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PEL 32

OTWAY BASIN

1988 SOIL GAS ALKANE SURVEY

FINAL REPORT

Submitted by

Ultramar Australia Inc.
1988

MINES AND ENERGY
SOUTH AUSTRALIA

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Petrofocus

Geochemical exploration surveys for petroleum exploration

SOIL GAS ALKANE SURVEY

PEL 32
OTWAY BASIN
SOUTH AUSTRALIA

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1. SUMMARY

A reconnaissance geochemical survey carried out over the Katnook and associated prospects and leads to the west of Katnook in PEL 32 confirmed the area as having hydrocarbon potential.

The Katnook prospect has a relatively strong geochemical expression, although a sample taken at the Katnook -1 well was low in soil gas alkanes. Samples taken to the south-east of the Katnook prospect highlighted the presence of at least one other zone of interest with comparable concentrations of the alkanes. Several smaller zones of interest were also highlighted in the vicinity of Katnook by this survey.

About 40% of the samples in the present survey were collected away from the Katnook area to investigate several leads and prospects in the west of the survey area. Although this area doesn't appear as prospective as Katnook there is encouragment for further work to be done in the area. Several of the leads outlined by seismic in the western area have samples containing anomalously high concentrations of at least two of the alkanes tested.

2. INTRODUCTION

Ultramar Australia Inc. commissioned Petrofocus to conduct a soil gas geochemical survey over PEL 32. The survey was carried out along seismic lines across paddocks, in conjunction with the Penola seismic survey and adjacent to roads and tracks away from the seismic survey.

The survey area is located over the central portion of the onshore part of the Otway Basin. Hydrocarbons are known to occur in the area as indicated by the recently drilled Katnook - 1 which recovered gas on test.

Two areas were covered in this survey the main area of interest was to the south-west of Penola township and covered the Katnook and associated prospects. It was a moderately detailed survey consisting of a first pass at a sample spacing of 1000m off the defined prospects and 500m over the prospects. The sample spacing was further reduced to between 200 to 250m over areas of interest highlighted by the first pass.

The second part of the survey was carried out to the west of the Penola seismic grid. Once again samples were taken at 1000m spacing off the leads and at 500m over the leads. No infill samples were taken in this area.

Since 1981, Petrofocus, and its predecessor Petrosearch, have carried out soil gas geochemical surveys, both in a broad-spaced reconnaissance mode in wildcat regions, and detailed, intensive sampling surveys over seismic survey leads and prospects. In addition, more than 20 orientation surveys have been carried out over and adjacent to oil and gas fields in the Surat, Eromanga and Amadeus Basins, and these show enhanced concentrations of the light alkane gases to be present in soils above or peripheral to the fields.

3. SURVEY METHODS

3.1 Introduction

Although success has been claimed over the past thirty or more years for various geochemical exploration techniques, enthusiasm for their employment is not widely shared by professionals in the petroleum industry.

Anomalous concentrations of hydrocarbon gases were first reported above petroleum reservoirs in the 1930's (Laubmeyer, 1933; Sokolov, 1933; Horvitz, 1939). These results quickly led to the development of techniques for use in petroleum exploration, and in 1959 Sokolov summarised successful applications of the techniques in the U.S.S.R. as follows:

"Under favourable geological conditions, the proportion of correct predictions (from geochemical surveys) is rather high - about 70 percent. For instance, in the North Caucasus (Kuban), predictions made by gas surveys were confirmed in thirteen cases out of seventeen."

Although successful uses of geochemical techniques have been documented in the western literature results obtained by industry users in the course of normal exploration have commonly produced negative or, at best, equivocal results which have led the techniques to disfavour. In many instances the unsatisfactory results can be attributed to poor sample collection, storage, preparation and analytical procedures. Most importantly, however, results of many surveys have not been interpreted properly. There is, in general, a poor understanding of what can be expected from geochemical methods and, particularly, of their limitations.

Within the past few years there has been, however, renewed interest in geochemical exploration techniques following the successful identification of surface anomalies above petroleum reservoirs by the Geosat Committee's study in which the Multispectral Scanner and the Thematic Mapper, now aboard Landsat 4, were flown over three test sites in the USA. The alteration features, verified on the ground, in soils, rocks and/or vegetation have been shown to result from leakage of light hydrocarbon gases from the moderately deep reservoirs (Rock, 1984; Patton and Manwaring, 1984; Matthews et al., 1984.

3.2 Microseeps

Successful employment of geochemical exploration techniques relies upon the phenomenom of vertical migration of light hydrocarbons that leak in trace amounts from petroleum reservoirs. This has been a hotly disputed issue, but the weight of evidence from reliable sources clearly demonstrates that vertical migration does, in fact, occur. It must now be conceded that light hydrocarbon gases do leak from at least some moderately deep to deep petroleum reservoirs and can be detected as microseeps located vertically above, or peripheral to, the surface projection of the reservoir as :

(i) free gas in the soil or absorbed to soil minerals (Debnam, 1969; Devine and Sears, 1977; Horvitz, 1972, 1979; Jones and Drozd, 1983; Richers et al., 1982; Rock, 1984; Matthews et al., 1984), or

(ii) as a chemical or mineralogical alteration of soil and surface rocks (Karstev, 1959; Donovan, 1974), or

(iii) in vegetation as either morphological or chemical effects (Donovan and Dalziel, 1977; Richers et al., 1982; Rock, 1984).

In addition, case studies conducted by Petrofocus since 1980 unambiguously show anomalous concentrations of light hydrocarbon gases directly above or peripheral to the surface projection of 14 known petroleum reservoirs in the Surat, Cooper, Eromanga and Amadeus Basins.

3.3 Detection of Hydrocarbon Gas Microseeps

There are now in use several indirect techniques which exploit various manifestations of the vertical migration of hydrocarbons or associated gases leaking from deep petroleum reservoirs. These include magnetic, electrical (electromagnetic and induced polarization), radiometric and helium emanometry methods. However, the principal disadvantage in employing these methods is that the effects they respond to can also be produced by causes unrelated to the leekage of hydrocarbon gases.

Clearly, it is advantageous to detect and quantify the hydrocarbon microseeps themselves - this is the approach adopted by Petrofocus in which the light hydrocarbon gases in the soil are detected.

The detection of the light hydrocarbon gases was selected as the most reliable sampling medium since only gaseous hydrocarbons can pass directly through aquifers which are commonly present above petroleum reservoirs in many Australian sedimentary basins. On the other hand, hydrocarbons transported in solution, including dissolved gases, will be entrained in the aquifer or in the surficial groundwater system and may be released at some remote location which can not be related to the parent petroleum reservoir.

In Petrofocus surveys soil gas samples are carefully collected from depths ranging from 0.5 to 1 metres using a probe of proprietary design and pre-prepared microsyringes. The gas samples are carefully packed in airtight containers for shipment to the analytical facility, which is located at the field base camp. Samples are analysed for the light alkanes methane through butane by a gas chromatograph technique. The sensitivity of the chromatograph, as presently employed, is approximately 0.5 ppmV methane, 0.05 ppmV ethane, 0.02 ppmV propane, and 0.005 ppmV butane. The alkane concentrations of samples are determined by comparison with known concentrations in a specially prepared gas standard. Reproducibility of results is typically better than $\pm 5\%$.

3.4 Interpretation of Results

Because of differences in the proportion of oil and gas from reservoir to reservoir, and in the composition of oil and gas phases, together with differences in reservoir parameters and in soil characteristics from region to region, an attempt is made to carry out orientation surveys over known reservoirs as close as possible to the survey area. By comparing results from the survey area with those from the known reservoir an estimate can be made of the type of hydrocarbons giving rise to the microseeps detected in the survey area. Estimates of the size of the hydrocarbon reservoir in the survey area are difficult to establish and can only be attempted in areas having closely similar reservoir and soil characteristics because the magnitude of an anomaly may be determined by the ease of the migration gases from the reservoir, rather than by the volume of gas in the reservoir. There is emerging some confidence that the ratios of the various alkanes present in soil gas can be an indication of the type of parent hydrocarbons in the reservoir (Jones and Drozd, 1983; Richers et al., 1982). The various ratios which may include the "oilyness" of a reservoir are determined for each anomaly detected, but this serves only as a non-definitive indicator, since the parameters which govern the amount and type of hydrocarbon gases present in near-surface environments are only imperfectly understood. They include the following:

(i) *Depth of reservoir* and the nature of the overlying rocks.

(ii) *Reservoir characteristics* relating to the form of the reservoir, the integrity of its seal, the proportion of gas and the pressure under which it is constrained.

(iii) *Soil properties*, particularly the clay content, degree of compaction and moisture content of the soil.

(iv) *Atmospheric variables*, particularly atmospheric pressure, ambient temperature and rainfall.

When an area is re-surveyed it is commonly found that the location and intensity of soil gas anomalies has changed somewhat. The reasons for this are not always simple, but commonly conditions under which the later surveys are conducted are different from those pertaining during the original survey. The greatest effects are experienced after substantial rainfall when soil gas concentrations are greatly reduced due to their being flushed out of the near-surface zone. Anomalous areas defined by the original survey are much subdued after rainfall but generally can still be distinguished over depressed background readings.

However, the interpretation of results of soil gas surveys is more concerned with the anomaly to background contrast rather than with the absolute magnitude of anomalies. Comparison with results obtained over known reservoirs considerably facilitates interpretation of those obtained from survey areas, but when comparisons with known reservoirs in the same region is not undertaken estimates of the commercial significance of soil gas anomalies cannot be reliably given.

4. OPERATIONS

PEL 32 is located in the south eastern part of South Australia adjacent to the border with Victoria and covers a portion of the onshore Otway Basin. Field operations and the analytical facility were established in the township of Penola to the north and east of the two areas of the survey.

The present survey was conducted over a period of eight days between 5th April and 12th April 1988 inclusive, including two days mobilisation/demobilisation. Mobilisation was from Sydney to Melbourne by air and then from Melbourne to Penola by rented four wheel drive vehicle.

Two hundred and eighty-seven samples were taken and analysed during the survey. As can be seen in the accompanying maps, enclosures 1, 2 &3, three main areas of interest were surveyed, an area of new seismic lines south of Penola and two areas to the west of Penola which were over leads and prospects defined from earlier seismic. Sampling in the latter two areas was carried out from uncontaminated sites adjacent to roads, tracks and easements. In the seismic area samples were mainly collected from uncontaminated sites adjacent to 1988 seismic lines in the process of being "shot" across paddocks and fields. Initially, in all of these areas, samples were taken at 1km spacing off leads and prospects as defined by the operator and at 1/2km spacing over them. Thirty-seven samples, in addition to the original programme of 250, were taken in the seismic area at the request of the operator. Most of them were used to infill over zones that had encouraging results from the initial sampling and resulted in the sample spacing being reduced to between 200 to 250m.

Access to most of the traverses and lines was good. In the area of the seismic survey, pegs were set at the vibration points and were used as markers for the samples. Table 1 lists the survey points and the corresponding sample points. Access away from the seismic area was along roads , farm tracks and along easements. no problems were encountered.

Soils in the area range from well developed black loams covering the farm lands to skeletal sandy soils in the forestry areas. The soil profiles were approimately 250 to 750cm deep and in the case of the black loams, organic rich. Care was taken to collect the samples from below any zones which may have produced contamination from organically derived gases. The soils were often damp at depth and in some cases waterlogged such that it was impossible to draw a sample of gas through the probe, in these instances another nearby location was chosen. It should be noted that most of the area covered by the present survey is low lying and was, in fact, swampland until drained in the early part of this century.

During the survey the weather was mostly fine and dry. There were a few showers during the first day of sampling but the remainder of the survey was dry. Mild and overcast to warm and clear conditions predominated for the rest of the survey. Maximum daily temperatures ranged from 19 deg C to 28 deg C. Conditions were occasionally windy with quite strong winds blowing mainly from the south-west. Some rainfall had been recorded in the weeks prior to the survey and this may have had the effect of supressing concentrations of the alkanes tested in the soil gas.

5. RESULTS

The methane, ethane, propane and n-butane concentrations in the soil gas samples collected in the present survey are in the moderately low to low range. Alkane concentrations in the soil gas are listed in Table 1. The range, mean and standard deviation of the sample population are shown at the end of the table.

The locations that the samples were taken from are shown in the accompanying maps. enclosures 1, 2 & 3.

The usual method of determining the areas of interest in a soil gas alkane survey is to establish threshold concentrations for each alkane from the study of cumulative frequency curves and distribution histograms. These are then used to define anomalous populations for each of the components which are then plotted onto a base map. Clusters of anomalous samples on the map usually indicate the presence of accumulations of hydrocarbons at depth. Over fifty percent of the samples in the present survey were taken over what has proved to be a quite petroliferous area resulting in a proportionally larger anomalous population than is usual. Plotting the anomalous samples in the Katnook seismic area in the manner described resulted in the map becoming visually cluttered. Discrete clusters were difficult to define so it was decided that the best way to define areas of interest in the Katnook area was to generate profiles of the concentrations along selected seismic lines and to use these in conjunction with distribution histograms, cumulative frequency curves and contoured maps to arrive at the zones of interest represented on the maps.

The distribution histograms and cumulative frequency curves for methane, ethane, propane and butane can be seen in figures 1 to 4. Profiles of the concentrations of the light alkanes are presented in figures 5 to 18.

Examination of figure 1a, the distribution histogram for the methane concentrations, shows a broad basically normal distribution with a slight skew to the lower concentrations. The cumulative frequency curve for the same values indicates that at least three populations are present. Ignoring the very high and very low values the gradient of the

joining the cumulative frequency points undergoes a slight change at around 4.5 ppm. This has been taken as the lower threshold for the anomalous population of methane and samples containing this concentration or greater are considered anomalous. Using this threshold value gives an anomalous population of approximately 20%, somewhat higher than expected.

Examination of the distribution histogram for the ethane concentrations shows a more or less normal distribution with a very slight skew towards the higher concentrations. There is no indication from this curve to suggest the presence of an anomalous population, however study of the cumulative frequency curve shows that the distribution is fairly complex. The cumulative frequency curve indicates the presence of up to five populations. Ignoring the upper- and lower-most populations the central portion of the curve has breaks in slope at approximately 0.55ppm and approximately 0.3ppm. The latter value has been choosen as the threshold value giving an anomalous population size of, once again, around 20%.

The distribution histogram for propane shows a relatively normal distribution but with a suggestion of an overlapping second generation starting at the 0.15 to 0.2ppm concentration. Examination of the cumulative frequency curve confirms this, it plots as a relatively straight line. However a closer analysis of the plot reveals a number of breaks in the slope. The break at approximately 0.2ppm has been chosen as the threshold, giving an anomalous population size of approximately 25%.

A somewhat truncated distribution is presented by the frequency distribution histogram for butane. There is a skewing of the distribution towards the higher values representing a distinct lack of low values in the whole population. However the histogram does show evidence of an overlapping anomalous population with the break between the two between 0.09 and 0.1ppm. This is confirmed on examination of the cumulative frequency curve for butane. If the highest and lowest data points are ignored a significant break in the slope can be seen at around the 0.1ppm level. This has been taken as the threshold for the anomalous population and results in an anomalous population of nearly 30%. This is significantly higher than the anomalous population sizes of the other components due to the skewing of the whole population distribution to the higher concentrations.

Subsequent plotting of profiles along several of the traverses made during the survey confirmed the results obtained from the statistical analysis. These profiles are presented in figures 5 to 18.

Examination of the profiles in association with the maps (enclosures 1, 2 and 3) shows that anomalous values are present over most of the leads and prospects defined in the survey area. Several of them show a charcteristic "bunny ears" profile, best seen in figures 5, 6, 7, 11 and 13. This phenomenon is well documented in the literature and is believed to be the result of microseepage around the edges of an accumulation, the cap rocks directly over the accumulation having been made more impermeable due to seepage over time. Continued seepage over an accumulation, in some cases, leads to the precipitation of carbonate minerals often at the level of the water table. Calcite cement was seen in rocks immediately above the pay zone in Katnook -1 (pers. com.). If the density of the sampling is high enough over these types of areas to enable contouring of the values then a halo effect is seen where an arcuate or circular zone of anomalous samples partially or completely surrounds the area immediately above the hydrocarbon accumulation at depth. The patterns produced by the contouring of the propane values, as shown in enclosure 1, suggest that a halo is present over the Katnook area.

Another possible explanation, and probably the dominant mechanism in this area, is the preferential seepage or focusing of the seepage of the light alkanes along faults. Several of the leads and prospects covered in the present survey appear, from seismic mapping, to be fault bounded. It is most likely that the patterns of anomalous values seen at the surface in the Katnook area (see enclosure 1) are the result of a combination of both of these mechanisms with the structure and faulting having the greatest effect.

Figures 5, and 7 (profiles along seismic lines 88-081 and 88-071 respectively) show profiles over the Katnook structure. Examination of figure 7 reveals two areas with anomalously high values either side of the structures as defined with elevated concentrations over the top of the structure. Figure 5 shows a similar, but less well defined type of profile, also associated with the Katnook structure.

Figure 6 is a profile along one of the cross seismic lines (88-021) and shows elevated concentrations over the Katnook structure. The samples to the south eastern end of the line, between samples 47 and 89, show a similar magnitude of concentrations to those over the Katnook structure. Examination of figures 8 and 9, profiles over the south eastern anomalous zone seen in figure 6 reveals one peak on each of the profiles although the magnitudes are once again much the same as those over Katnook. It should be noted that the concentrations along these lines are generally elevated and a true background level is not seen on either of them.

Figure 14 is a profile of samples taken along an extension of line 88-071 to the south-west to Kalangadoo -1, a well drilled in the sixties and found to contain only insignificant amounts of hydrocarbon gas and carbon dioxide.

dioxide. The profile shows that although the concentrations are elevated near the well, the Katnook prospect has far more significant concentrations associated with it. (Figure 14 overlaps and extends figure 7).

Figures 17 and 18 complete the set of profiles plotted over the Katnook area. Figure 17 is a profile along the seismic line 88-091 and represents the north-western edge of the Katnook field as defined by seismic. There is an anomalous sample at the south western end of this line (sample 16) that suggests that there may be a further zone of interest to the south. Examination of figure 18 reveals a similar situation to that seen along line 88-091. This profile may represent the eastern edge of the the Katnook structure.

Figure 10 shows a profile of concentrations in samples taken to the west of the Penola seismic area along roads and tracks. Several methane peaks can be seen possibly associated with near surface faults. Two samples (177 & 189) show anomalous concentrations of more than two of the heavier alkanes tested while two of the other methane peaks have associated ethane. Figure 16 (line G - G') shows generally low concentrations for all of the samples along its length. Generally this area of the survey appears to be of lower priority, the only area warranting any further work being around samples 177 and 189.

Figure 11 is an extension of the profile shown in figure 10. There is an overlap of the two profiles as shown between sample points 192 and 195. The anomalous zones in this southern area are rather more encouraging than those in the north. There are two comparitively moderate peaks that contain at least three of the four alkanes tested in anomalous proportions. As seen in the Katnook area the geochemical anomalies seem to be associated with the edges of leads mapped with seismic, suggesting that it may be fault governed and/or effected by the amount of cementation over the actual accumulation. Cross line D - D' (figure 13) also shows elevated concentrations associated with the leads defined as C, D and I, as does line C - C' (figure 12) in the same general area. Both of the areas at the southern end of line B - B' are suggested for further geochemical surveying.

Eleven samples taken along the road which passes Banyula - 1, a dry well, didn't show any significantly high concentrations in the samples nearest the well location. However samples 179 and 178 at the eastern end of this line (see profile F - F', figure 15) do show elevated concentrations of all four alkanes and may warrant further work if the geological and geophysical factors are favourable.

It should be noted that several of the profiles have extremely high methane peaks comprised of only one sample. This type of peak is often associated with faults which extend to the near-surface. Such is the case with samples 26 and 64 on lines 88-081 (figure 5) and 88-031 (figure 9) respectively.

6. CONCLUSIONS

The present survey in PEL 32 has confirmed and enhanced the hydrocarbon prospectivity for the area.

The area around the Katnook - 1 gas well is charaterised by anomalous samples confirming the presence of hydrocarbons at depth, although a sample taken from adjacent to the well site contained only background levels of the gases. Further indications from this part of the survey are that there may be an additional similar accumulation of hydrocarbons to the south east of the Katnook well. Smaller anomalous areas are also highlighted by this part of the survey.

It is not clear from the surface geochemical expression whether the whole area in the vicinity of the Katnook prospect is a single large accumulation characterised by a halo effect modified by the preferential seepage along the many faults in the area or, as is more likely from a study of the seismic maps of the area, several smaller accumulations of hydrocarbons in this generally petroliferous area.

The western part of the survey, conducted off the Penola seismic survey indicates this area is not as significant as the Katnook area. However, there is some geochemical activity at the surface, particularly in the area of leads C, D and I, which warrants further investigation.

7. REFERENCES

Debnam, A.H., 1969. Geochemical prospecting for petroleum and natural gas in Canada. Geol. Surv. Can. Paper 64:15.

Devine, S.B. and Sears, H.W., 1977. Soil hydrocarbon geochemistry, a potential exploration tool in the Cooper Basin, Australia. J. Geochem. Explor. 8, pp. 397-414.

Donovan, T.J., 1974. Petroleum microseepage at Cement, Oklahoma; evidence and mechanism. Bull. Amer. Assoc. Petrol. Geol., 58 pp. 429-446.

Donovan, T.J. and Dalziel, M.C., 1977. Late diagenic indicators of buried oil and gas. U.S. Geol. Surv. Open File Rept. pp. 77-817.

Horvitz, L., 1939. On geochemical prospecting. Geophys. 4, pp. 210-225.

Horvitz, L., 1972. Vegetation and geochemical prospecting for petroleum. Bull. Amer. Assoc. Petrol. Geol. 56. pp. 925-940.

Horvitz, L., 1979. Near surface evidence of hydrocarbon movement from depth. In Problems of Petroleum Migration. Amer. Assoc. Petrol. Stud. Geol., 10, pp. 241-270.

Jones, V.T. and Drozd, R.J., 1983. Predictions of oil or gas potential by near surface geochemistry. Amer. Assoc. Petrol. Geol. Bull. 67 pp.932-952.

Karstev, A.A., Tabasaranski, Z.A., Subbota, M.I. and Mogilevskii, G.A., 1959. Geochemical methods of prospecting and exploration for petroleum and natural gas. UCLA Press.

Laubmeyer, G., 1933. A new geophysical prospecting method, especially for deposits of hydrocarbons. Petroleum, 29, pp. 1-4.

Matthews, M.D., Jones, V.T., and Richers, D.M., 1984. Remote sensing and surface hydrocarbon seepage. Remote Sensing for Exploration Geology Conference, Colorado Springs, April 1984. Environmental Research Institute of Michigan, pp. 1-6.

Patton, K.H. and Manwaring, M., 1984. Evaluation of a Landsat derived tonal anomaly for hydrocarbon microseepage, Southwest Kansas. Remote Sensing for Exploration Geology Conference, Colorado Springs, April 1984. Environmental Research Institute of Michigan, p. 66.

Richers, D.M., Reed, R.J., Horstman, K.C., Michels, G.D., Baker, R.N., Lundel, L., and Marrs, R.W., 1982. Landsat and soil-gas geochemical study of Patrick Draw oil field, Sweetwater County, Wyoming. Amer. Assoc. Petrol. Geol. Bull., 66 pp. 903-922.

Rock, B.N., 1984. Remote detection of geobotanical anomalies associated with hydrocarbon microseepage. Remote Sensing for Exploration Geology Conference, Colorado Springs, April 1984. Environmental Research Institute of Michigan, p.24.

Sokolov, V.A., 1933. New prospecting method for petroleum and gas. Technika. Feb. Bull. NGRI No. 1.

Sokolov,V.A., 1959. Geochemical methods of prospecting for oil and gas deposits. Izd. Akad. Nauk SSR, Moscow.

TABLE 1. Methane, ethane, propane, butane concentrations (ppmv) and derived ratios for soil gas samples

SOIL GAS ALKANE SURVEY PEL 32 ULTRAMAR APR 88

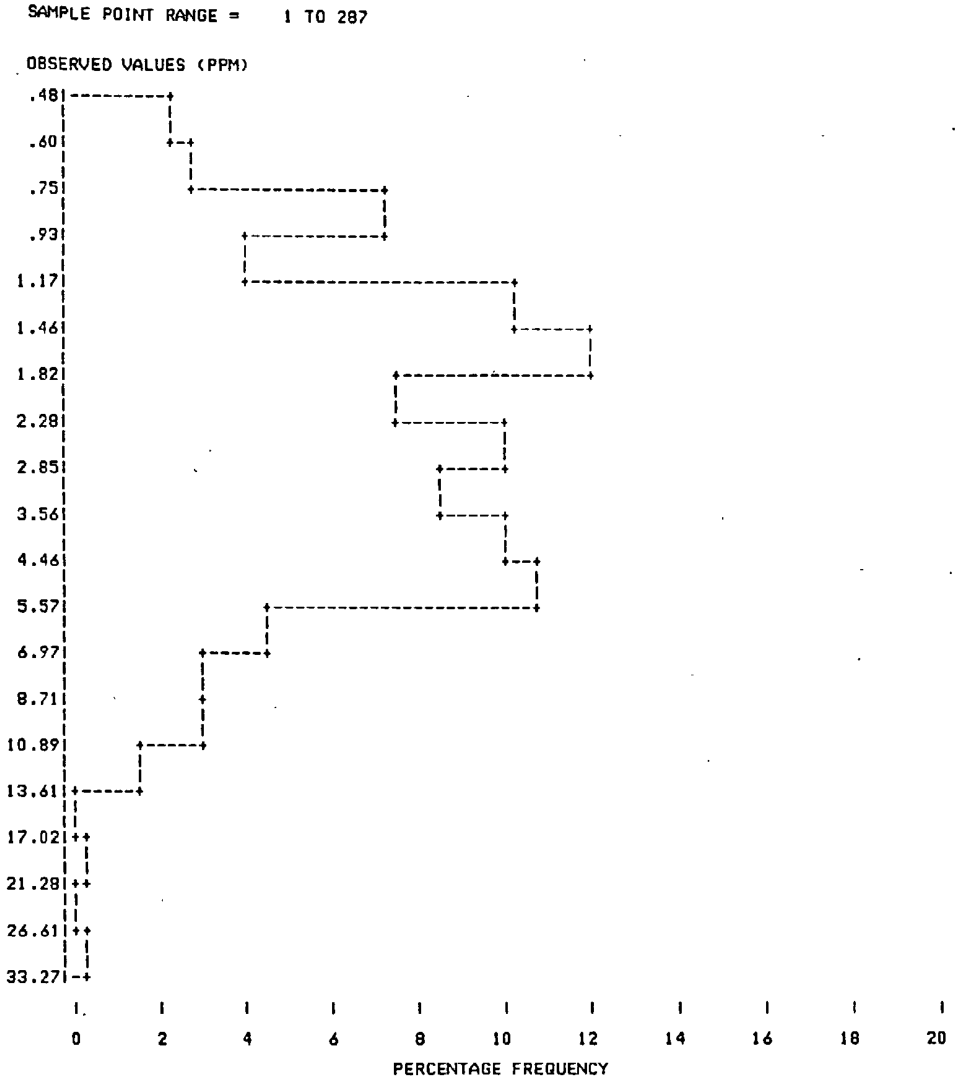
REF NO.	LINE		SAMPLE NUMBER	C1	C2	C3	C4	C1 / C1+C2+C3+C4	C1 / C2	% Wetness C2+C3+C4 / C1+C2+C3+C4
1	88-091	418	1	19.40	.10	.24	.04	.981	194.00	1.92
2		374	2	6.70	.19	.09	.03	.956	35.26	4.42
3		330	3	4.10	.09	.06	.03	.958	45.56	4.21
4	88-022	100	4	2.90	.06	.04	.02	.960	48.33	3.97
5		144	5	4.30	.08	.06	.02	.964	53.75	3.59
6	88-091	286	6	3.20	.10	.06	.03	.944	32.00	5.60
7	88-012	100	7	4.50	.10	.08	.03	.955	45.00	4.46
8		144	8	1.90	.09	.06	.03	.913	21.11	8.65
9		188	9	2.60	.15	.10	.04	.900	17.33	10.03
10		210	10	5.00	.27	.11	.04	.923	18.52	7.75
11	88-091	242	11	7.90	.21	.11	.04	.956	37.62	4.36
12		220	12	4.30	.19	.16	.03	.919	22.63	8.12
13		198	13	2.50	1.01	.45	.09	.617	2.48	38.27
14		176	14	1.60	.13	.08	.03	.870	12.31	13.04
15		132	15	1.70	.11	.08	.06	.872	15.45	12.82
16		100	16	5.40	2.40	.84	.11	.617	2.25	38.29
17	88-081	100	17	1.50	.24	.13	.04	.785	6.25	21.47
18		144	18	5.20	.29	.23	.07	.898	17.93	10.19
19		188	19	5.60	.28	.10	.05	.929	20.00	7.13
20		230	20	5.70	.38	.24	.06	.893	15.00	10.66
21		252	21	4.20	.32	.16	.05	.888	13.12	11.21
22		273	22	12.40	.44	.29	.07	.939	28.18	6.06
23		294	23	3.10	.28	.24	.12	.829	11.07	17.11
24		315	24	4.50	.34	.28	.13	.857	13.24	14.29
25	88-022	180	25	2.30	.33	.29	.11	.759	6.97	24.09
26	88-081	336	26	27.80	.28	.43	.11	.971	99.29	2.87
27		378	27	1.40	.13	.14	.10	.791	10.77	20.90
28		420	28	1.20	.13	.13	.05	.795	9.23	20.53
29		456	29	1.50	.16	.13	.05	.815	9.38	18.48
30	88-061	404	30	1.30	.19	.14	.11	.747	6.84	25.29
31		364	31	1.10	.13	.14	.09	.753	8.46	24.66
32		320	32	3.20	.32	.20	.11	.836	10.00	16.45
33		299	33	1.20	.15	.14	.09	.759	8.00	24.05
34		278	34	1.30	.14	.14	.08	.783	9.29	21.69
35		257	35	.50	.21	.19	.06	.521	2.38	47.92
36		236	36	2.20	.57	.55	.21	.623	3.86	37.68
37		215	37	1.50	.27	.20	.10	.725	5.56	27.54
38		194	38	.50	.19	.16	.07	.543	2.63	45.65
39		173	39	.50	.29	.22	.08	.459	1.72	54.13
40		131	40	3.00	.17	.06	.03	.920	17.65	7.98
41		100	41	4.50	.12	.07	.03	.953	37.50	4.66
42	88-051	100	42	9.20	.31	.30	.07	.931	29.68	6.88
43		142	43	6.30	.56	.36	.07	.864	11.25	13.58
44		180	44	7.80	.18	.17	.03	.954	43.33	4.65
45		200	45	8.00	.40	.22	.05	.923	20.00	7.73
46	88-012	290	46	4.40	.18	.17	.05	.917	24.44	8.33
47		330	47	5.60	.07	.05	.03	.974	80.00	2.61
48	88-051	220	48	7.70	.25	.23	.03	.938	30.80	6.21
49		240	49	4.30	.11	.07	.03	.953	39.09	4.66
50		260	50	2.40	.09	.03	.03	.941	26.67	5.88
51		280	51	1.70	.08	.07	.03	.904	21.25	9.57
52	88-022	260	52	3.80	.10	.08	.04	.945	38.00	5.47
53		300	53	5.50	.10	.09	.03	.962	55.00	3.85
54	88-051	300	54	4.50	.22	.21	.10	.895	20.45	10.54
55		320	55	7.20	.47	.41	.11	.879	15.32	12.09
56		360	56	4.30	.11	.09	.05	.945	39.09	5.49
57	88-041	200	57	5.20	.30	.26	.10	.887	17.33	11.26
58		180	58	10.20	.85	.63	.16	.861	12.00	13.85
59		160	59	3.30	.16	.20	.10	.878	20.62	12.23
60		140	60	6.10	.24	.24	.11	.912	25.42	8.82
61		100	61	4.30	.30	.18	.12	.878	14.33	12.24
62	88-031	100	62	5.60	.46	.34	.15	.855	12.17	14.50
63		140	63	5.30	.78	.33	.08	.817	6.79	18.34
64		160	64	10.90	.18	.14	.05	.967	60.56	3.28
65	88-012	386	65	10.80	.54	.29	.08	.922	20.00	7.77

66	88-031	180	66	8.40	.53	.26	.06	.908	15.85	9.19
67		200	67	6.30	.59	.30	.13	.861	10.68	13.93
68		220	68	4.30	.23	.09	.06	.919	18.70	8.12
69		240	69	5.10	.33	.16	.10	.896	15.45	10.37
70	88-022	348	70	2.80	.28	.14	.07	.851	10.00	14.89
71		328	71	1.50	.12	.12	.05	.838	12.50	16.20
72	88-031	260	72	4.20	.24	.19	.11	.886	17.50	11.39
73		280	73	5.40	.19	.15	.12	.922	28.42	7.85
74		310	74	5.20	.33	.18	.11	.893	15.76	10.65
75	88-041	314	75	5.40	.25	.19	.09	.911	21.60	8.94
76		270	76	4.70	.34	.27	.13	.864	13.82	13.60
77		240	77	3.30	.17	.19	.11	.875	19.41	12.47
78		220	78	5.10	.28	.22	.13	.890	18.21	10.99
79	88-141	428	79	7.10	.28	.37	.16	.898	25.36	10.24
80		380	80	1.60	.15	.14	.06	.821	10.67	17.95
81	88-021	362	81	9.30	.43	.35	.10	.914	21.63	8.64
82		340	82	2.50	.15	.14	.05	.880	16.67	11.97
83		320	83	3.50	.19	.16	.06	.895	18.42	10.49
84		300	84	1.10	.10	.09	.03	.833	11.00	16.67
85		280	85	2.10	.18	.20	.07	.824	11.67	17.65
86		260	86	3.50	.22	.20	.10	.871	15.91	12.94
87		240	87	1.90	.19	.20	.10	.795	10.00	20.50
88		220	88	2.10	.17	.16	.05	.847	12.35	15.32
89	88-012	406	89	2.80	.14	.15	.06	.889	20.00	11.11
90		426	90	2.00	.20	.18	.07	.816	10.00	18.37
91	88-021	200	91	1.80	.26	.20	.09	.766	6.92	23.40
92		175	92	1.10	.15	.13	.07	.759	7.33	24.14
93		150	93	.90	.14	.15	.06	.720	6.43	28.00
94	88-011	318	94	12.70	.31	.30	.08	.948	40.97	5.15
95		280	95	2.60	.17	.12	.05	.884	15.29	11.56
96		260	96	1.90	.19	.08	.03	.864	10.00	13.64
97		240	97	9.20	.70	.59	.12	.867	13.14	13.29
98		220	98	2.30	.17	.07	.04	.891	13.53	10.85
99		180	99	1.20	.05	.04	.03	.909	24.00	9.09
100		140	100	2.30	.11	.08	.04	.909	20.91	9.09
101		120	101	1.90	.18	.09	.05	.856	10.56	14.41
102		100	102	1.00	.15	.08	.04	.787	6.67	21.26
103	88-141	100	103	2.70	.13	.08	.05	.912	20.77	8.78
104		142	104	1.90	.14	.10	.04	.872	13.57	12.84
105		180	105	1.80	.19	.11	.05	.837	9.47	16.28
106		220	106	3.80	.29	.12	.13	.876	13.10	12.44
107		240	107	4.30	.34	.20	.16	.860	12.65	14.00
108		260	108	4.00	.44	.15	.16	.842	9.09	15.79
109		280	109	1.40	.14	.13	.05	.814	10.00	18.60
110		300	110	1.20	.10	.09	.04	.839	12.00	16.08
111		340	111	.80	.11	.09	.04	.769	7.27	23.08
112	88-071	440	112	2.60	.16	.12	.15	.858	16.25	14.19
113		400	113	11.50	.92	.71	.25	.859	12.50	14.05
114		360	114	2.80	.14	.10	.13	.883	20.00	11.67
115		340	115	3.60	.14	.11	.10	.911	25.71	8.86
116		320	116	1.80	.20	.12	.10	.811	9.00	18.92
117	88-022	210	117	4.20	.33	.13	.06	.890	12.73	11.02
118	88-071	300	118	1.60	.21	.13	.09	.788	7.62	21.18
119		280	119	4.20	.42	.28	.12	.837	10.00	16.33
120	KATNOOK-1		120	1.90	.11	.11	.10	.856	17.27	14.41
121	88-071	260	121	3.70	.55	.33	.14	.784	6.73	21.61
122		240	122	1.40	.27	.15	.09	.733	5.19	26.70
123	88-012	240	123	7.20	.67	.42	.16	.852	10.75	14.79
124	88-071	220	124	4.20	.28	.16	.11	.884	15.00	11.58
125		200	125	5.50	.47	.22	.11	.873	11.70	12.70
126		180	126	7.30	.45	.28	.12	.896	16.22	10.43
127		160	127	6.80	.41	.33	.12	.888	16.59	11.23
128		120	128	3.20	.09	.17	.13	.891	35.56	10.86
129	EXT 071		129	2.90	.15	.18	.12	.866	19.33	13.43
130			130	.70	.15	.17	.08	.636	4.67	36.36
131			131	2.90	.21	.26	.13	.829	13.81	17.14
132			132	3.00	.26	.22	.12	.833	11.54	16.67
133			133	1.40	.17	.17	.08	.769	8.24	23.08
134			134	1.50	.16	.17	.09	.781	9.38	21.87
135			135	1.50	.18	.23	.11	.743	8.33	25.74
136			136	1.80	.21	.22	.10	.773	8.57	22.75
137			137	1.60	.14	.19	.07	.800	11.43	20.00
138			138	1.90	.21	.20	.08	.795	9.05	20.50
139			139	1.50	.23	.17	.08	.758	6.52	24.24
140			140	1.60	.22	.17	.07	.777	7.27	22.33

141		141	4.00	.43	.35	.19	.805	9.30	19.52
142		142	1.00	.15	.17	.15	.680	6.67	31.97
143	LEAD B	143	5.40	.19	.11	.06	.938	28.42	6.25
144		144	1.70	.12	.11	.04	.863	14.17	13.71
145		145	2.40	.21	.13	.03	.866	11.43	13.36
146		146	1.20	.10	.09	.03	.845	12.00	15.49
147		147	3.50	.31	.19	.05	.864	11.29	13.58
148	LECONFIELD	148	1.30	.18	.13	.04	.788	7.22	21.21
149	PROSPECT	149	1.00	.17	.06	.02	.800	5.88	20.00
150		150	1.60	.20	.11	.03	.825	8.00	17.53
151		151	.50	.12	.05	.01	.735	4.17	26.47
152		152	.80	.08	.08	.03	.808	10.00	19.19
153		153	1.30	.12	.10	.03	.839	10.83	16.13
154		154	1.20	.12	.11	.04	.816	10.00	18.37
155		155	1.00	.06	.07	.02	.870	16.67	13.04
156		156	1.00	.13	.09	.03	.800	7.69	20.00
157		157	2.10	.08	.08	.06	.905	26.25	9.48
158		158	1.10	.15	.10	.06	.780	7.33	21.99
159		159	.80	.10	.06	.06	.784	8.00	21.57
160		160	2.60	.33	.10	.10	.831	7.88	16.93
161		161	1.40	.03	.08	.07	.886	46.67	11.39
162		162	1.20	.05	.05	.04	.896	24.00	10.45
163		163	1.00	.33	.04	.04	.709	3.03	29.08
164		164	.80	.05	.05	.04	.851	16.00	14.89
165		165	.80	.06	.05	.04	.842	13.33	15.79
166		166	.80	.01	.10	.08	.808	80.00	19.19
167		167	6.10	.15	.13	.07	.946	40.67	5.43
168		168	12.10	.19	.20	.09	.962	63.68	3.82
169		169	4.40	.07	.05	.03	.967	62.86	3.30
170		170	2.60	.07	.06	.05	.935	37.14	6.47
171		171	5.10	.29	.09	.10	.914	17.59	8.60
172		172	4.80	.21	.10	.08	.925	22.86	7.51
173	LEAD B	173	8.80	.12	.14	.07	.964	73.33	3.61
174		174	4.40	.18	.21	.07	.905	24.44	9.47
175		175	2.30	.10	.07	.06	.909	23.00	9.09
176		176	2.60	.14	.08	.07	.900	18.57	10.03
177		177	3.40	.19	.13	.18	.872	17.89	12.82
178	BANYULA-1	178	5.10	.30	.22	.08	.895	17.00	10.53
179		179	9.30	.19	.18	.12	.950	48.95	5.01
180		180	.90	.12	.07	.04	.796	7.50	20.35
181		181	.90	.10	.07	.04	.811	9.00	18.92
182		182	.80	.14	.05	.03	.784	5.71	21.57
183		183	.90	.07	.04	.03	.865	12.86	13.46
184		184	1.40	.07	.07	.04	.886	20.00	11.39
185		185	1.20	.06	.04	.04	.896	20.00	10.45
186		186	1.90	.09	.09	.02	.905	21.11	9.52
187		187	1.30	.07	.06	.02	.897	18.57	10.34
188		188	2.40	.02	.13	.07	.916	120.00	8.40
189	LEAD B	189	6.10	.32	.31	.12	.891	19.06	10.95
190		190	4.90	.11	.09	.05	.951	44.55	4.85
191		191	1.30	.07	.08	.03	.878	18.57	12.16
192		192	1.10	.08	.09	.03	.846	13.75	15.38
193		193	.90	.05	.06	.02	.874	18.00	12.62
194		194	.50	.05	.04	.01	.833	10.00	16.67
195	LEAD I	195	1.10	.17	.16	.08	.728	6.47	27.15
196		196	.90	.09	.10	.03	.804	10.00	19.64
197		197	3.50	.31	.29	.12	.829	11.29	17.06
198		198	4.70	.41	.39	.15	.832	11.46	16.81
199		199	.80	.09	.11	.04	.769	8.89	23.08
200		200	.60	.07	.12	.03	.732	8.57	26.83
201		201	.70	.11	.13	.04	.714	6.36	28.57
202	LEADS C&D	202	2.80	.19	.18	.09	.859	14.74	14.11
203		203	.60	.08	.13	.04	.706	7.50	29.41
204		204	.50	.05	.12	.03	.714	10.00	28.57
205		205	2.10	.08	.03	.01	.946	26.25	5.41
206		206	.90	.07	.04	.01	.882	12.86	11.76
207		207	.70	.18	.08	.03	.707	3.89	29.29
208		208	2.80	.41	.13	.05	.826	6.83	17.40
209		209	5.20	.45	.33	.06	.861	11.56	13.91
210		210	1.70	.14	.08	.02	.876	12.14	12.37
211		211	3.90	.11	.07	.04	.947	35.45	5.34
212		212	2.10	.15	.06	.02	.901	14.00	9.87
213		213	1.50	.12	.06	.02	.882	12.50	11.76
214		214	.90	.06	.04	.02	.882	15.00	11.76
215		215	1.50	.12	.07	.03	.872	12.50	12.79

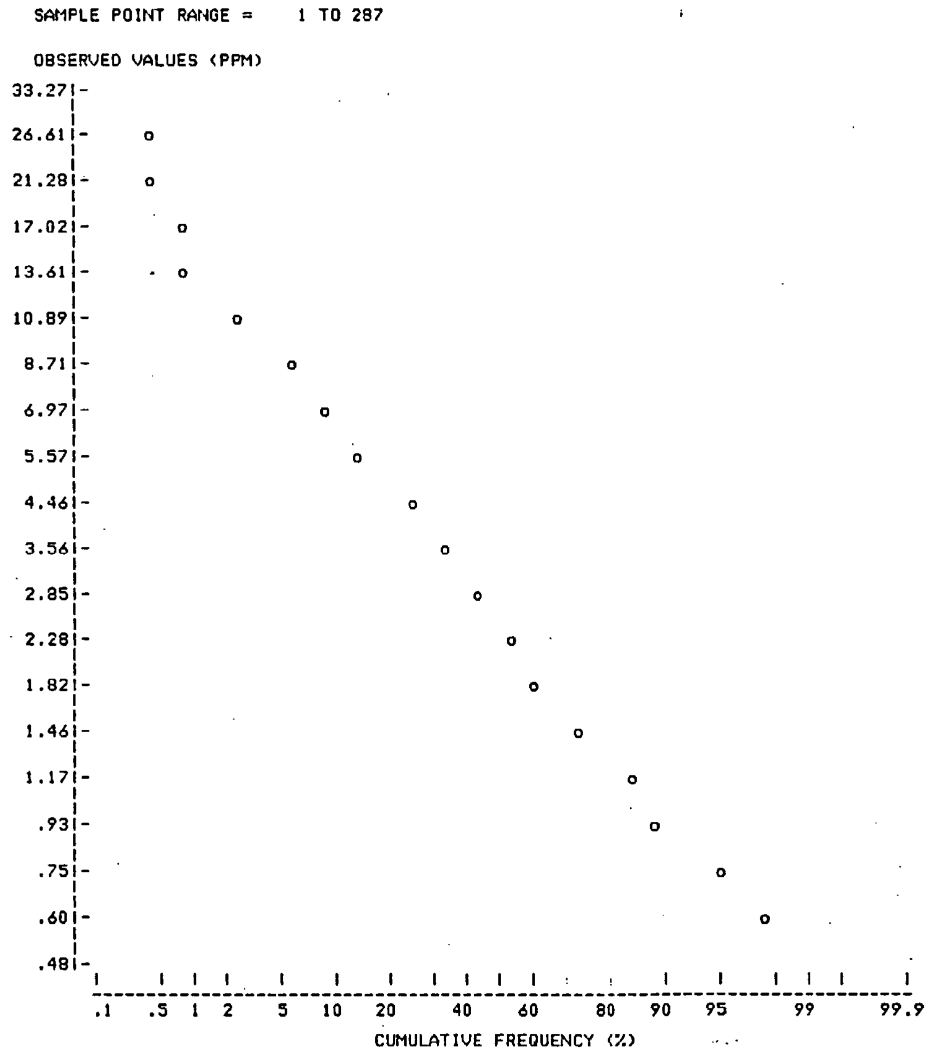
216			216	1.90	.10	.06	.03	.909	19.00	9.09
217			217	1.50	.15	.07	.03	.857	10.00	14.29
218			218	5.40	.22	.10	.04	.938	24.55	6.25
219			219	2.50	.11	.06	.03	.926	22.73	7.41
220			220	3.10	.20	.08	.04	.906	15.50	9.36
221			221	4.20	.42	.14	.06	.871	10.00	12.86
222			222	3.30	.35	.18	.09	.842	9.43	15.82
223			223	2.20	.24	.12	.04	.846	9.17	15.38
224			224	3.50	.43	.14	.08	.843	8.14	15.66
225			225	1.60	.15	.11	.07	.829	10.67	17.10
226			226	1.30	.19	.12	.05	.783	6.84	21.69
227	LEAD I		227	4.80	.22	.08	.07	.928	21.82	7.16
228			228	2.80	.25	.15	.09	.851	11.20	14.89
229			229	1.60	.12	.08	.04	.870	13.33	13.04
230	LEADS C&D		230	5.80	.59	.43	.13	.835	9.83	16.55
231			231	4.60	.28	.34	.19	.850	16.43	14.97
232			232	1.80	.14	.18	.13	.800	12.86	20.00
233			233	1.30	.11	.12	.04	.828	11.82	17.20
234			234	1.20	.12	.16	.14	.741	10.00	25.93
235			235	1.60	.26	.24	.13	.717	6.15	28.25
236			236	.90	.15	.16	.05	.714	6.00	28.57
237			237	1.30	.17	.22	.13	.714	7.65	28.57
238			238	2.20	.19	.09	.07	.863	11.58	13.73
239	LEAD I		239	2.60	.36	.28	.14	.769	7.22	23.08
240			240	1.20	.20	.21	.12	.694	6.00	30.64
241			241	.70	.30	.12	.04	.603	2.33	39.66
242			242	.70	.13	.17	.05	.667	5.38	33.33
243			243	2.30	.21	.28	.08	.801	10.95	19.86
244			244	2.40	.33	.27	.19	.752	7.27	24.76
245			245	2.40	.28	.21	.14	.792	8.57	20.79
246			246	1.80	.32	.23	.18	.711	5.63	28.85
247			247	.60	.18	.16	.15	.550	3.33	44.95
248			248	1.20	.24	.19	.06	.710	5.00	28.99
249			249	.80	.20	.22	.13	.593	4.00	40.74
250			250	.50	.09	.17	.10	.581	5.56	41.86
251			251	.80	.18	.18	.07	.650	4.44	34.96
252			252	2.30	.40	.27	.19	.728	5.75	27.22
253	88-081	325	253	8.90	.51	.35	.10	.903	17.45	9.74
254		305	254	3.60	.25	.20	.06	.876	14.40	12.41
255		285	255	2.90	.11	.08	.03	.929	26.36	7.05
256		265	256	3.30	.15	.09	.04	.922	22.00	7.82
257		245	257	4.10	.35	.17	.06	.876	11.71	12.39
258	88-012	218	258	1.50	.15	.07	.03	.857	10.00	14.29
259		230	259	1.90	.17	.11	.08	.841	11.18	15.93
260		250	260	1.30	.07	.05	.02	.903	18.57	9.72
261		261	261	3.10	.12	.09	.03	.928	25.83	7.19
262	88-071	211	262	2.90	.11	.07	.03	.932	26.36	6.75
263		251	263	1.80	.08	.05	.02	.923	22.50	7.69
264		271	264	1.30	.06	.05	.06	.884	21.67	11.56
265	88-012	280	265	2.90	.11	.06	.05	.929	26.36	7.05
266	88-061	246	266	4.40	.32	.25	.12	.864	13.75	13.56
267	88-041	164	267	5.20	.29	.18	.09	.903	17.93	9.72
268		150	268	1.70	.32	.14	.06	.766	5.31	23.42
269		130	269	2.70	.11	.10	.05	.912	24.55	8.78
270		190	270	2.90	.16	.09	.05	.906	18.13	9.37
271		210	271	1.60	.24	.18	.14	.741	6.67	25.93
272	88-031	210	272	1.60	.08	.04	.03	.914	20.00	8.57
273		190	273	.80	.02	.04	.02	.909	40.00	9.09
274		170	274	4.50	.12	.05	.09	.945	37.50	5.46
275	88-012	376	275	10.80	.47	.29	.15	.922	22.98	7.77
276		396	276	6.10	.49	.49	.10	.850	12.45	15.04
277		356	277	2.20	.10	.15	.13	.853	22.00	14.73
278	88-031	150	278	1.80	.13	.33	.03	.786	13.85	21.40
279		130	279	2.00	.05	.24	.07	.847	40.00	15.25
280		110	280	5.50	.20	.41	.18	.874	27.50	12.56
281	LEAD J		281	5.00	.13	.30	.04	.914	38.46	8.59
282			282	1.30	.25	.21	.07	.710	5.20	28.96
283			283	3.80	.29	.17	.08	.876	13.10	12.44
284			284	1.20	.05	.21	.03	.805	24.00	19.46
285			285	2.00	.36	.13	.11	.769	5.56	23.08
286			286	4.40	.45	.21	.16	.843	9.78	15.71
287			287	.80	.17	.14	.08	.672	4.71	32.77

MAXIMUM	27.80	2.40	.84	.25
MINIMUM	.50	.01	.03	.01
MEAN	3.30	.22	.16	.07
STD. DEVN.	2.99	.20	.11	.04



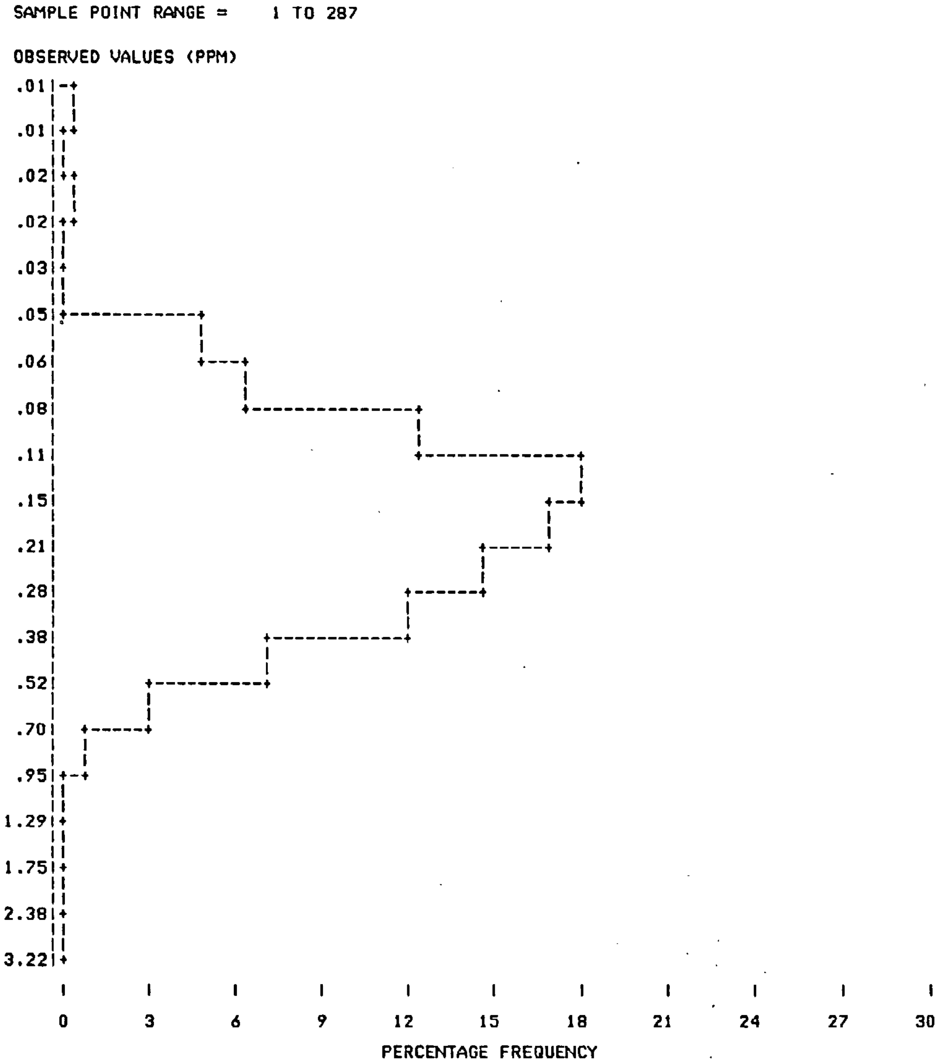
SOIL GAS ALKANE SURVEY PEL 32 ULTRAMAR APRIL 1988 METHANE

Figure 1(a):Histogram of methane concentrations of 287 soil gas samples from PEL 32.



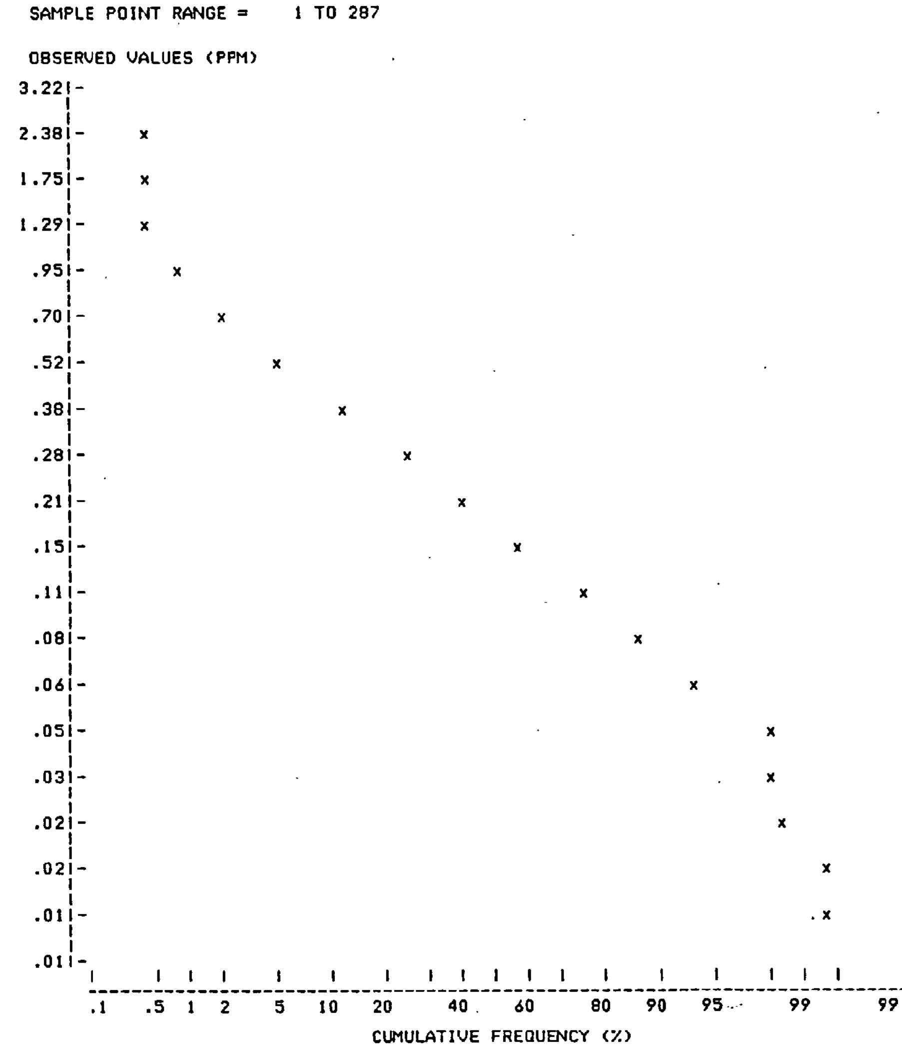
SOIL GAS ALKANE SURVEY PEL 32 ULTRAMAR APRIL 1988 METHANE

Figure 1(b):Cumulative frequency curve derived from (a)



SOIL GAS ALKANE SURVEY PEL 32 ULTRAMAR APRIL 1988 ETHANE

Figure 2(a):Histogram of ethane concentrations of 287 soil gas samples from PEL 32.



SOIL GAS ALKANE SURVEY PEL 32 ULTRAMAR APRIL 1988 ETHANE

Figure 2(b):Cumulative frequency curve derived from (a)

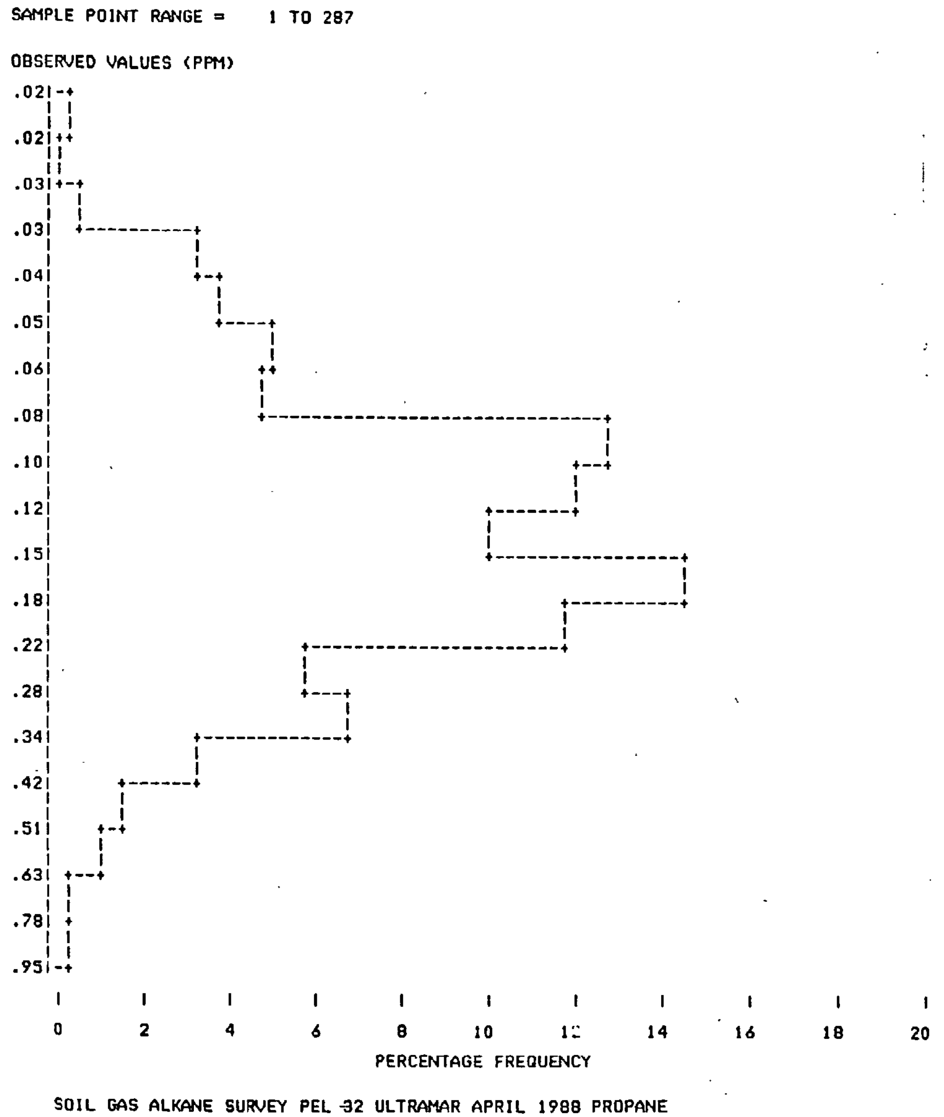


Figure 3(a):Histogram of propane concentrations of 287 soil gas samples from PEL 32.

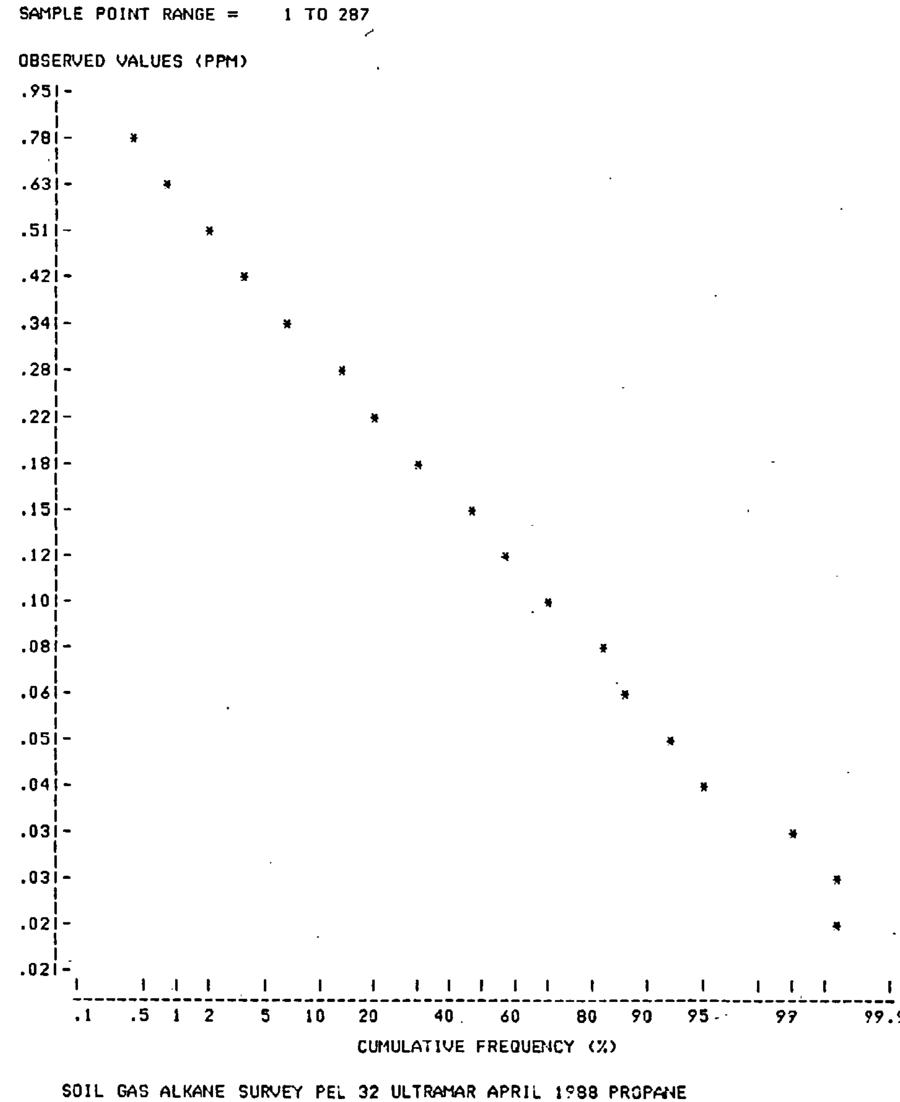


Figure 3(b):Cumulative frequency curve derived from (a)

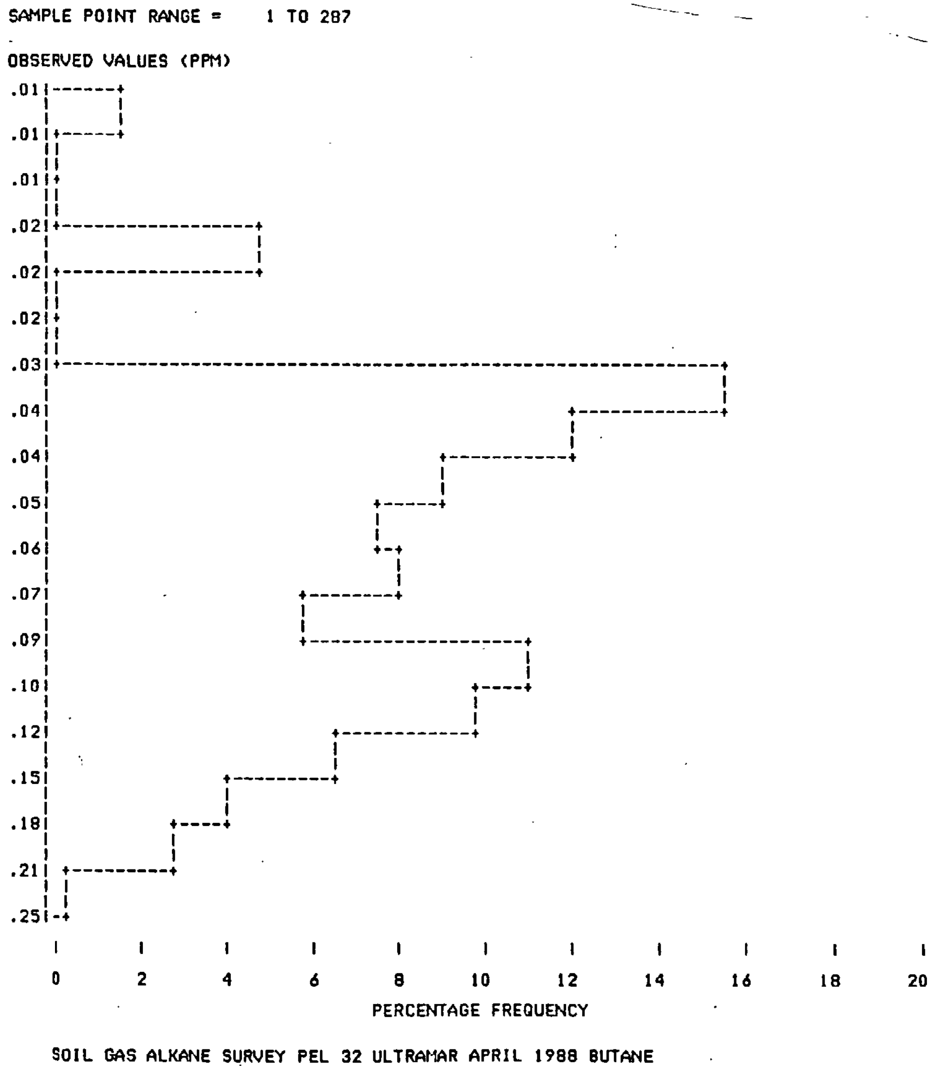


Figure 4(a):Histogram of n-butane concentrations of 287 soil gas samples from PEL 32.

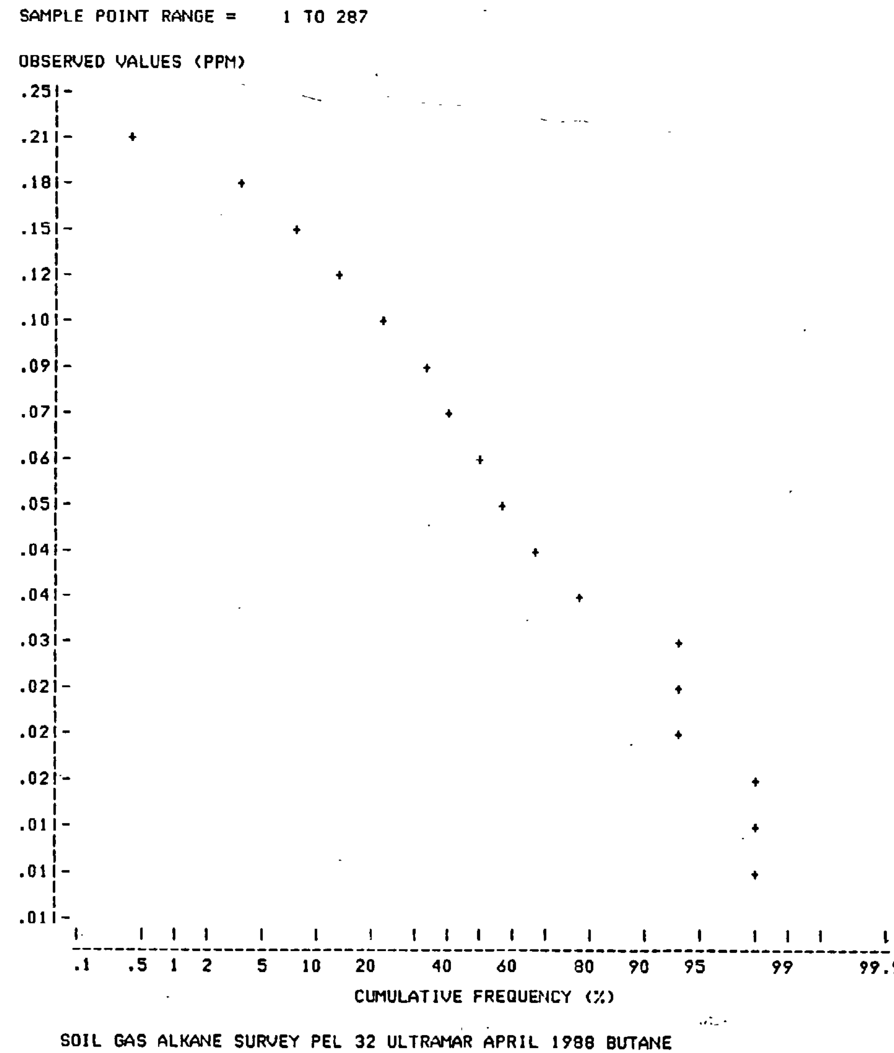
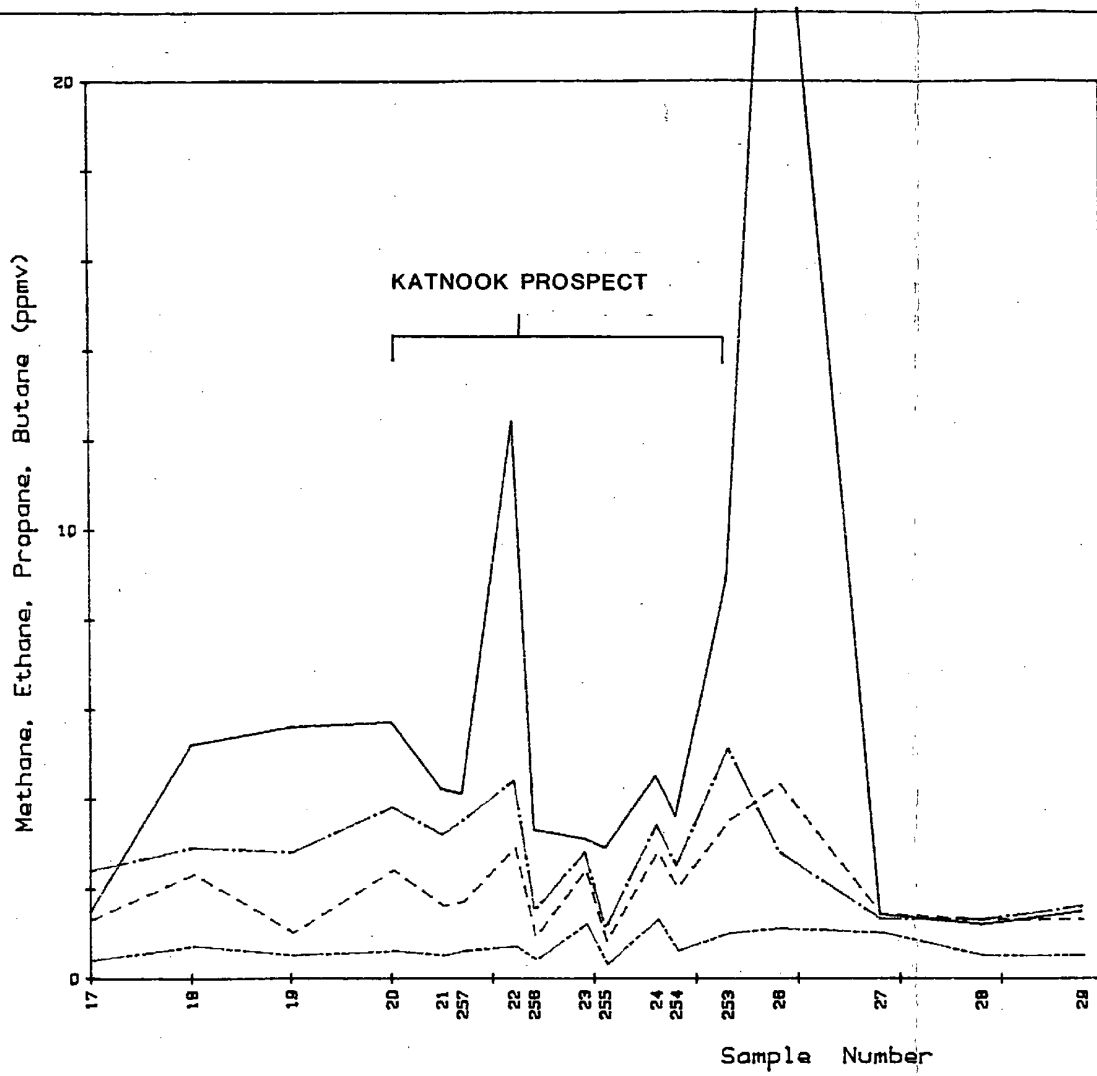


Figure 4(b):Cumulative frequency curve derived from (a)



Legend

————	Methane		ppmv
—·—·—	Ethane	x 10	ppmv
- - - - -	Propane	x 10	ppmv
—··—··—	Butane	x 10	ppmv

0 2 4 6 km

Horizontal Scale (1 km = 20 mm)

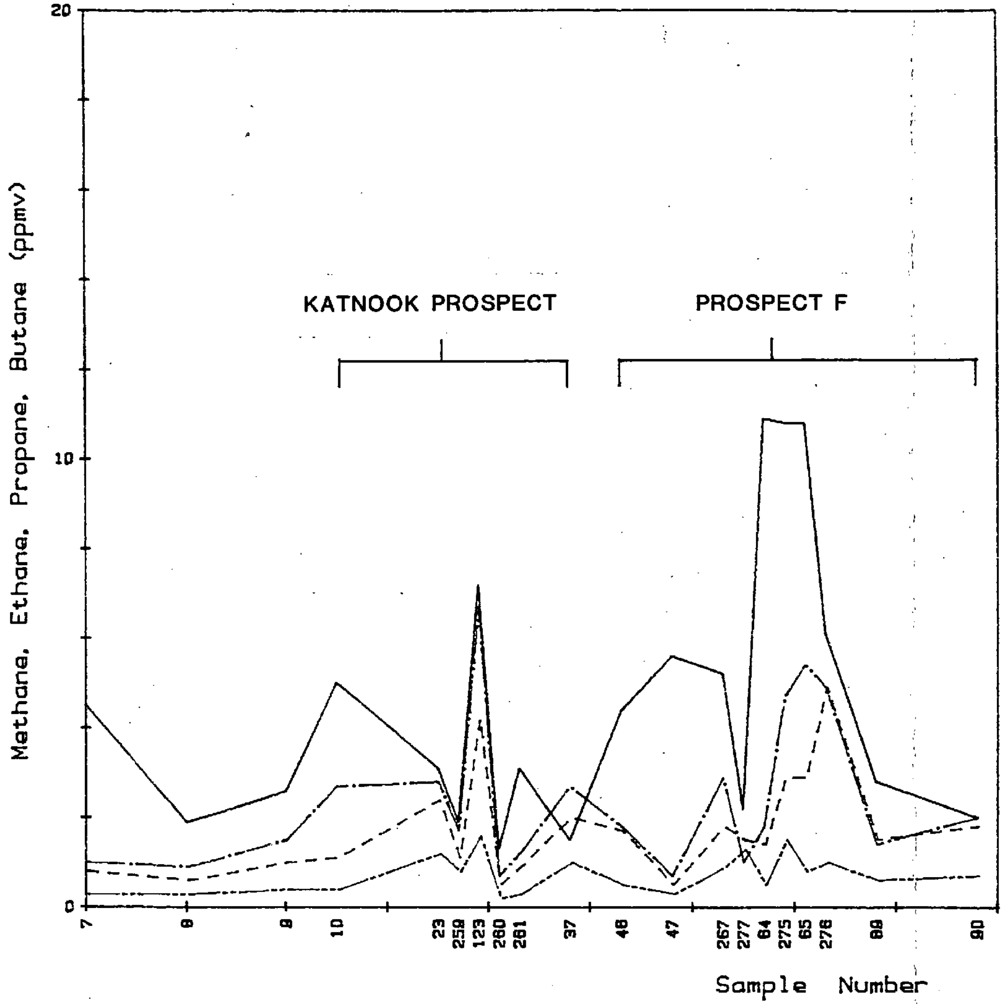
PETROFOCUS PTY. LTD.

SOIL GAS SURVEY

PEL 32

LINE 88-081

APRIL 88 | FIGURE 5



Legend

————	Methane		ppmv
—·—·—	Ethane	x 10	ppmv
- - - - -	Propane	x 10	ppmv
—··—··	Butane	x 10	ppmv

0 2 4 6 km

Horizontal Scale (1 km = 20 mm)

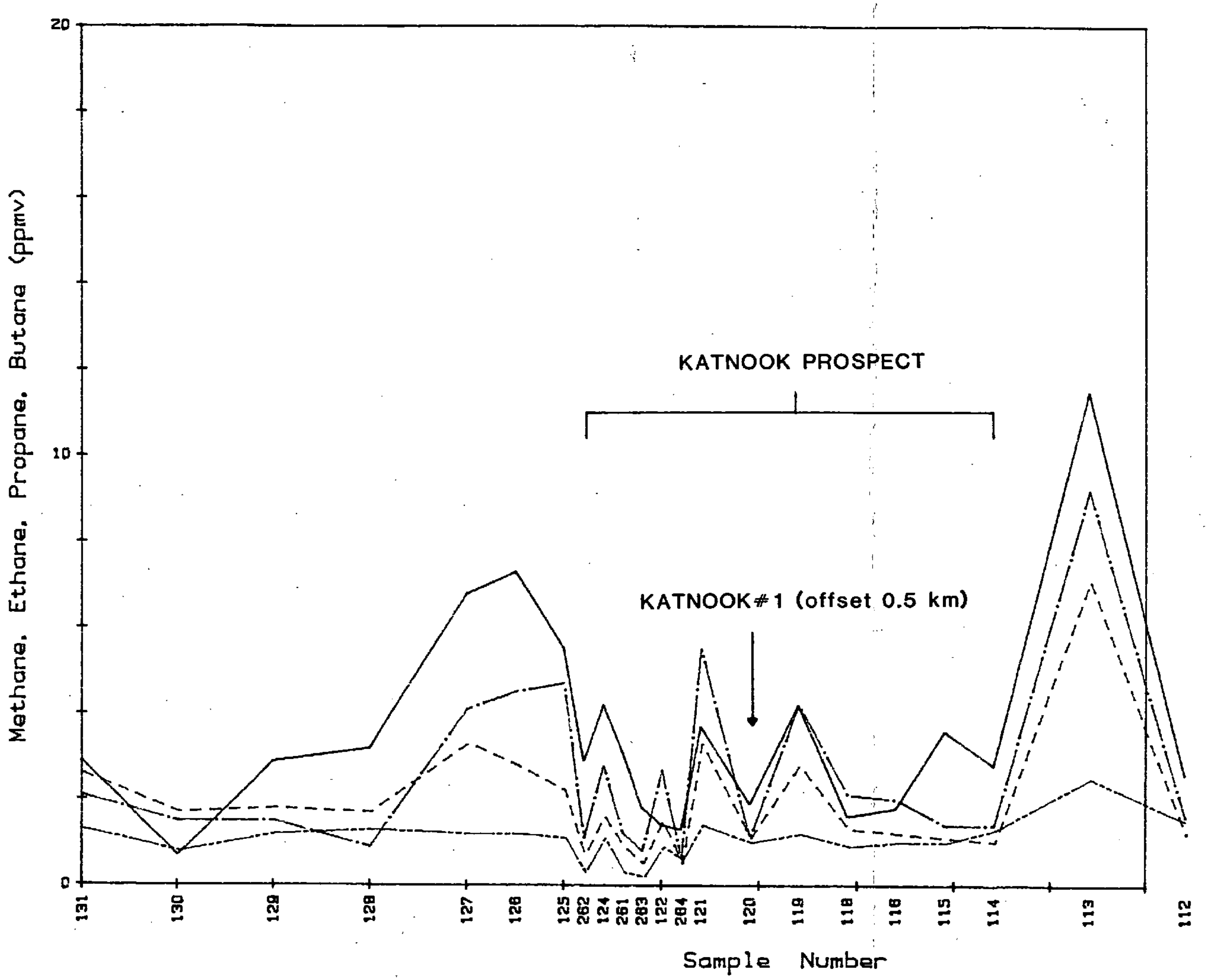
PETROFOCUS PTY. LTD.

SOIL GAS SURVEY

PEL 32
LINE 88-012

APRIL 88 | FIGURE 6

000032



Legend

————	Methane		ppmv
—·—·—	Ethane	x 10	ppmv
- - - - -	Propane	x 10	ppmv
-·-·-·-	Butane	x 10	ppmv

0 2 4 6 km

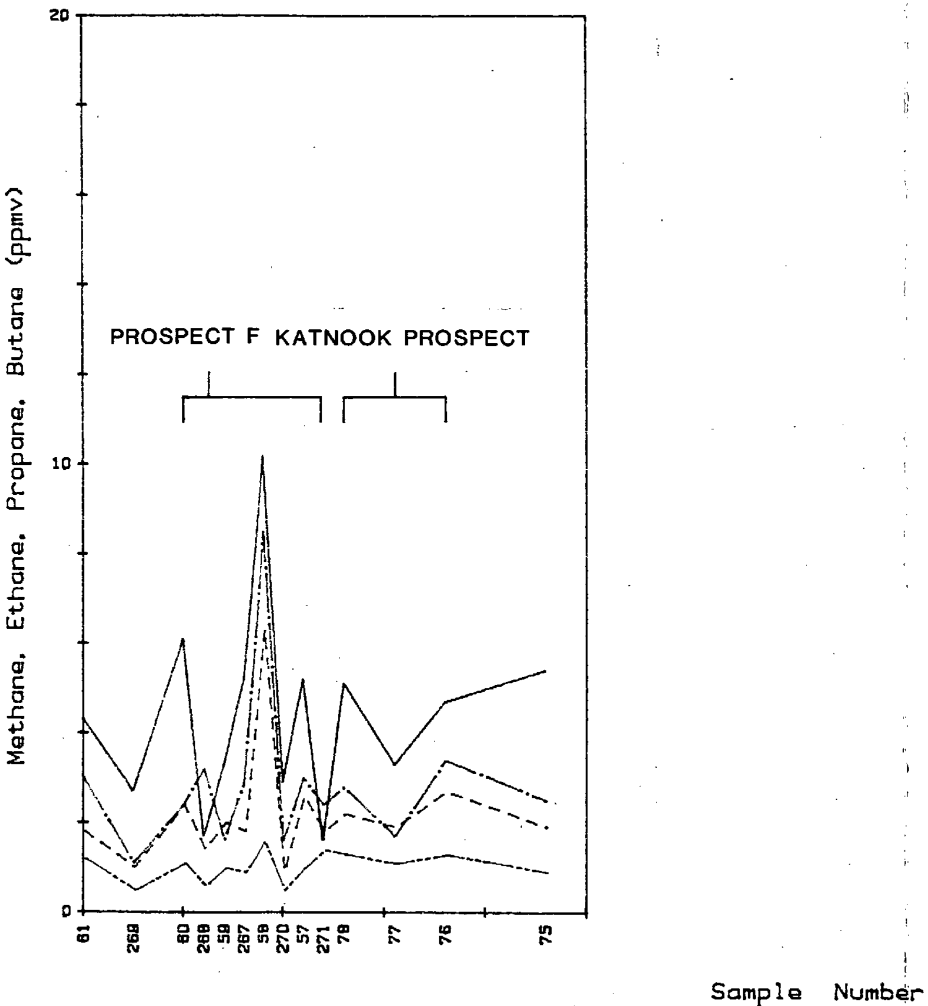
Horizontal Scale (1 km = 20 mm)

PETROFOCUS PTY. LTD.

SOIL GAS SURVEY

PEL 32
LINE 88-071

APRIL 88 | FIGURE 7



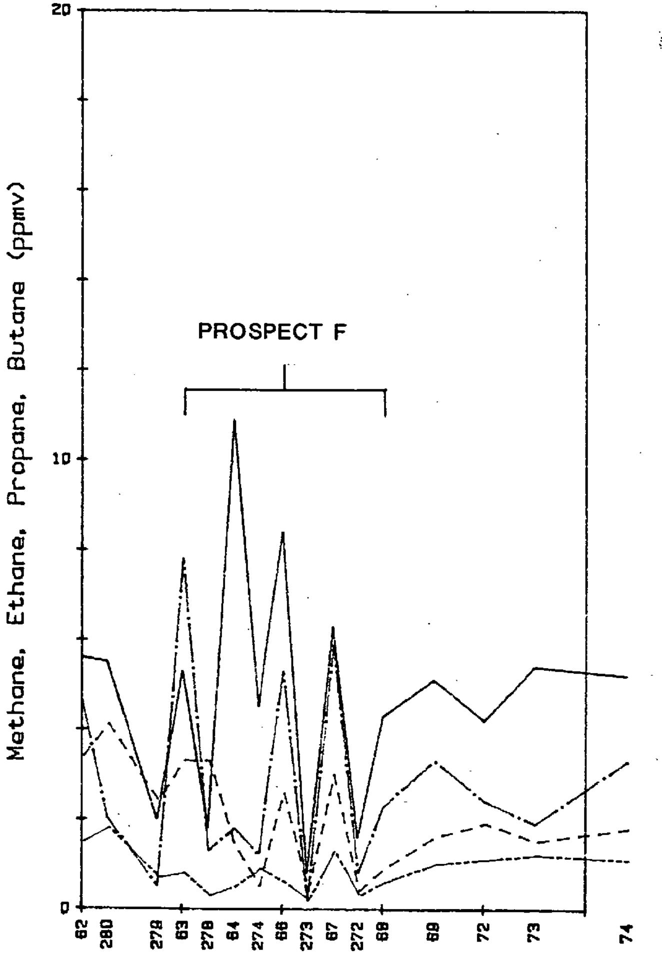
Legend

————	Methane		ppmv
—·—·—·	Ethane	x 10	ppmv
- - - - -	Propane	x 10	ppmv
············	Butane	x 10	ppmv

0 2 4 6 km

Horizontal Scale (1 km = 20 mm)

PETROFOCUS PTY. LTD.	
SOIL GAS SURVEY	
PEL 32 LINE 88-041	
APRIL 88	FIGURE 8



Legend

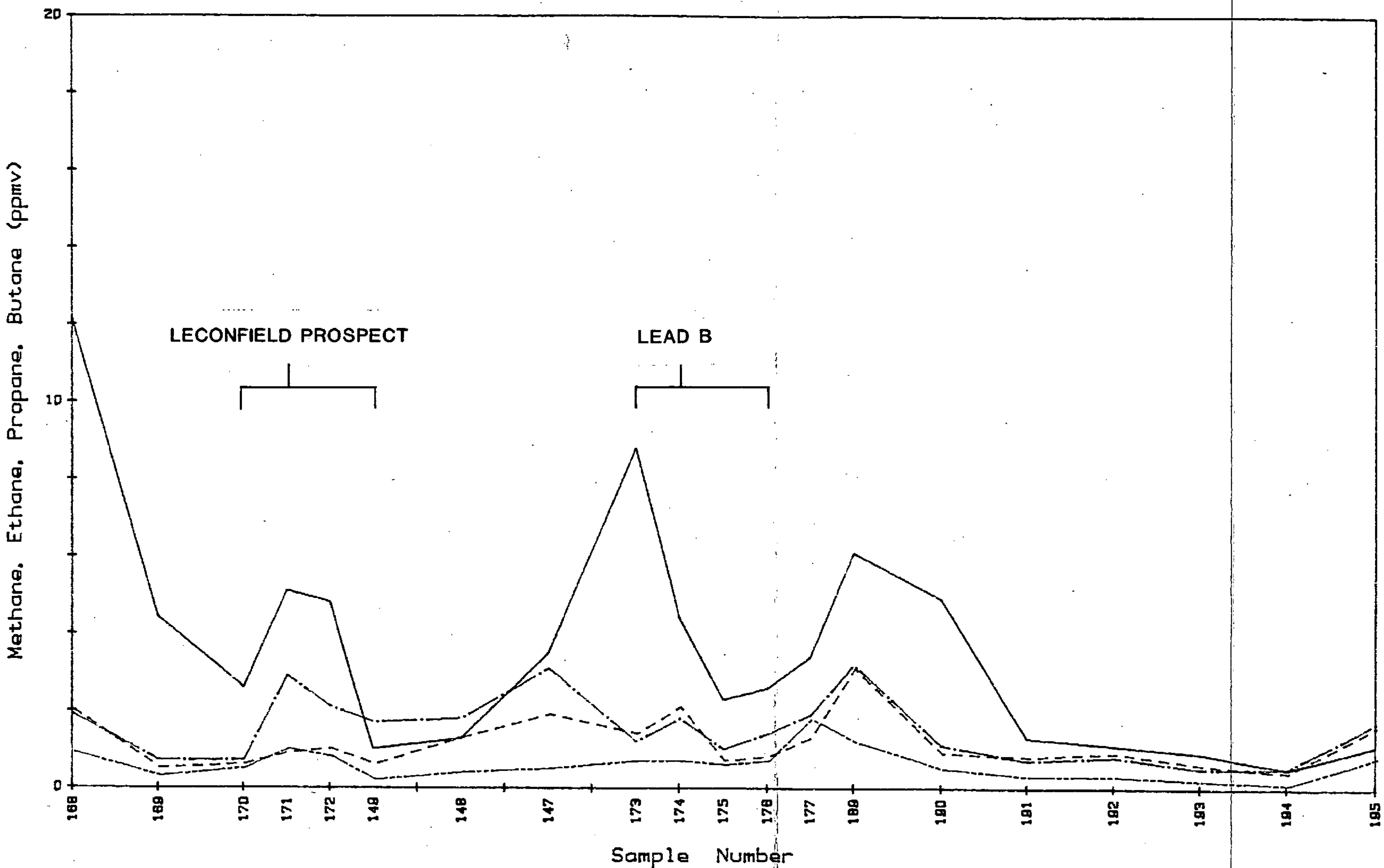
———	Methane		ppmv
—·—·—	Ethane	x 10	ppmv
- - - -	Propane	x 10	ppmv
—··—··	Butane	x 10	ppmv

0 2 4 6 km

Horizontal Scale (1 km = 20 mm)

PETROFOCUS PTY. LTD.	
SOIL GAS SURVEY	
PEL 32 LINE 88-031	
APRIL 88	FIGURE 9

000035



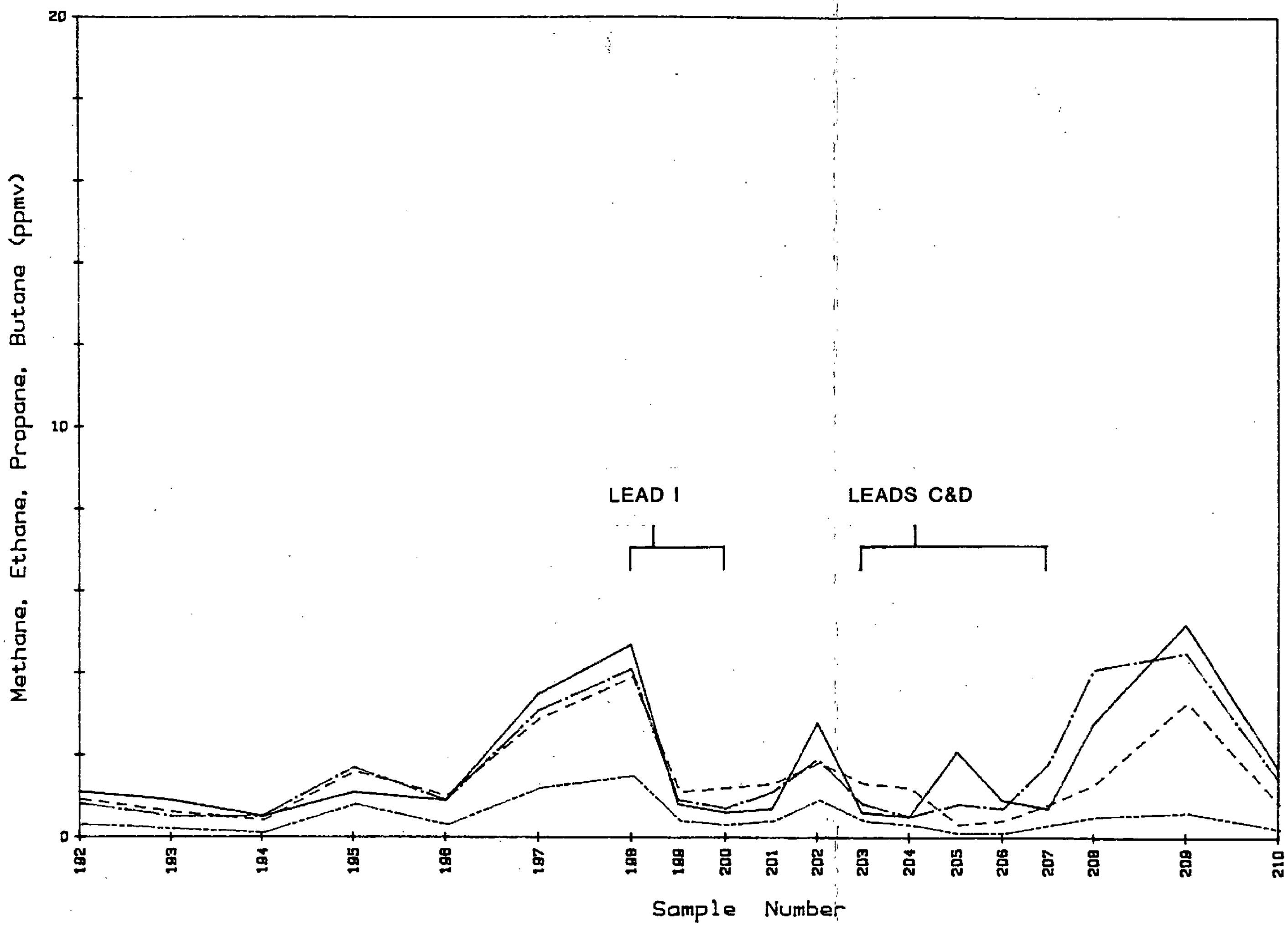
Legend

————	Methane		ppmv
—·—·—	Ethane	x 10	ppmv
- - - - -	Propane	x 10	ppmv
—··—··—	Butane	x 10	ppmv

0 2 4 6 km

Horizontal Scale (1 km = 20 mm)

PETROFOCUS PTY. LTD.	
SOIL GAS SURVEY	
PEL 32 LINE A-A'	
APRIL 88	FIGURE 10



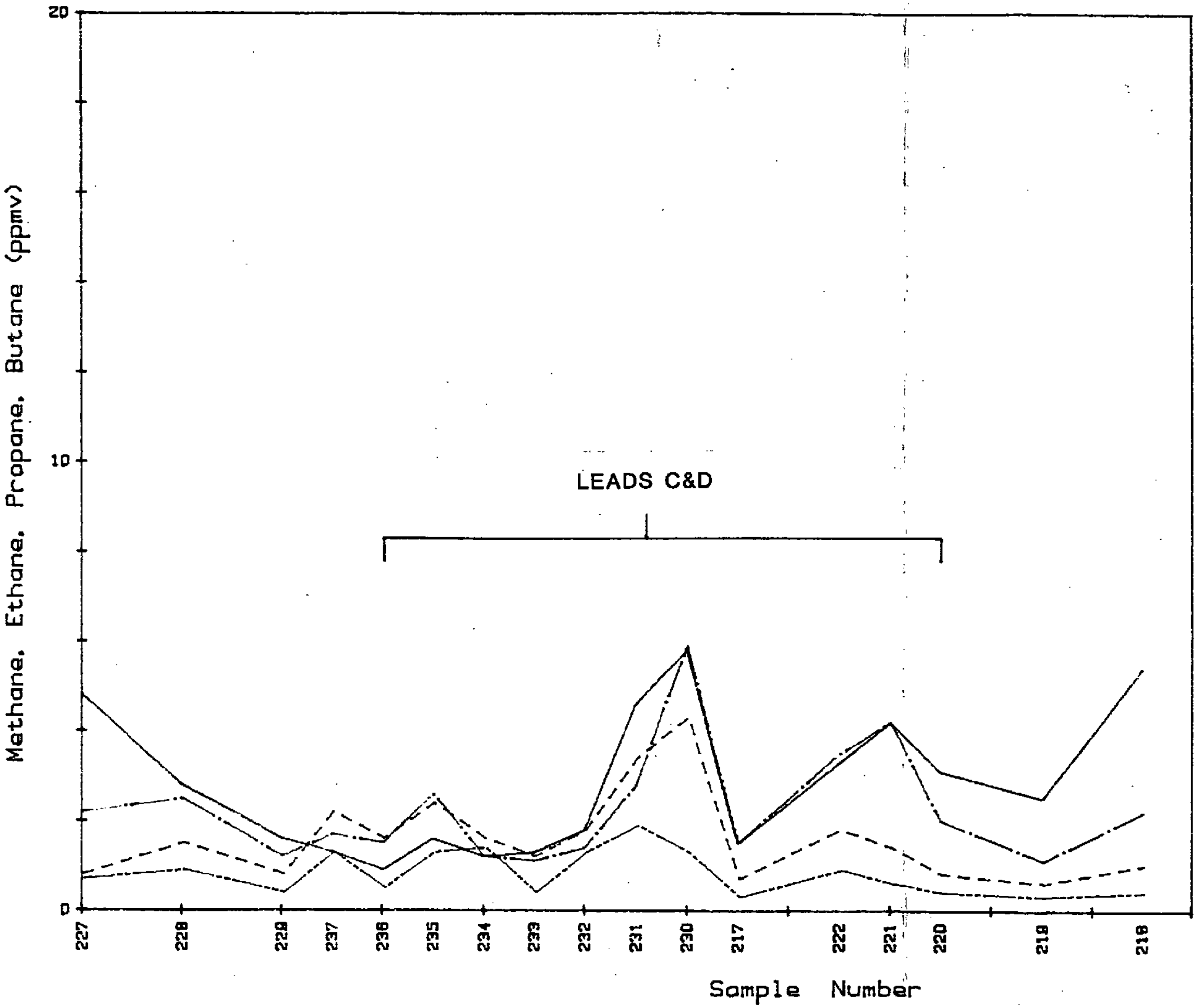
Legend

————	Methane		ppmv
—·—·—	Ethane	x 10	ppmv
- - - - -	Propane	x 10	ppmv
-··-··-	Butane	x 10	ppmv

0 2 4 6 km

Horizontal Scale (1 km = 20 mm)

PETROFOCUS PTY. LTD.	
SOIL GAS SURVEY	
PEL 32 LINE B-B'	
APRIL 88	FIGURE 11



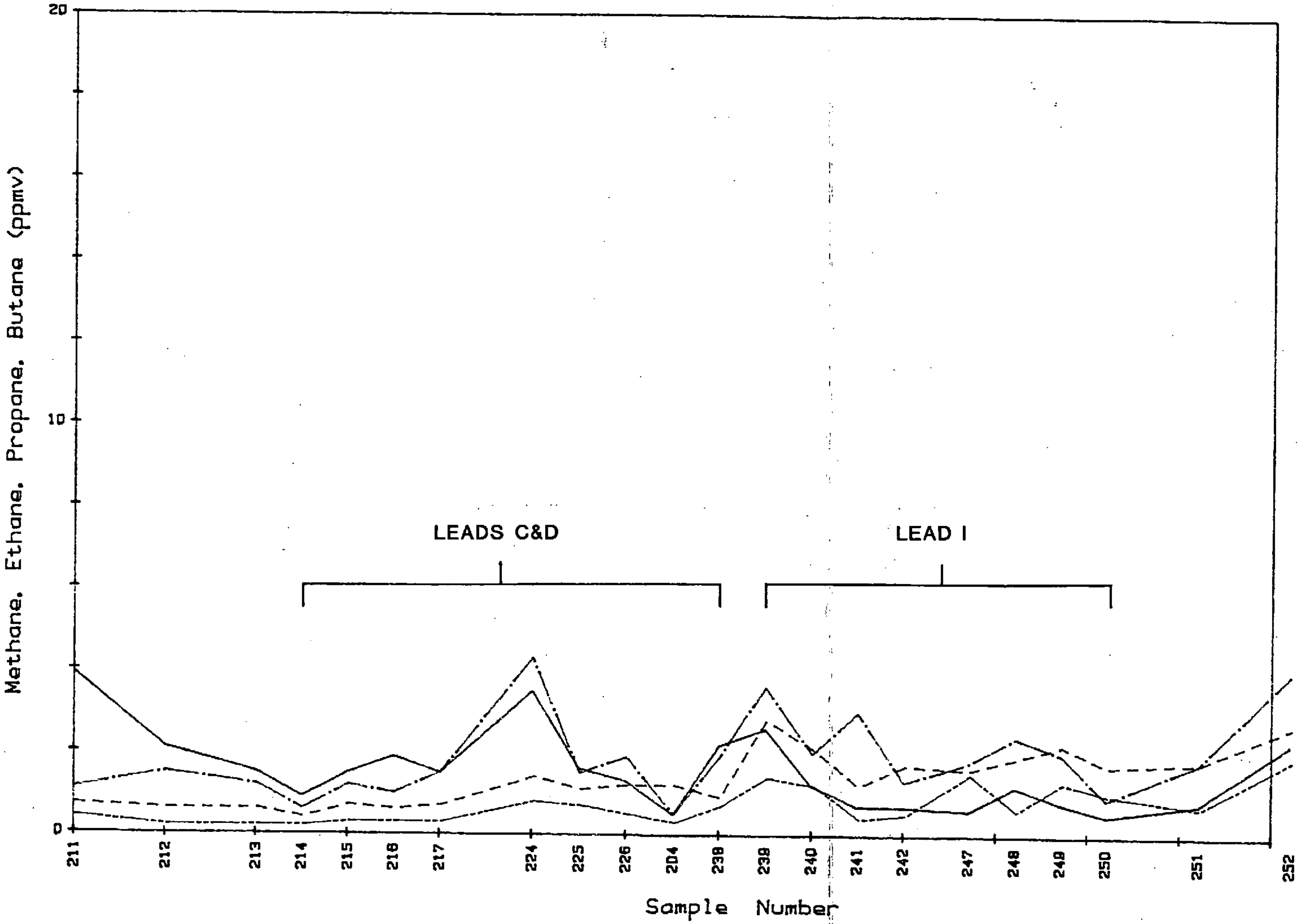
Legend

————	Methane		ppmv
-·-·-·-	Ethane	x 10	ppmv
- - - - -	Propane	x 10	ppmv
————	Butane	x 10	ppmv

0 2 4 6 km

Horizontal Scale (1 km = 20 mm)

PETROFOCUS PTY. LTD.	
SOIL GAS SURVEY	
PEL 32 LINE C-C'	
APRIL 88	FIGURE 12

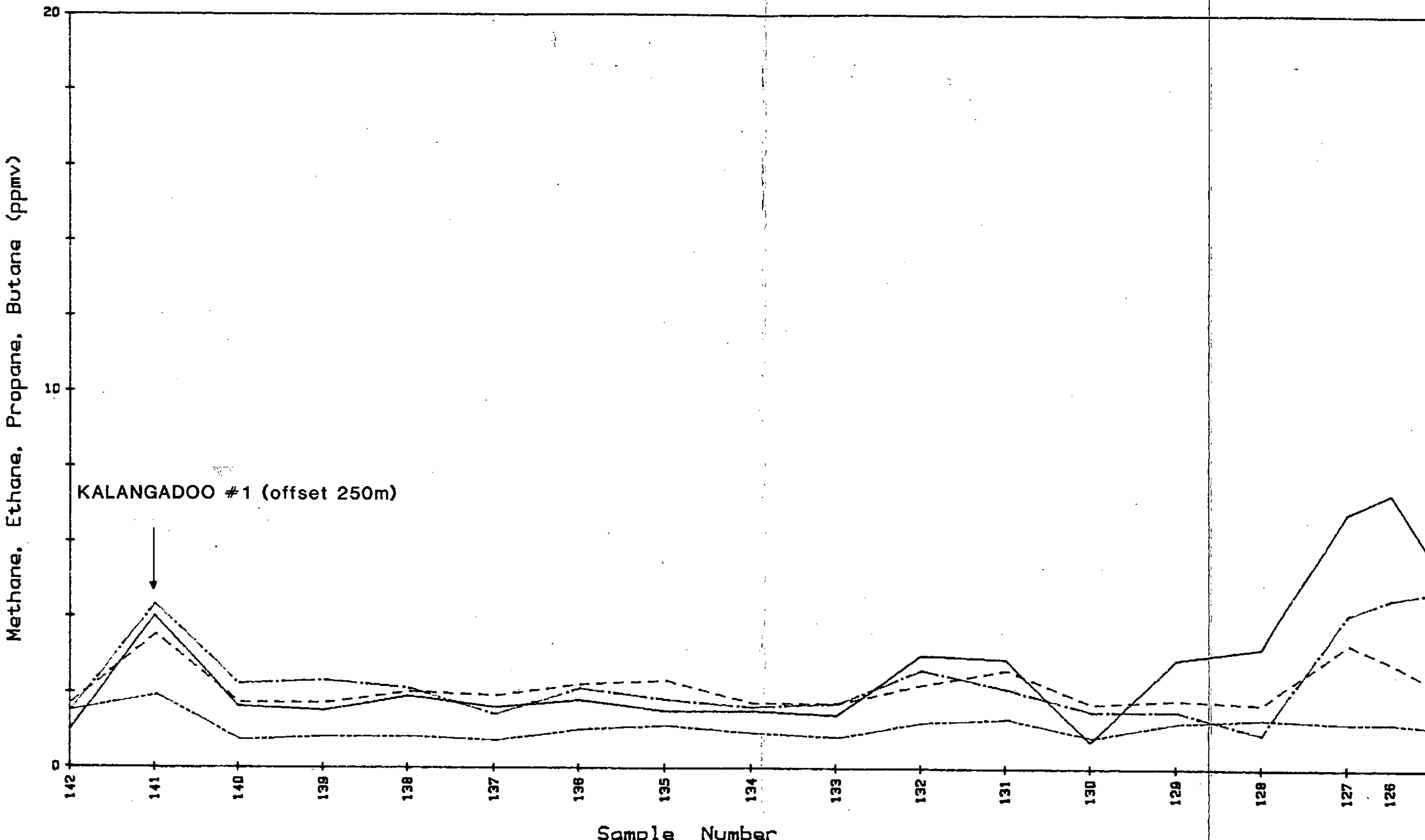


Legend

————	Methane		ppmv
—·—·—·—	Ethane	x 10	ppmv
- - - - - -	Propane	x 10	ppmv
————	Butane	x 10	ppmv

0 2 4 6 km
Horizontal Scale (1 km = 20 mm)

PETROFOCUS PTY. LTD.	
SOIL GAS SURVEY	
PEL 32 LINE D-D'	
APRIL 88	FIGURE 13



Legend

Methane		ppmv	
Ethane	x 10	ppmv	
Propane	x 10	ppmv	
Butane	x 10	ppmv	

0 2 4 6 km

Horizontal Scale (1 km = 20 mm)

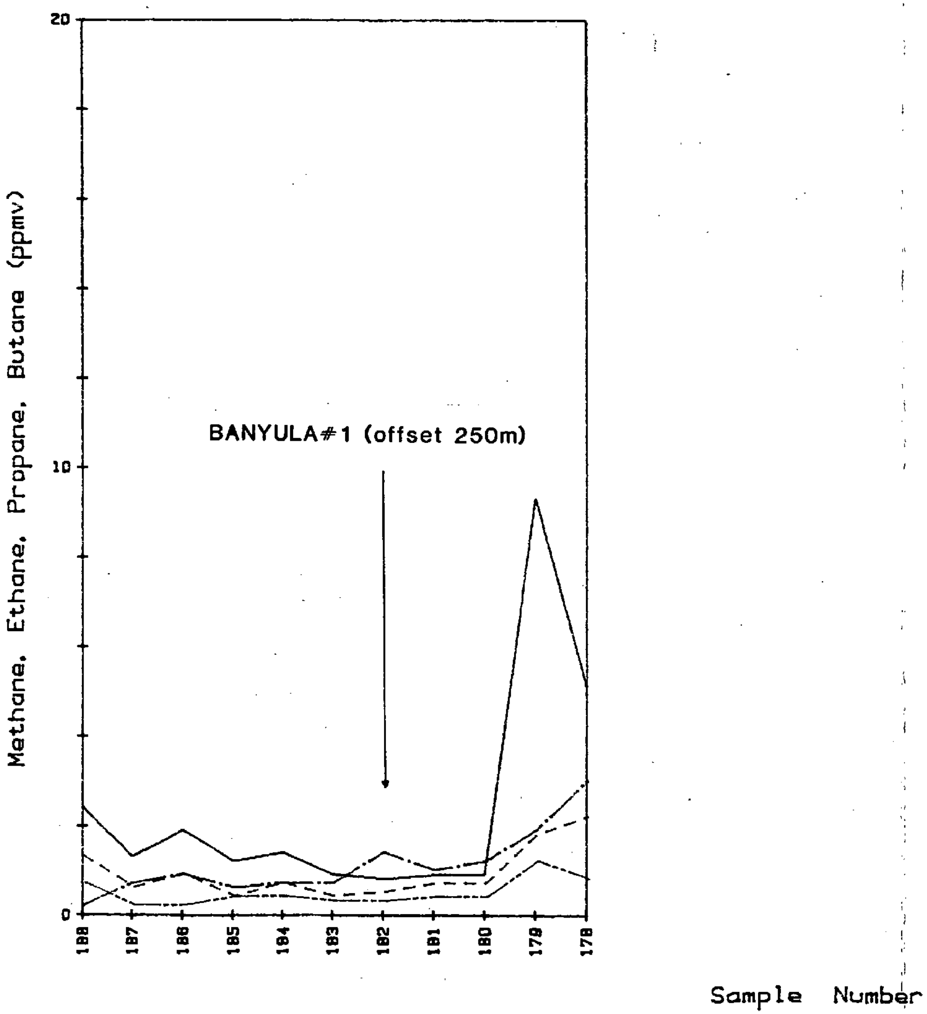
PETROFOCUS PTY. LTD.

SOIL GAS SURVEY

PEL 32
LINE E-E'

APRIL 88 | FIGURE 14

0000040



Legend

———————	Methane		ppmv
—·—·—..	Ethane	x 10	ppmv
- - - - - -	Propane	x 10	ppmv
-·-·-·-·-	Butane	x 10	ppmv

0 1 2 3 4 5 6 7 km

Horizontal Scale (1 km = 20 mm)

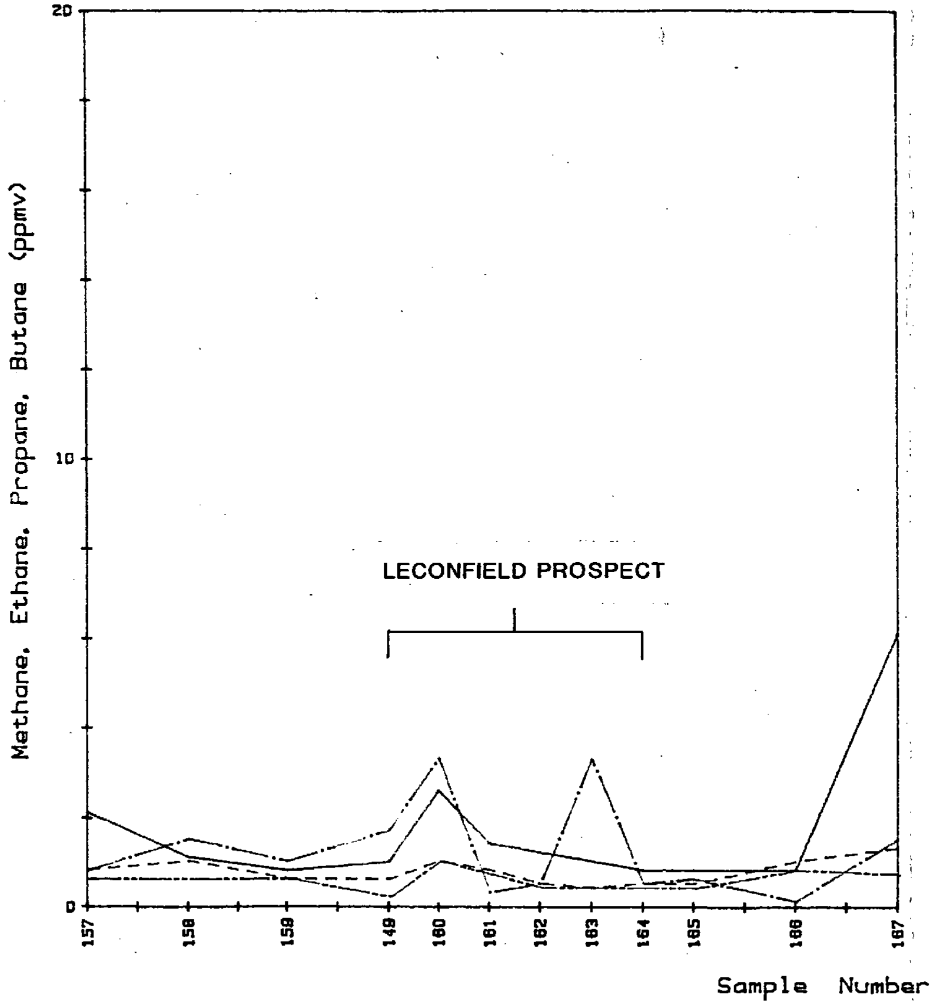
PETROFOCUS PTY. LTD.

SOIL GAS SURVEY

PEL 32
LINE F-F'

APRIL 88

FIGURE 15



Legend

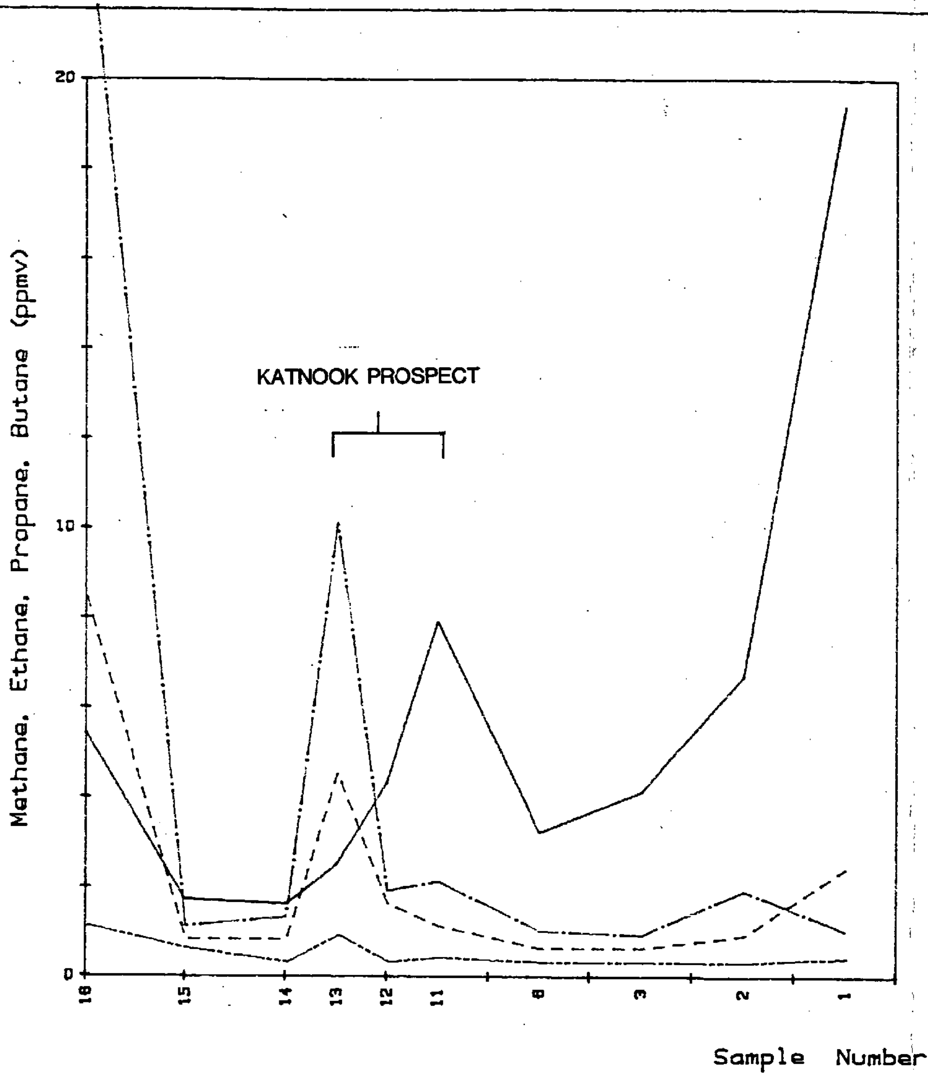
————	Methane		ppmv
-·-·-·——	Ethane	x 10	ppmv
- - - - -	Propane	x 10	ppmv
-·-·-·-·-	Butane	x 10	ppmv

0 1 2 3 4 5 6 7 km

Horizontal Scale (1 km = 20 mm)

PETROFOCUS PTY. LTD.	
SOIL GAS SURVEY	
PEL 32 LINE G-G'	
APRIL 88	FIGURE 16

000042



Legend

————	Methane		ppmv
—·—·—	Ethane	x 10	ppmv
- - - - -	Propane	x 10	ppmv
—··—··	Butane	x 10	ppmv

0 2 4 6 km

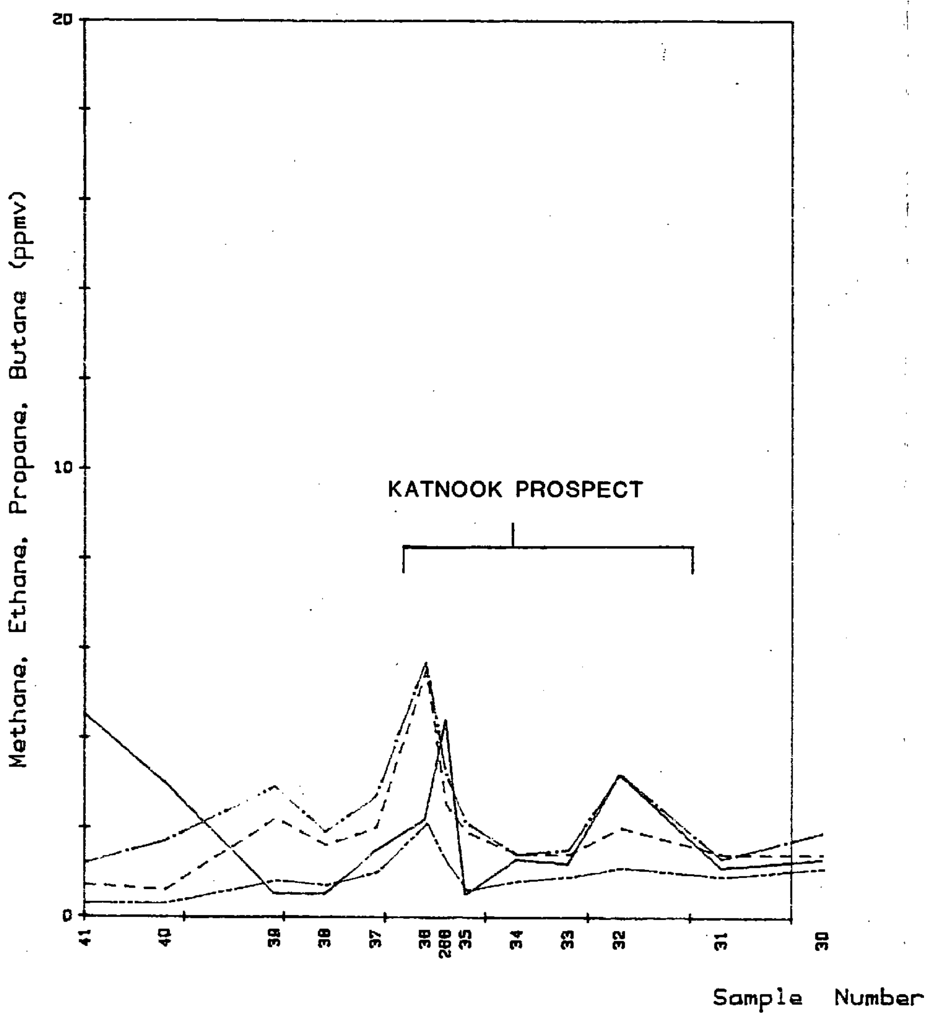
Horizontal Scale (1 km = 20 mm)

PETROFOCUS PTY. LTD.

SOIL GAS SURVEY

PEL 32
LINE 88-091

APRIL 88 | FIGURE 17



Legend

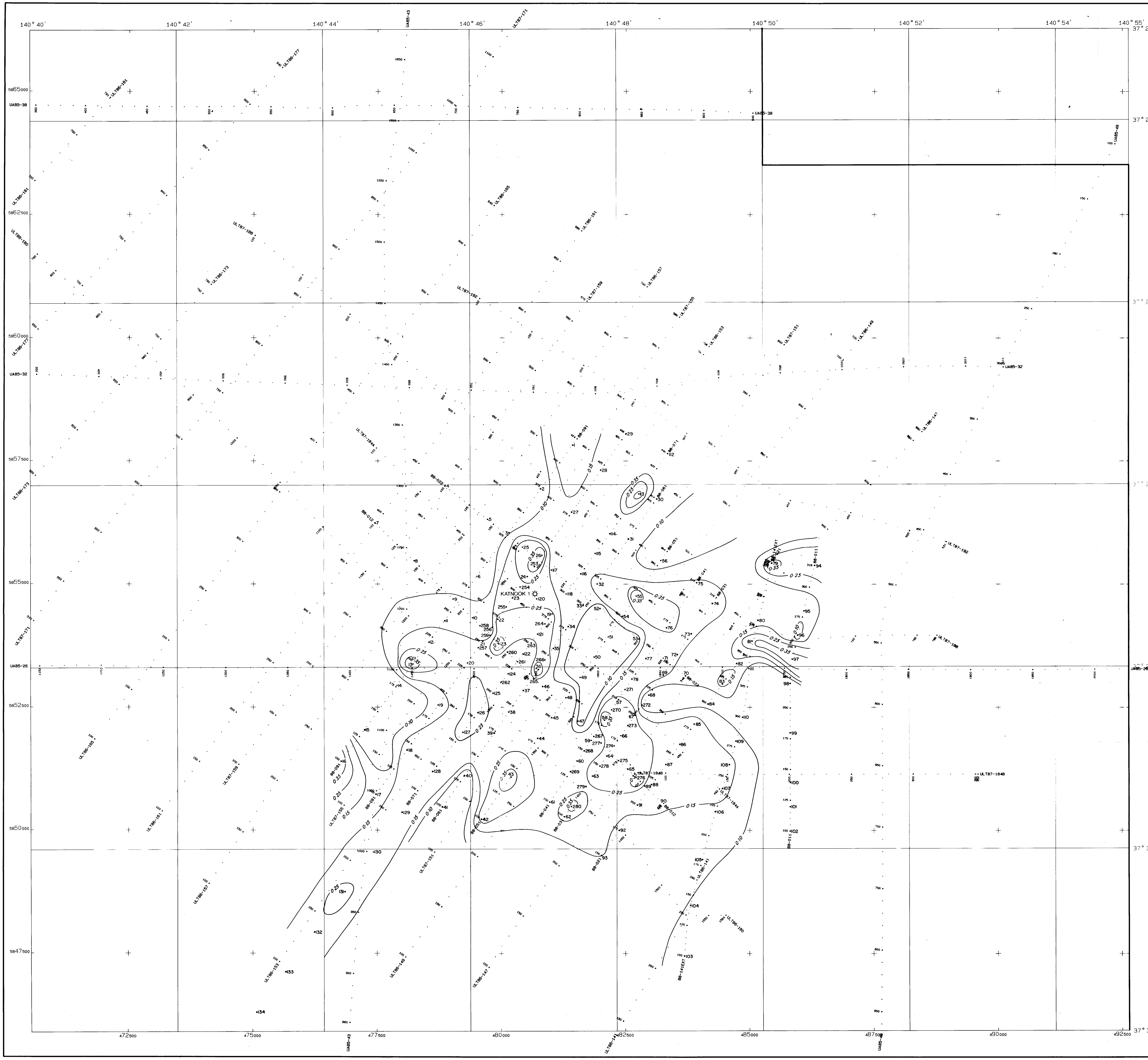
Methane		ppmv
Ethane	x 10	ppmv
Propane	x 10	ppmv
Butane	x 10	ppmv

0 2 4 6 km

Horizontal Scale (1 km = 20 mm)

PETROFOCUS PTY. LTD.	
SOIL GAS SURVEY	
PEL 32 LINE 88-061	
APRIL 88	FIGURE 18

00044



•52 Soil gas sample location

Map Production By
ENCOM PROCESSING SERVICES
Australian Map Grid
Australian National Spheroid
Central Meridian 141 Degrees
Zone 54
April, 1988

SCALE

1: 25000

0 200 400 600 800 1000 m

8904-1 **Enclosure 1**

PETROFOCUS PTY. LTD.

PEL 32
Otway Basin, S.A.

SOIL GAS ALKANE SURVEY
SAMPLE LOCATION MAP
AND CONTOURS OF
PROPANE CONCENTRATIONS

Compiled by: B.C.F/A.M.	Date: APRIL 1988
Drawn by: L.G.	Drawing No.:

Map Production By
ENCOM PROCESSING SERVICES
Australian Map Grid
Australian National Spheroid
Central Meridian 141 Degrees
Zone 54
April, 1988

•52 Soil gas sample location

Areas with anomolous and elevated concentrations of the light alkane gases.

Leads and Prospects shown as defined from seismic by the operator.

SCALE

1: 50000

0 500 1000 1500 2000 2500 3000 m

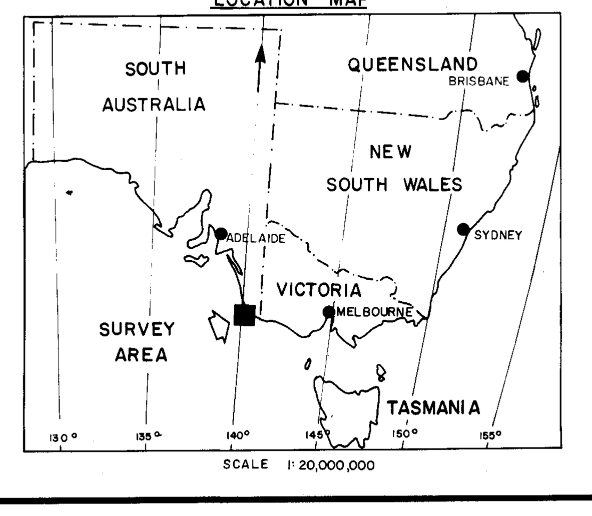
8904-2 **Enclosure 2**

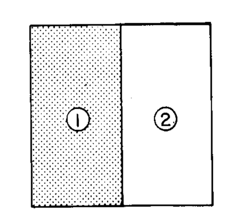
PETROFOCUS PTY. LTD.

PEL 32
Otway Basin, S.A.

SOIL GAS ALKANE SURVEY
SAMPLE LOCATION MAP

Compiled by: B.C.F./A.M.	Date: APRIL 1988
Drawn by: L.G.	Drawing No.:





KILOMETRES

•184 Soil gas sample location

Areas with anomolous and elevated concentrations of the light alkanes.

Leads and Prospects shown as defined from seismic by the operator.

8904-3

Enclosure 3

PETROFOCUS PTY. LTD.

PEL 32
Otway Basin, S.A.

SOIL GAS ALKANE SURVEY
SAMPLE LOCATION MAP

Compiled by : B.C.F/A.M.	Date : APRIL 1988
Drawn by : L.G.	Drawing No. :