1920	0.10	20.7	"	". " (").
1960	0.12	20.6	"	". " ("). Clayey fill.
2000	0.13	20.6	"	". " (").
2040	0.10	20.5	"	". " (").
2080	0.10	20.7	"	". " (").
2120	0.12	20.6	"	". " (open - filled 8-12-92, measured 10-12-92).
2160	0.11	20.7	"	". " (filled). ?Oil filter in hole.
2200E	0.13	20.6	"	". " (").

Atmospheric oxygen = 20.9%

Drill Hole and soil air CO_2/O_2 data, Cottage Dam prospect, Olary 1:250,000 sheet, S.A.

Traverses 59 (drill holes) and 54 (soil) 8-12-92

Coordinates	CO_2%	O_2%	Depth (cm)	Comments
Line 59,				Drill holes
1400E	0.05	20.8	150	Bare ground. RAB hole (filled).
1440	0.07	20.8	"	". RAB hole (filled).
1480	0.14	20.6	"	". " (").
1520	0.10	20.6	"	". " (open - filled 8-12-92, measured 10-12-92).
1560	0.08	20.9	"	". " (filled).
1600	0.08	20.9	"	". " (").
1640	0.11	20.6	"	". " (").
1680	0.10	20.2	"	". " (").
1720	0.09	20.5	"	". " (").
1760	0.10	20.5	"	". " (").
1800	0.08	20.7	"	". " (").
1840E	0.05	20.8	"	". " (").
Line 54,				Soils
020N	0.09	20.8	75	1% green cover to 6cm high.
040	0.07	20.8	"	2% green to 4cm high.
060	0.10	20.6	"	Bare ground. Sparse "roly-poly" bushes to 0.3m high.
080	0.06	20.8	"	Trace green cover. Sparse "roly-poly" bushes to 0.3m high.
100	0.17	20.6	"	2% green cover to 15cm high (weak).
120N	0.20	20.6	"	3% green cover to 10cm high.

Atmospheric oxygen = 20.9%

Drill Hole and soil air CO_2/O_2 data, West Mingary Dam area, Mingary EL 1624, Olary 1:250,000 sheet, S.A.

Traverse lines 33 and 35 8-12-92

Coordinates	CO_2%	O_2%	Depth (cm)	Comments
Line 33,				RAB Drill holes+
-160E	0.08	20.8	150	Bare ground.
-120	0.06	20.9	"	Bare ground.
-80	0.26	19.8	120	Road gutter. Mud cracks. Hard to pull gas. Probe wet. Dried barley grass.
-40	0.08	20.6	150	Bare ground.
0	0.12	20.7	"	". Surface veneer of sump oil.
40	0.16	20.3	"	". Surrounded by dried barley grass.
80	0.05	20.7	"	Bare clay pan.
120	0.15	20.6	"	Sparse salt and blue bush to 0.2m high.
160	0.04	20.8	"	Bare clay pan.
200	0.31	18.8	"	Dried barley grass. Sparse Salvation Jane to 0.35m high. Probe wet.
240	0.05	20.8	"	Bare clay pan.
280	0.06	20.8	"	".
320E	0.22	19.2	"	Dried barley grass 10cm high.
Line 35,				RAB Drill Holes+
640N	0.22	20.2	150	Bare ground 1m from drill hole collar. Adjacent gilgai cavities. Relatively denser green vegetation about hole.
680	0.10	20.6	"	Bare ground.
720	0.13	20.6	"	". <1% pyrite in RAB cuttings.
760	0.07	20.8	"	".
800	0.14	20.7	"	".
840	0.08	20.8	"	".
880N	0.06	20.8	"	".
Line 35,				Soil
600N	0.09	20.8	75	2% grass to 3cm high.
620	0.14	20.7	"	5% green cover to 15cm high.
640	0.30	20.6	50-75	15% green to 20cm. No air below 50cm.
640	0.11	20.7	75	5% green to 4cm high.
660	0.11	20.7	"	5% green to 5cm high.
680N	0.10	20.7	70	5% green to 4cm high.

+ all drill holes filled. Atmospheric oxygen = 20.9%

Drill Hole and soil air CO_2/O_2 data, Tepco prospect, Mingary EL 1624, Olary 1:250,000 sheet, S.A.

Traverse line 1, Anomaly MA 13 10-12-92

Coordinates	CO_2%	O_2%	Depth (cm)	Comments
300N	0.26	20.5	75	10% dried grass. 1% green cover to 10cm high.
310	0.22	20.5	"	50% dried grass. 1% green cover to 10cm high. V. sparse blue bush to 0.5m.
320	0.29	20.4	"	80% dried grass. 2% green cover to 4cm. Very sparse blue bush to 0.5m high.
330	0.22	20.5	"	50% dried barley grass. Very sparse blue bush to 0.5m.
340	0.35	20.3	"	75% dried barley grass. Very sparse blue bush to 0.5m.
350	0.21	20.4	"	50% dried barley grass. Very sparse blue bush to 0.5m.
360	0.24	20.5	"	50% dried barley grass. Sparse salt bush to 0.35m.
370	0.28	20.4	"	50% dried barley grass.
380	0.28	20.3	"	70% dried barley grass. Trace green cover to 10cm.
390	0.25	20.3	"	80% dried barley grass.
400	0.23	20.3	"	60% dried barley grass.
410	0,22	20.5	"	60% dried barley grass.
420	0.27	20.4	"	80% dried barley grass.
430	0.29	20.3	"	80% dried barley grass.
440	0.33	20.1	"	50% dried barley grass. Very sparse salt bush to 0.4m.
450	0.20	20.3	"	30% dried barley grass.
460	0.16	20.6	"	60% dried barley grass. Trace green cover to 10cm.
470	0.07	20.6	"	Bare ground.
480	0.15	20.3	"	Bare ground. Sparse salt bush to 0.3m.
490	0.27	20.2	"	70% dried barley grass. Sparse salt bush to 0.4m high.
500	0.11	20.4	"	50% dried barley grass. Sparse salt bush to 0.3m plus blue bush to 0.4m high.
510	0.12	20.5	"	45% dried barley grass.
520	0.12	20.6	"	30% dried barley grass. 10% green cover to 10cm.
530	0.07	20.6	"	Bare ground (½m radius). Half of rest 10% green cover to 10cm.
540	0.50	20.0	"	90% dried barley grass.
550N	0.29	19.6	"	60% dried barley grass.

Atmospheric oxygen = 20.9%

Drill Hole CO_2/O_2 data, Tepco prospect, Mingary EL 1624, Olary 1:250,000 sheet, S.A.

Traverse line 1, Anomaly MA 13 9-12-92

Coordinates	CO_2%	O_2%	Depth (cm)	Comments
Tepco Bore				
Hole, 458N	0.14	20.5	150	Inside hole (capped). Collar set in 2m x 2m concrete slab.
PM 17, 400N	0.06	20.5	"	Inside hole (capped). Open slot in PVC collar allowing gas escape.
	0.19	20.4	110	Outside PVC collar. 50% dried barley grass to 8cm. Sparse blue bush to 0.25m.
PM 20, 365N	0.35	20.3	150	Inside hole (capped).
	0.30	20.5	100	Outside PVC collar. 50% dried barley grass cover to 5cm high.

Atmospheric oxygen = 20.9%.

Soil air CO_2/O_2 data, Ballara prospect, Cutana EL 1772, Olary 1:250,000 sheet, S.A.

Seltrust Percussion holes and TEM grid line 6550N 9-12-92

Coordinates	CO_2%	O_2%	Depth (cm)	Comments
Seltrust percussion drill holes. Samples taken alongside of collars.				
Hole 19	0.09	20.6	150	Bare ground. Hole not capped.
Hole 19	0.08	20.7	"	". ". 1% po at b.o.x.
Hole 21	0.17	20.6	"	". Hole capped. ½% po at b.o.x.
Hole 22	0.14	20.5	"	". ".
Hole ?34	0.13	20.6	110	". ". ≤1% py at b.o.x.
Hole 35	0.07	20.6	90	". ". 5% py at b.o.x.
				TEM grid line 6550N
Line 6550N				
4875E	0.17	20.7	75	15% green cover to 10cm. Sparse salt, blue bush to 0.4m.
4895	0.11	20.9	"	5% green cover to 5cm. Sparse blue bush to 0.35m.
4915	0.20	20.7	"	2% green cover to 5cm. Sparse blue bush to 0.35m plus salt bush to 0.4m.
4935	0.17	20.7	"	1% green cover to 5cm. Sparse blue bush to 0.4m. 20% dried grass to 6cm.
4955	0.20	20.8	"	Trace grass to 4cm. Sparse blue, salt bush to 0.5m.
4975	0.27	20.7	"	3% trace grass to 4cm. Sparse blue, salt bush to 0.4m.
4995	0.26	20.6	70	10% green cover to 10cm. Sparse blue bush to 0.4m.
5015	0.33	20.5	75	Trace green cover to 5cm. Sparse blue bush to 0.4m plus salt bush to 0.35m.
5035	0.38	20.5	"	30% trace green cover to 8cm. Very sparse blue bush to 0.6m.
5055	0.24	20.6	"	Trace green cover to 8cm. Sparse blue, salt bush to 0.75m high.
5075E	0.26	20.6	"	5% trace green cover to 10cm. Sparse blue, salt bush to 0.4m.

Atmospheric oxygen = 20.9%

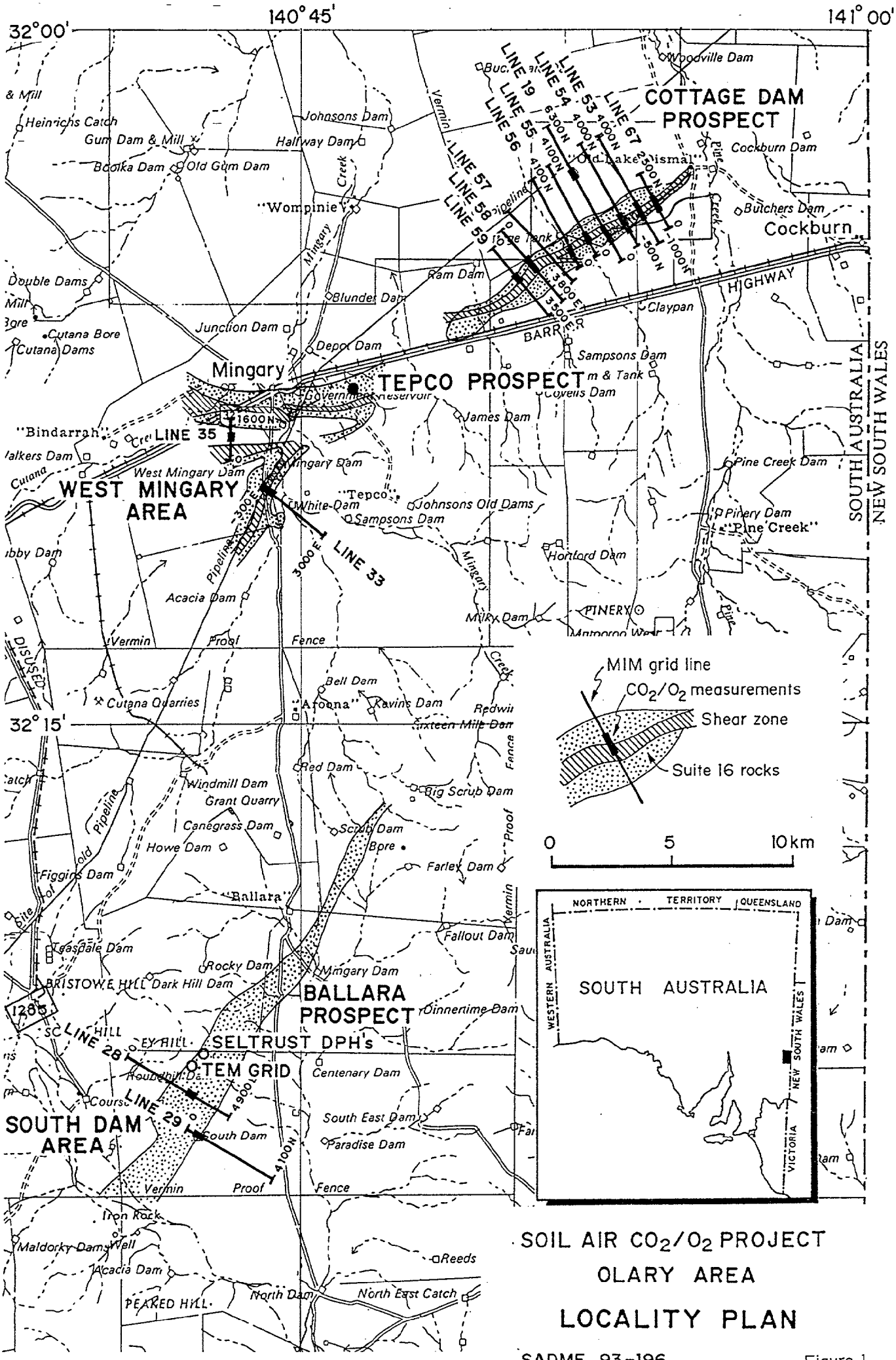
Abbreviations: py = pyrite, po = pyrrhotite, b.o.x. = base of oxidation.

Drill hole CO_2/O_2 data, South dam area, Cutana EL 1772, Olary 1:250,000 sheet, S.A.

Traverse lines 28 and 29 9-12-92

Coordinates	CO_2%	O_2%	Depth (cm)	Comments
Line 28,				
2900E	0.22	20.7	150	15% green cover to 8cm. Sparse salt bush to 0.4m high.
2940	0.18	20.7	"	30% green cover to 8cm. Sparse salt bush to 0.4m high.
2980	0.25	20.6	"	5% green cover to 10cm. Sparse salt bush to 0.4m high.
3020	0.28	20.6	"	5% green cover to 10cm. Sparse salt bush to 0.4m high.
3060	0.32	20.5	"	5% green cover. Sparse salt bush to 0.35m high.
3100	0.29	20.5	"	35% green cover to 10cm.
3140	0.59	20.0	"	20% green cover to 10cm. Sparse salt, blue bush to 0.5m high.
3180	0.28	20.5	130	10% green cover to 5cm. Sparse salt, blue bush to 0.4m high.
3220	0.18	20.6	150	20% green cover to 5cm. Sparse salt, blue bush to 0.5m high.
3260	0.27	20.6	"	10% green cover to 5cm. Sparse salt, blue bush to 0.35m high.
Line 29,				
400E	0.23	20.7	150	15% green cover to 10cm high.
440	0.16	20.8	"	20% green cover to 10cm. V. sparse blue bush to 0.4m high.
480	0.21	20.7	"	15% green cover to 10cm. V. sparse blue bush to 0.3m.
520	0.22	20.7	"	25% green cover to 10cm. V. sparse blue bush to 0.3m.
560	0.20	20.7	"	15% green cover to 10cm. V. sparse blue bush to 0.3m.
600	0.20	20.7	"	15% green cover to 10cm. V. sparse blue bush to 0.3m.
640	0.20	20.7	"	20% green cover to 10cm. V. sparse blue bush to 0.2m.
680	0.16	20.7	"	10% green cover to 10cm. V. sparse blue bush to 0.2m.
720	0.20	20.6	"	5% green cover to 10cm. V. sparse blue bush to 0.3m.
760	0.11	20.8	"	10% green cover to 10cm. V. sparse blue bush to 0.3m.
800E	0.19	20.7	"	15% green cover to 10cm. V. sparse blue + salt bush to 0.3m.

Atmospheric oxygen = 20.9%

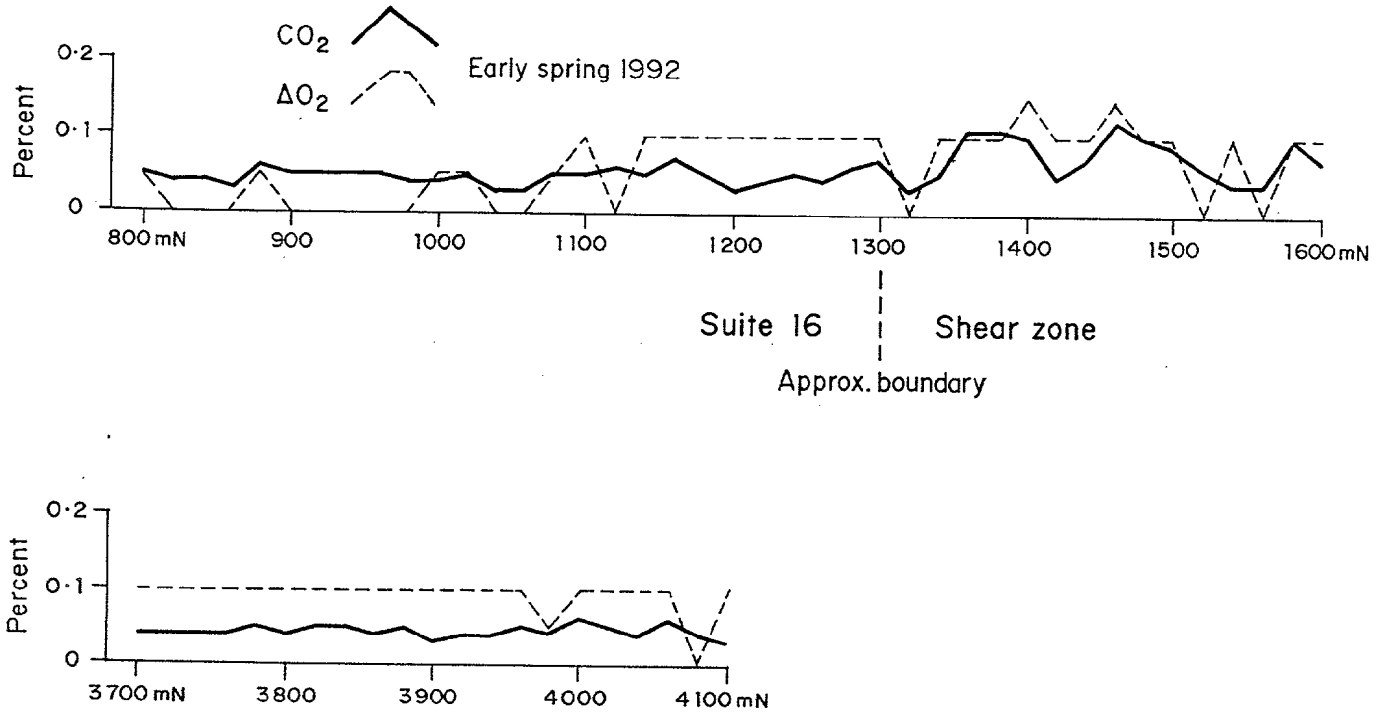


SOIL AIR CO_2/O_2 PROJECT

OLARY AREA

LOCALITY PLAN

SADME 93-196 Figure 1



SOIL AIR CO_2/O_2 PROJECT

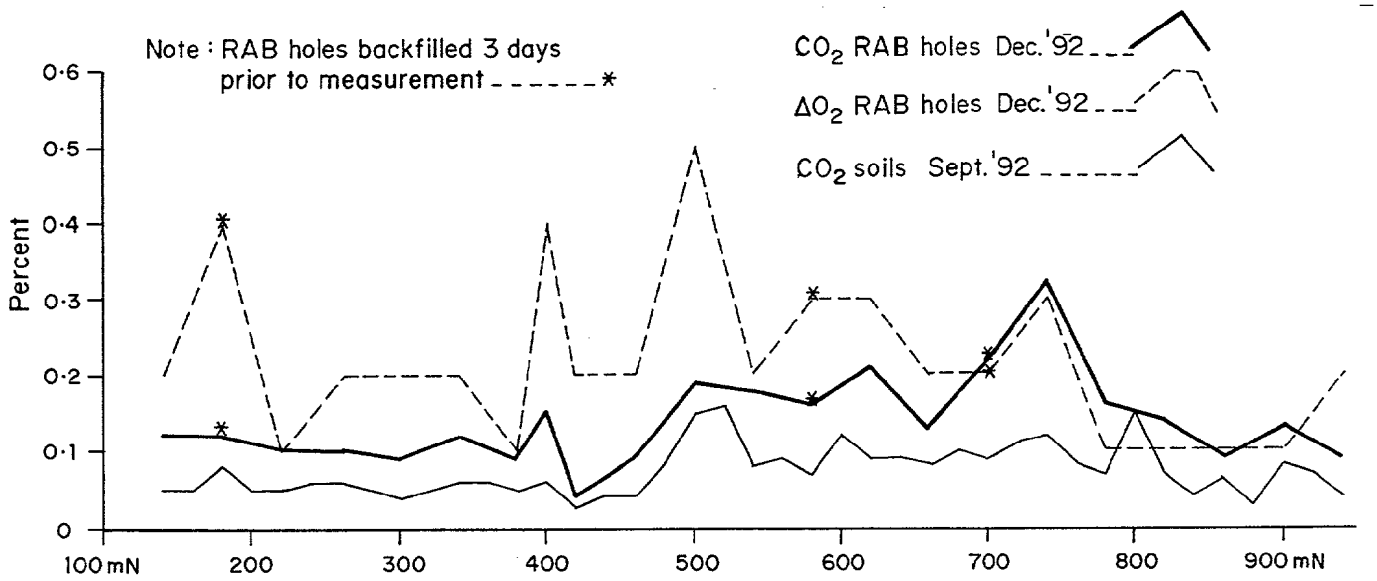
COTTAGE DAM PROSPECT – OLARY AREA

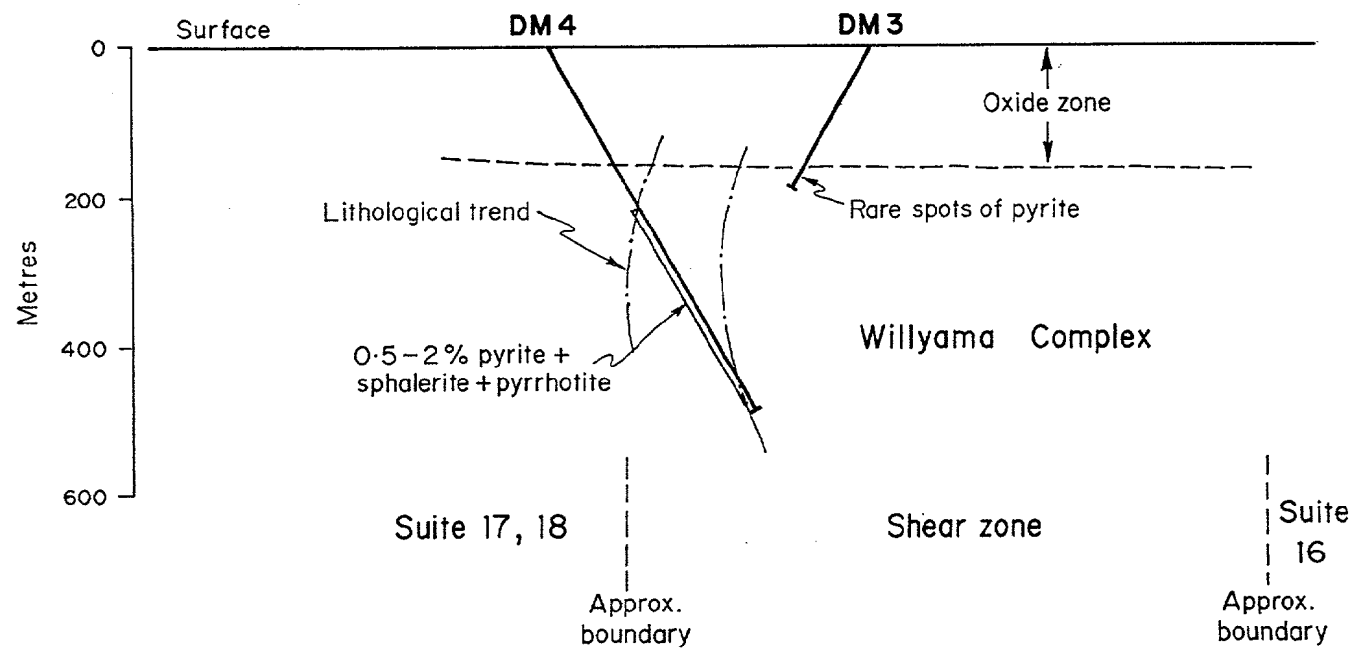
LINE 19

Figure 2

SADME 93-197

5764



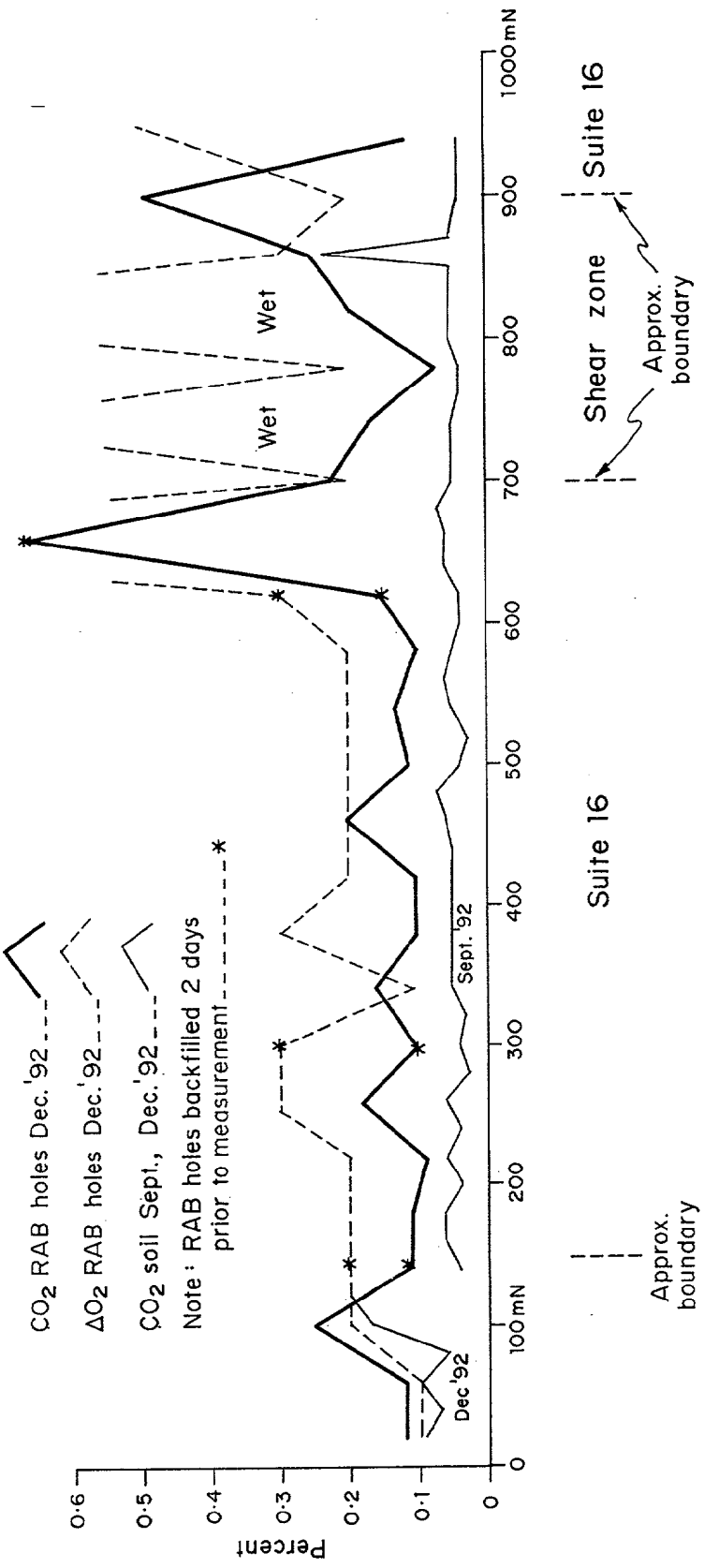


SOIL AIR CO_2/O_2 PROJECT
COTTAGE DAM PROSPECT – OLARY AREA
LINE 53

Figure 3

SADME 93-198

5764



SOIL AIR CO_2/O_2 PROJECT

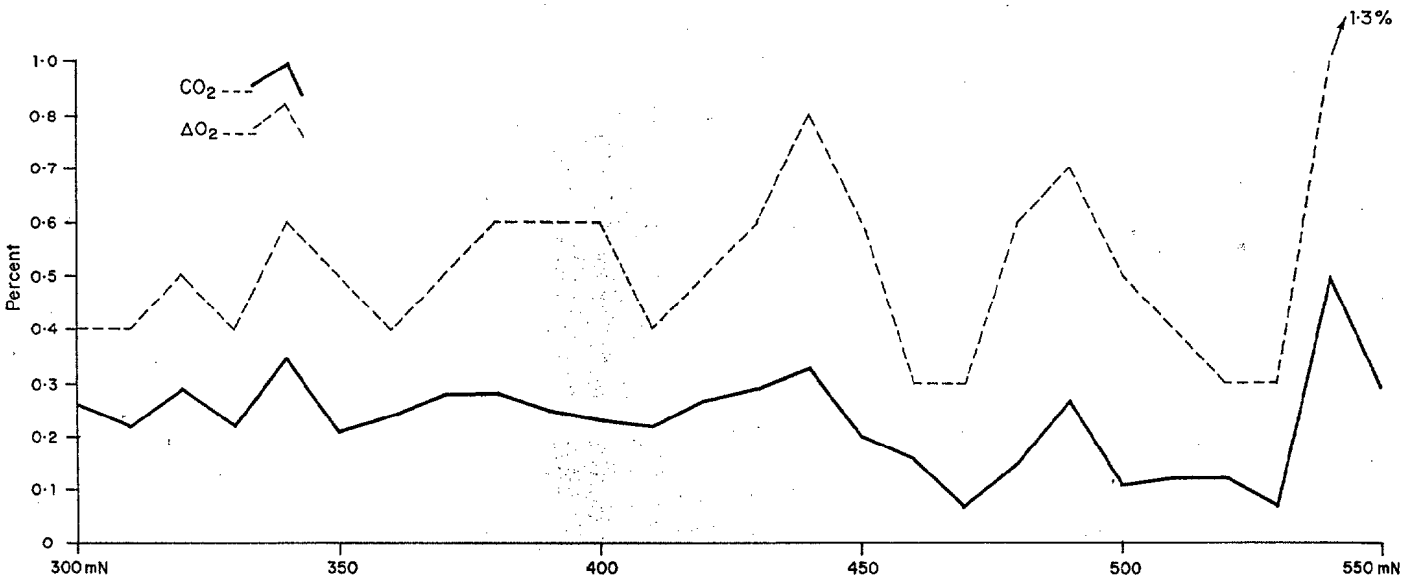
COTTAGE DAM PROSPECT - OLARY AREA

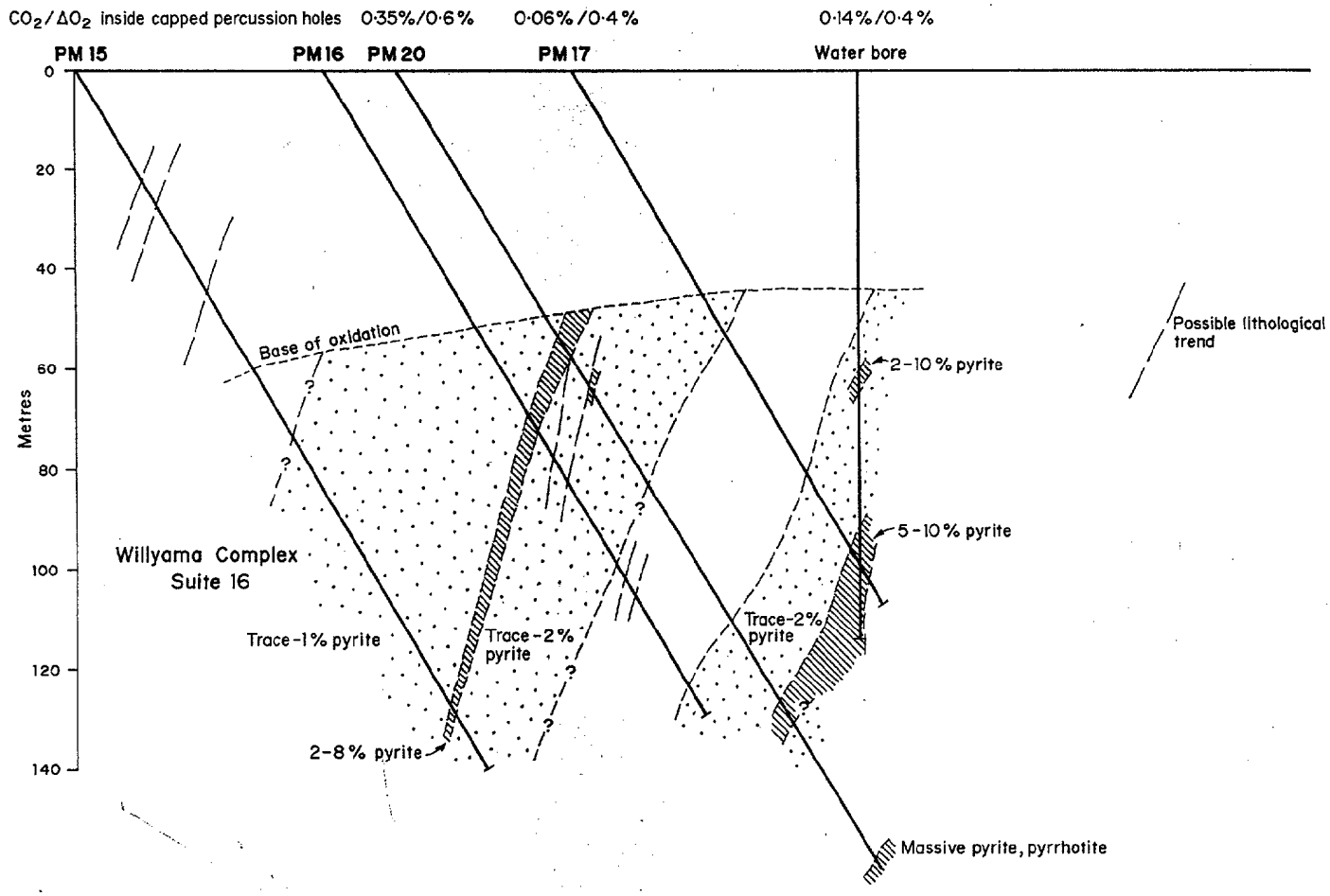
LINE 54

Figure 4

SADME 93-199

5764





SOIL AIR CO_2/O_2 PROJECT

TEPCO PROSPECT - OLARY AREA

LINE 1 ANOMALY MA 13

Figure 5

SADME 93-200