

AIRBORNE HYDROCARBON GAS SURVEY

AND

SOIL GAS SURVEY

AT

OP 175

AMADEUS BASIN, NORTHERN TERRITORY

September, 1981.

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SUMMARY

An airborne hydrocarbon gas sensor survey flown over selected areas of OP 175 and two anticlinal structures in OP 178 detected over 30 zones of anomalous hydrocarbon microseepage. The largest of these zones were associated with the Mereenie oilfield and the Palm Valley gasfield. Zones of major microseepage were also recorded at Hermannsburg, Merrick, Mt. Holder and Wallera on OP 175 and at Tarawera and Undandita on OP 178, but these have smaller areal dimensions than those at Mereenie or Palm Valley. A further 16 zones of moderate hydrocarbon microseepage were outlined, but previous drilling results into some of these have shown their source to be only minor gas or oil shows.

Limited ground surveys showed anomalous concentrations of methane, ethane and propane (C1, C2 and C3) above the Mereenie oilfield, but reliable samples could not be collected at Palm Valley because of the lack of soil development. Ten other microseepage zones were surveyed on the ground and weakly anomalous concentrations of C1, C2 and C3 occur in soil gas over the Mt. Holder, McMinn and, perhaps, the Merrick prospects. Other prospects sampled on the ground appear to have less potential, but deserve to be tested by a more comprehensive ground survey, utilising more sensitive collection methods for areas dominated by loose sand cover.

1. INTRODUCTION

The large extent of many petroleum exploration permits, the often imprecise knowledge of their geology, and the high cost of seismic surveys have demanded the assessment of new techniques for oil and gas exploration in Australia. Vaporsearch Pty. Ltd. has carried out orientation geochemical surveys, using both airborne and ground techniques, over known oil and gas reservoirs in south-west Queensland and has compiled a number of successful case studies which show detectable concentrations of light hydrocarbon gases in the atmosphere above these reservoirs. This information provides benchmarks for interpretation of anomalous levels of gaseous hydrocarbons detected in surveys elsewhere.

Airborne surveys are followed by a programme of ground sampling in which soil gas is collected from lines over and beyond the anomaly detected by the airborne survey. This leads to better definition of the anomaly on the ground and chemical analysis of the soil gas can give information which indicates the nature of the source hydrocarbons (e.g. oil, gas condensate, dry gas) in the reservoirs.

Pancontinental Petroleum contracted Vaporsearch to survey a number of known anticlinal structures in OP 175 and two structures in OP 178 in the Amadeus Basin using an airborne hydrocarbon sensor. Orientation surveys were conducted over the Mereenie oilfield and the Palm Valley gasfield, in addition to a number of other areas which had been previously drilled and found to contain only minor or insignificant amounts of oil or gas. Results from these known situations enable qualitative (but subjective) rating of anomalies detected in undrilled areas.

A limited amount of ground sampling was planned to immediately follow the airborne survey, but it was recognised that this would not provide data sufficient to define the extent and intensity of anomalies on the ground or to give definitive information on the possible hydrocarbon source. The data derived from the ground survey was expected to permit priorities to be assigned for later, comprehensive surveys.

2. OPERATIONS

Geochemical surveys were conducted over OP 175 and over the selected structural targets in OP 178 during July, 1981. During the period 10th to 25th July, an airborne geochemical survey was conducted under contract to Vaporsearch by Geochemical Systems Corporation of Dallas, Texas. This survey employed a hydrocarbon gas detector mounted on a Bell Jet Ranger III helicopter chartered from Central Australian Helicopters Pty. Ltd. of Alice Springs. For the first 8 days the survey was based at Alice Springs but to survey the western area the base was moved to Wallera Ranch.

A programme of ground geochemical sampling designed to characterise the Mereenie and Palm Valley fields, and anomalous zones of hydrocarbon microseepage detected by the airborne survey was undertaken from 19th to 26th July. Soil gas samples collected in the survey were analysed at the base camp by Geochemical Service Inc., a subsidiary of Texas Instruments of Dallas, Texas.

The scope of the ground survey was limited by the availability of the helicopter for transport, particularly in the western part of OP 175, where road access is difficult. However, where possible, the ground surveys were conducted by four-wheel drive vehicle. The time constraints imposed by helicopter availability and budget meant that, generally, only one line of ground samples were collected over zones of hydrocarbon microseeps detected during the airborne survey, and that others could not be surveyed at all.

3. SURVEY METHODS

Although macroseeps of both gaseous and liquid hydrocarbons, which are recognised by smell or sight, have led to the discovery of numerous commercial petroleum fields, the potential of microseeps, which cannot be recognised with unaided human senses, has not been appreciated. Despite many tests being carried out above known gaseous or liquid hydrocarbon reservoirs no convincing case histories showing the presence of light hydrocarbon species in soil gas or in the atmosphere have been published. This has led to scepticism of the use of geochemical methods for petroleum exploration. However, many previous geochemical surveys were inconclusive as they employed insensitive analytical methods which were incapable of detecting nanogram quantities of light hydrocarbon gases. Furthermore, many previous surveys encountered serious problems with sample collection and transport to the laboratory of soil gas containing very dilute, readily diffusable hydrocarbon species.

There remains in the petroleum exploration industry a general disbelief that significant quantities of light hydrocarbons do escape from gas and/or oil reservoirs at depth and can be detected directly above or peripheral to the reservoirs. Nevertheless, there is a growing body of evidence which attests to the migration of gaseous hydrocarbons taking place, but the mechanisms of migration have not been resolved.

During the past year in Australia Vaporsearch has carried out orientation surveys over some fifteen known gas and/or oil reservoirs and has assembled case histories which show the presence of detectable light hydrocarbon gases (methane through pentane) in both soil pore spaces (termed "soil gas") and in the near-surface atmosphere. Many of the problems associated with the field and laboratory procedures have been satisfactorily overcome to permit limited conclusions to be drawn from the results but it is stressed that the techniques must be further refined and extended to permit confident and precise analysis of the results.

The case studies compiled by Vaporsearch demonstrate that a flux of light hydrocarbon gases is present above accumulations of gaseous and/or liquid hydrocarbons and that these can be detected in soil gas or in the near-surface atmosphere. To detect and map the distribution of the gases in the atmosphere, a hydrocarbon sensor is mounted on a helicopter which traverses the survey area at heights of 5 to 10 metres at a speed of some 70 knots.

The sensor transmits highly directional pulses of electromagnetic energy at precisely controlled frequencies from a rotating antenna located under the helicopter. Energy is absorbed by hydrocarbon gas molecules which pass to a higher energy state. When the pulse is completed the molecules return to their original energy state, emitting characteristic radiation which is detected by the sensor. The intensity of the signal is a function of the amount of gas present and the angular position of the antenna indicates direction, while the distance to the gas discharge is indicated by the time differences between transmission and return of the signal. The above parameters are displayed on a cathode ray tube presenting a map of near-surface atmospheric hydrocarbon concentrations. This information is manually transferred to topographic maps or air photographs, which are used for ground follow-up.

The airborne sensor does not distinguish the different hydrocarbon species which may be present in the atmosphere. Care must be exercised to recognise the presence of biogenically-derived methane which does not relate to the presence of petroleum at depth. Further, the airborne sensor is ineffective in areas with thick or dense brush cover.

Following an airborne survey, anomalous areas are defined and characterised by a ground survey technique in which soil gas samples are collected from profiles extending from non-anomalous (background) areas through the anomaly and again into background areas. The

number of samples collected depends on many factors including financial and time constraints, the areal extent of airborne sensor anomalies and the availability of suitable soils for sampling. In general, some 50 soil gas samples are collected to adequately characterise anomalies detected by the airborne sensor.

Ground surveys may be carried out without prior airborne survey if target areas are known or tenement blocks are sufficiently small. This type of survey is considerably cheaper and gives results which can be directly interpreted as to the likely source of hydrocarbons in near-surface soil gas.

For the ground surveys, soil gas samples are carefully collected from depths ranging from 0.5 to 1 metre using a probe of proprietary design and pre-prepared microsyringes. The samples are carefully packed in air-tight containers for shipment to the laboratory.

The soil gas samples are analysed for the light hydrocarbons methane through pentane (C1 to C5) by a commercial laboratory employing conventional hydrogen flame gas chromatography.

Because of differences in the proportion of oil and gas from reservoir to reservoir, and in the composition of the oil and gas phases, together with differences in reservoir parameters and in soil characteristics from region to region, an attempt is always 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 within areas having closely similar reservoir and soil characteristics. This is because the magnitude of an anomaly may be determined by the ease of the migration of gases from the reservoir, rather than by the volume of gas in the reservoir.

The parameters which govern the amount and type of hydrocarbon gases present in near-surface environments are only imperfectly understood but include the following:

- (i) 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.
- (ii) Soil properties, particularly the clay content, degree of compaction and moisture content of the soil.
- (iii) 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. The reasons for this are not always simple but, commonly, conditions under which the later surveys are conducted are different from those experienced 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 : background contrast rather than with the absolute magnitude of anomalies. Comparison with results obtained from over known reservoirs considerably facilitates interpretation of those obtained from survey areas.

4. SURVEY AREAS

The airborne and limited ground follow-up surveys were conducted with the understanding that three areas of OP 175 would be available for farm-in. These areas are shown in Figure 1. In the areas of OP 175 excluded from the farm-in, Pancontinental Petroleum contracted Vaporsearch to assess as many known anticlinal structures as possible in 6 days of airborne survey. In the farm-in areas the objective was to assess known anticlinal structures and also the sand-covered areas, particularly of Area 1, where the geology is poorly known.

4.1 Airborne survey

Because of the large size of OP 175 and the limited budget the helicopter-borne hydrocarbon sensor was intensively employed only over known anticlinal structures, which were surveyed at flight line spacings of about 2 km. Elsewhere, line spacings were about 5 km, but in Area 1, south of the Wallera Ranch road, known anticlines were surveyed as before, but in sand-covered areas flight lines were to 10 km apart and permit only partial assessment of this region.

During survey, the helicopter was flown as close to ground level as practicable and when hydrocarbon microseepages were detected, the extent and magnitude of the anomalous area was defined by flying a series of smaller box patterns until the most intense part, or parts, of the anomaly could be mapped. Following this, several cross-lines were typically flown to better define the limits of the anomalous zone.

The areas of anomalous gas microseepages, as indicated on 1:250 000 topographic maps (Figs. 2 - 7) are imprecise in many instances, due to the lack of defineable features on the ground. Errors of as much as ± 2 km may be present.

4.2 Ground survey

Soil gas orientation surveys were conducted on two lines over the Mereenie oilfield, but a similar survey to characterise the Palm Valley gasfield was unsuccessful due to the lack of soil cover over the Palm Valley anticline. Ten anomalies defined by the airborne sensor in OP 175 have been partially evaluated by ground soil gas surveys, but the number and locations of samples are not adequate to allow statistical determination of either anomalous or background values. These are best determined by an examination of the results from a sufficient number of samples collected from pre-determined, regular grids layed-out over the survey area to cover both anomalous and background areas.

5. RESULTS

5.1 Airborne survey

The helicopter-borne sensor detected over 30 zones of light hydrocarbon gas microseepage in OP 175, and 3 in OP 178 (Figs. 2 - 7). All but the weakest microseepages are listed in Table 1, along with their rating and approximate surface dimensions.

In the area surveyed, 8 zones of major hydrocarbon microseepage were detected. These include the Mereenie oilfield, Palm Valley gasfield, and the Tarawera and Undandita anomalies in OP 178. In OP 175 major microseepages occur, and have been designated as Hermannsburg (Fig. 4), Merrick, Mt. Holder and Wallera (Fig. 5). The Hermannsburg anomaly is situated in Area 2, the Mt. Holder anomaly is mostly in Area 1, and the Wallera anomaly is wholly within Area 1. Slightly weaker zones of microseepage detected at McMinn and Mt. Ormerod (Fig. 5) are situated within Area 1.

Zones of moderate hydrocarbon microseepage are distributed throughout OP 175, but their surface dimensions are, generally, smaller than those of the more significant microseepages. It is striking that all major microseepages occur in the western half of OP 175 and that the zones of microseepage over the known reservoirs at Mereenie and Palm Valley have significantly greater surface dimensions than those detected in other areas.

It must be borne in mind, however, that the intensity or surface dimensions of zones of hydrocarbon microseepage may not reflect the size of the hydrocarbon reservoir at depth. However, in areas characterised by similar lithologies, reservoir characteristics and soil types, the intensity and dimensions of the microseepage may serve as an indication of reservoir size.

This assumption appears to be valid for the Mereenie and Palm Valley fields, which contain large concentrations of petroliferous hydrocarbons. Extending the assumption, the Undandita, Tarawera and Hermannsburg microseepages may also reflect substantial concentrations of hydrocarbons at depth.

5.2 Ground survey

The light hydrocarbon gases have been determined at stations on one or more lines over 12 microseeps detected by the helicopter-borne survey. Although some 262 samples were collected, this number is insufficient to permit the extent of the anomalies to be defined on the ground or to adequately define background concentrations of hydrocarbons in soil gas. The number of samples collected was limited due to budgetary constraints, particularly as these affected the amount of helicopter support.

5.2.1 Mereenie oilfield

Soil gas samples were collected from two profiles in the Mereenie area near known well-sites, although time constraints prevented extending the second line beyond the anomalous area revealed from the airborne survey.

Soil types in the Mereenie area are generally sandy and often only loosely compacted. However, skeletal soils are developed over parts of the profile lines and near dried water courses very compacted, clay-rich soils are present.

Samples on traverse 1 (samples 118 to 135, Fig. 8) were collected at half kilometer stations from a line bearing about 205° passing near the East Mereenie No. 2 and 4 wells from prominent rocky walls on each side of a fairly flat valley. Acceptable samples could not be obtained from stations at each end of the lines due to the rocky nature of the soil profile. Stations remote from the exploration wells were about 3 km distant and at these sites C1 content of soil gas is about 15 - 20 ppm, C2 is 2.0 - 2.5 ppm and C3 is 0.5 - 1.5 ppm. The very small number of samples collected does not permit a statistical definition of background values to be made, but the values from the remote stations give some indication of the lower limits likely to be encountered elsewhere in the Mereenie area.

Near the wellsites the concentrations of C1 peaks at about four times the lowest value and C2 is also nearly four times greater, whilst C3 is some four to six times more concentrated. The profile clearly shows a prominent peak near, and south-west from, the wellsites with lower values at each end of the profile.

The second profile (samples 136 to 150, Fig. 9), obtained some 11 km north-west from the first, was on a bearing of 205° and commenced as close as practicable to the rocky valley wall and extended to finish in rolling sand dune country. Samples were collected at half kilometer spacing, but near west Mereenie No. 2 well sample spacing was a quarter of a kilometer.

The lowest values recorded on this line are about 5 to 10 ppm C1, 1.5 to 2.0 ppm C2 and 0.5 to 1.0 ppm C3, from stations at the north-east part of the line.

5.2.2 Palm Valley gasfield

At Palm Valley outcrop is abundant and soils are only very patchily developed so that reliable soil gas samples could not be collected. At the eastern edge of the field, where thin, skeletal soils are present, an attempt was made to collect samples (numbers 21, 22 and 207 to 215, Fig. 10) but results from these certainly will not be representative of the flux of hydrocarbon gas escaping from the reservoir. Bearing this in mind, some limited interpretation is possible.

In the vicinity of the No. 1 and 2 wells, only low levels of hydrocarbons in soil gas were detected and range from 11 to 13 ppm C1, about 1.5 ppm C2 and less than 0.5 ppm C3. The C1:C2 ratio lies near 9, which is slightly higher than that for samples from Mereenie and may reflect the greater gas content of the Palm Valley field.

Away from the field the concentration of light hydrocarbon species in soil gas decreases, but the contrast of the lowest results to the highest (from near the wells) is only very low. This is interpreted as being due to the poor sampling conditions.

5.2.3 Wallaby prospect (Alice Springs Sheet; Fig. 2)

Samples 26 to 64 were collected in duplicate alongside the seismic line on which the well, Wallaby No. 1, was drilling. The soil gas contents for duplicate samples was very similar, and the same trends in the data were apparent. The results for the even-numbered samples are shown in Figure 11.

The C1 contents of all soil gas samples are fairly uniform, extending from about 8 to 14 ppm. The C2 contents, however, are quite variable from sample to sample and show a ratio of near 2 for the highest to lowest contents. The C3 contents of soil gas are fairly low, ranging from about 0.2 to 0.9 ppm.

The C1:C2 ratio of about 6 indicates an oil source for the hydrocarbons, but results from the Wallaby No. 1 well suggest that C1:C2 ratios of this magnitude may also reflect the presence of only gas. The low absolute concentrations of hydrocarbons in the soil gas evidently reflect the small size of the reservoir found by Wallaby No. 1.

Three soil gas samples collected near the Alice No. 1 well site, which is situated in the approximate centre of a small, moderately intense airborne anomaly to the west of Wallaby, contain only about 9 ppm C1, 1.5 to 1.8 ppm C2 and 0.7 ppm C3. The low C1:C2 ratio of about 6 suggests an oil-rich, rather than gas-rich source and is in agreement with the findings from Alice No. 1

5.2.4 Orange prospect (Rodinga Sheet; Fig. 3)

Samples 67 to 89 were collected from an approximate east-west line across the airborne sensor anomaly. Soils in the area range from well-compacted sandy types to loose dune sands. Over the entire profile the hydrocarbon contents of soil gas are low (Fig. 12) and no anomalous zone could be defined by the ground survey. It is possible that the ground traverse did not cross the most intense part of the anomaly defined by the airborne system.

The C1 contents of the samples taken ranges from about 8 to 12 ppm, but the C2 content is more variable, ranging from about 0.4 to 1.5 ppm. Whilst this represents an almost fourfold range, the peak concentrations are very low, and lie near background values at Mereenie.

An airborne gas sensor anomaly, located some 5 km east of the Orange anomaly, whilst having a smaller surface extent, has a similar microseepage intensity. This feature lies on an anticlinal structure which has been tested by the Orange No. 1 well which encountered gas shows in the Chandler Formation from 2286 to 2316m. It is possible that the Orange microseepage has a similar source to that encountered in the Orange No. 1 well.

5.2.5 Dingo prospect (Rodinga Sheet; Fig. 3)

Samples 90 to 106 were collected through the centre of the Dingo anomaly (Fig. 3). Soils in this region are loose-packed sands and dunes are common. The hydrocarbon contents of soil gas samples are low, and no anomalous zone is defined by the ground sampling (Fig. 13 and Table 3).

5.2.6 Merrick prospect (Henbury Sheet; Fig. 5)

Samples 1 to 11 were collected from a south-north line across the anomalous zone and 12 to 17 were collected from the western end of the zone, as shown in Figure 5. Soils are dominantly sandy, although the profiles are rocky due to scree material at the sides of Merrick Gully and stoney near the creek bed. Overall, samples were difficult to collect.

The lowest C1 content of soil gas samples is about 8 ppm, with peak values of about 16 ppm (Fig. 14 and Table 3). C2 contents range from 0.5 to 2.1 ppm and may define an anomalous area near the centre of the zone outlined by the airborne survey.

Two soil gas samples (18 and 19) were collected some 6 km from the centre of the Merrick airborne anomaly (Fig. 5) in an area where no hydrocarbon microseepages were previously detected. These samples give an indication of local background concentrations. The results (plotted on Fig. 15) show C1 contents to be about 8 to 10 ppm, C2 to be about 0.8 to 1 ppm and C3 contents to be near 0.1 ppm.

The James Range A No. 1 well, drilled in 1965 some 6 km east of the centre of the Merrick microseepage (Fig. 5) encountered no significant hydrocarbon zones. Although the size of a sub-surface source cannot be assessed reliably from consideration of the soil gas hydrocarbon contents, it seems reasonable to conclude that a hydrocarbon reservoir, having a petroliferous character, is responsible for the Merrick hydrocarbon gas microseepage.

5.2.7 McMinn prospect (Henbury Sheet; Fig. 5)

Samples 216 to 218 were collected along the Illamurta Spring road, but only the last few of these were from the most intense part of the airborne hydrocarbon sensor anomaly. Soils in the area are sandy, but near the end of the traverse skeletal types are present.

The light hydrocarbon contents of soil gas are fairly low and uniform for the first eleven samples, but the last two show a marked increase in C1, C2 and C3 contents (Fig. 15). This is interpreted as an encouraging result and the prospect deserves to be more fully tested.

5.2.8 Mt. Holder prospect (Henbury Sheet; Fig. 5)

Two traverses were made in this area. The first, samples 151 to 164, commenced near Illawilla Bore and was conducted in a south-westerly direction (Fig. 5). Soils were compact and sandy with clay-rich types present near the centre of the traverse.

The C1 content of soil gas samples shows a broad, low-amplitude peak located near the centre of the traverse, but this is not paralleled by the C2 content, which has a maximum value of near 50 ppm at station 151 and decreases toward the end of the traverse (Fig. 16a). The C3 contents of the soil gas samples are fairly uniform.

In an attempt to provide additional data to characterise the Mt. Holder anomaly, a west-to-east traverse was planned. However, very rocky soils prevented sample collection from the intended traverse and samples were collected only from the periphery of the anomaly. The results (Fig. 16b) show moderate contrast between the lowest and highest C1 and C2 contents and a sympathetic, but more subdued C3 response. This is interpreted as indicating a hydrocarbon source, and the C1 to C2 ratio of near 6 suggests it to be petroliferous.

5.2.9 Mt. Ormerod prospect (Henbury Sheet; Fig. 3)

Two traverses were made through the complex airborne hydrocarbon sensor anomaly at Mt. Ormerod (Fig. 5). The first (samples 165 to 175), were collected on a south-east to north-west traverse through rolling sand dune country. In these samples the C1 content is fairly uniform, although weakly anomalous concentrations are present in samples 168 and 169, which also contain anomalous concentrations of C2 (Fig. 17a). Throughout this traverse, the C1:C2 ratio is about 5 to 6, suggesting a petroliferous source.

The south to north traverse (samples 248 to 262), through the southern lobe of the Mt. Ormerod anomaly, was conducted in more compacted soils having a greater clay content than those on the previous traverse. The results (Fig. 17b) show a zone of broadly anomalous C1, C2 and C3 contents of soil gas in a zone extending northwards from sample station 253. The zone may extend in a north-easterly direction towards station 262.

5.2.10 Walleria prospect (Henbury Sheet; Fig. 5)

Two traverses were made across the Wallera anomaly, but these did not cross the most intense part of the anomaly. Soils ranged from sandy to clayey and near Olunga Well calcrete-rich types are present. In both traverses the C1 contents of the soil gas were low (Figs. 18a,b), ranging from about 0.5 to 1.5 ppm. On both traverses the greatest concentrations of hydrocarbons in the soil gas are in samples from near the axis of the airborne sensor anomaly.

5.2.11 Orange Creek prospect (Henbury Sheet; Fig. 5)

Nine samples from an approximate south to north line were collected from well-compacted clay soils through the airborne sensor anomaly which is located south of the Orange Creek station. The C1 contents of the soil gas is fairly constant, ranging between 10 and 15 ppm. C2 ranges from 1.5 to 3 ppm, and is high compared with the C1 concentrations, but it defines no obvious anomalous zone, and the highest concentration is present south of the airborne sensor anomaly. The C3 contents of soil gas are also fairly uniform but enhanced contents are present in soil gas from stations 109 and 110 (Fig. 19), which are located near the centre of the airborne sensor anomaly.

5.2.12 Calgary prospect (Henbury Sheet; Fig. 5)

Soil gas samples collected from a south to north line through sandy country show only low C1 contents, ranging from 7 to 11 ppm and closely parallel C2 contents, ranging from 0.6 to 1.2 ppm (Fig. 20). No zone of anomalous hydrocarbon microseepage was defined by ground sampling.

6. CONCLUSIONS

6.1 Airborne survey

The airborne survey detected more than 30 zones of light hydrocarbon gas microseepage, of which 8 are classified as major, 2 are major-moderate and 14 are moderate. The Mereenie and Palm Valley fields are zones of major microseepage and have the largest surface extents of all the zones detected in the survey. The Mereenie zone is an alliptical shape, some 32 x 7 km, and the Palm Valley zone is about 23 x 8 km. In OP 175 zones of major hydrocarbon microseepage with large dimensions are Hermannsburg (16 x 7 km), Merrick (10 x 5 km), Mt. Holder (14 x 6 km) and Wallera (17 x 5 km). On OP 178 major zones of microseepage were defined at Tarawera (15 x 7 km) and Undandita (17 x 7 km).

Although the intensity and surface dimensions of hydrocarbon microseeps cannot reliably indicate the size of the source, it is noteworthy that the largest, most intense microseeps occur over the largest known petroleum reservoirs. In addition to Mereenie and Palm Valley, microseepage zones were detected that had been drilled previously on structures that have only minor gas or oil contents. However, all of these are rated as moderate or minor zones and have small surface dimensions compared with Mereenie or Palm Valley microseeps. Surveys over dry wells, James Range A No. 1 and Waterhouse No. 1, did not detect hydrocarbon microseeps.

6.2 Ground survey

Ground survey coverage was very limited and it is not possible to draw any firm conclusions from the data. Orientation traverses of the Mereenie field show clearly anomalous concentrations of C1, C2 and C3 on one line over the reservoir, but results over a second line are far less obvious. Reliable results could not be

obtained at Palm Valley due to the poor development of soil cover.

Recognising the limitations of the data, clearly anomalous concentrations of C1 and C2, and sometimes of C3, were obtained from samples collected near the Mt. Holder and McMinn prospects. Less well defined results, but possibly also reflecting a significant hydrocarbon source, were obtained at the Merrick prospect. Results obtained for other prospects are less encouraging. However, as cautioned earlier, the intensity and surface dimensions of the microseeps need not reflect the size of the source at depth.

It should also be pointed out that results obtained from areas characterised by sandy soils, and particularly from loose dune sands, may be very much subdued, due to the soils being aerated and due to problems associated with collection of the sample.

The limited ground surveys conducted over the zones of microseepage are not sufficient to reliably define their surface extent or to enable characterisation of their source.

7. RECOMMENDATIONS

Although the intensity and areal extent of microseeps of light hydrocarbon gases cannot presently be used as reliable indicators of the size of their sub-surface sources, the presence of very significant microseepages over the Mereenie oilfield and the Palm Valley gasfield suggests that similar microseepages located in nearby areas of OP 175 and 178 may also reflect the presence of substantial petroleum accumulations at depth.

In view of the low cost of light hydrocarbon gas exploration methods, and their effectiveness in areas such as the Amadeus Basin, it is recommended that the most prospective microseeps detected in the present survey be comprehensively surveyed on the ground. The microseepage zones listed in this report should be rated using geological and geophysical criteria and the most prospective of these be surveyed by taking soil gas samples from several traverse lines extending over the anomalous areas and well into background. Results of these surveys should be intergrated with results of seismic surveys to define drilling targets.

It is recommended, as part of the above programme, that comprehensive ground sampling surveys be undertaken over the reservoirs at Mereenie and Palm Valley and over structures such as Wallaby and Orange which contain only small amounts of oil or gas.

TABLE 1: Listing of zones of anomalous hydrocarbon microseepage detected in airborne survey.

<u>1:250 000 map sheet</u>	<u>Anomaly name</u>	<u>Intensity of Microseepage</u>	<u>Approx. dimensions (km)</u>
Alice Springs (Fig. 2)	- Wallaby ¹ - Phillipson Pound ¹ - Todd - Waterhouse ¹	- Moderate - Moderate - Moderate - Minor	7 x 3 4 x 3 8 x 2 4 x 2
Rodinga (Fig. 3)	- Dingo - Orange ¹ - Ooraminna ¹ - Deep Well - Soakage Dam - Picnic Bore	- Moderate - Moderate - Moderate - Moderate - Moderate - Minor	8 x 4 8 x 4 7 x 4 7 x 3 3 x 2 3 x 2
Hermannsburg (Fig. 4)	- Palm Valley ² - Hermannsburg - Rodina - Gosses Bluff	- Major - Major - Minor - Minor	23 x 8 16 x 7 6 x 3 6 x 3
Henbury (Fig. 5)	- Palm Valley ² - Merrick - Mt. Holder - Walleria - Mt. Ormerod ¹ - McMinn - Maloney Bore - Orange Creek - Calvary - Desert Oaks - Tempe Downs - James Range B ¹ - Parke Pass - Areyonga	- Major - Major - Major - Major - Major-moderate - Major-moderate - Moderate - Moderate - Moderate - Moderate - Moderate - Moderate-minor - Minor - Minor	23 x 8 10 x 5 14 x 6 17 x 5 10 x 4 15 x 5 9 x 5 10 x 6 7 x 4 10 x 4 6 x 3 7 x 4 6 x 3 7 x 3
Mt. Liebig (Fig. 6)	- Mereenie ² - Tarawera - Undandita - Mt. Solitary	- Major - Major - Major - Minor	32 x 7 15 x 7 17 x 7 8 x 4
Lake Amadeus (Fig. 7)	- Meerenie ² - West Walker	- Major - Moderate	32 x 7 17 x 5

NOTES:

(1) More than one zone.

(2) Significant overlap on two map sheets.

Ground survey ● G

TABLE 2: Intensity and dimensions of hydrocarbon microseepage anomalies detected in the present survey compared with results obtained from previous drilling.

Microseepage anomaly			Well summary	
Name	Intensity	Dimensions (km)	Name	Results
Mereenie	Major	32 x 7	Numerous wells	Major oilfield
Palm Valley	Major	23 x 8	Numerous wells	Major gasfield
Wallaby	Moderate	7 x 3	Wallaby No. 1	Gas shows
West Wallaby	Moderate	4 x 3	Alice No. 1	Minor oil
East Orange	Moderate	5 x 4	Orange No. 1	Gas shows
Gosses Bluff	Minor	6 x 3	Gosses Bluff No. 1	Minor gas
Ooraminna	Minor	7 x 4	Ooraminna No. 1	Minor gas

TABLE 3: Approximate methane, ethane and propane contents of soil gas from ground surveys over zones of anomalous microseepage detected by the airborne hydrocarbon sensor.

Anomaly name	Approx. hydrocarbon contents of soil gas (ppm)					
	Possible 'background' areas			Possible 'anomalous' areas		
	C1	C2	C3	C4	C5	C6
Mereenie Traverse 1	15	2.2	0.8	60	7.5	4.8
Traverse 2	10	1.5	0.6	22	3.0	1.4
Mt. Holder	15	2.0	0.5	25	4.9	0.9
McMinn	15	2.0	0.5	35	4.3	2.0
Merrick	8	0.5	0.2	16	2.1	0.5
Wallaby	10	1.0	0.4	14	2.3	0.9
Mt. Ormerod Traverse 1	10	1.2	0.4	13	3.0	0.6
Traverse 2	10	1.0	0.4	15	2.0	0.6
Wallera Traverse 1	5	0.7	0.3	9	1.4	0.4
Traverse 2	5	0.5	0.2	8	1.0	0.4
Orange Creek	13	1.5	0.6	13	3.0	1.2
Orange	8	0.4	0.3	12	1.5	0.9
Dingo	8	0.7	0.3	10	1.1	0.5
Calvary	8	0.7	0.2	11	1.1	0.4

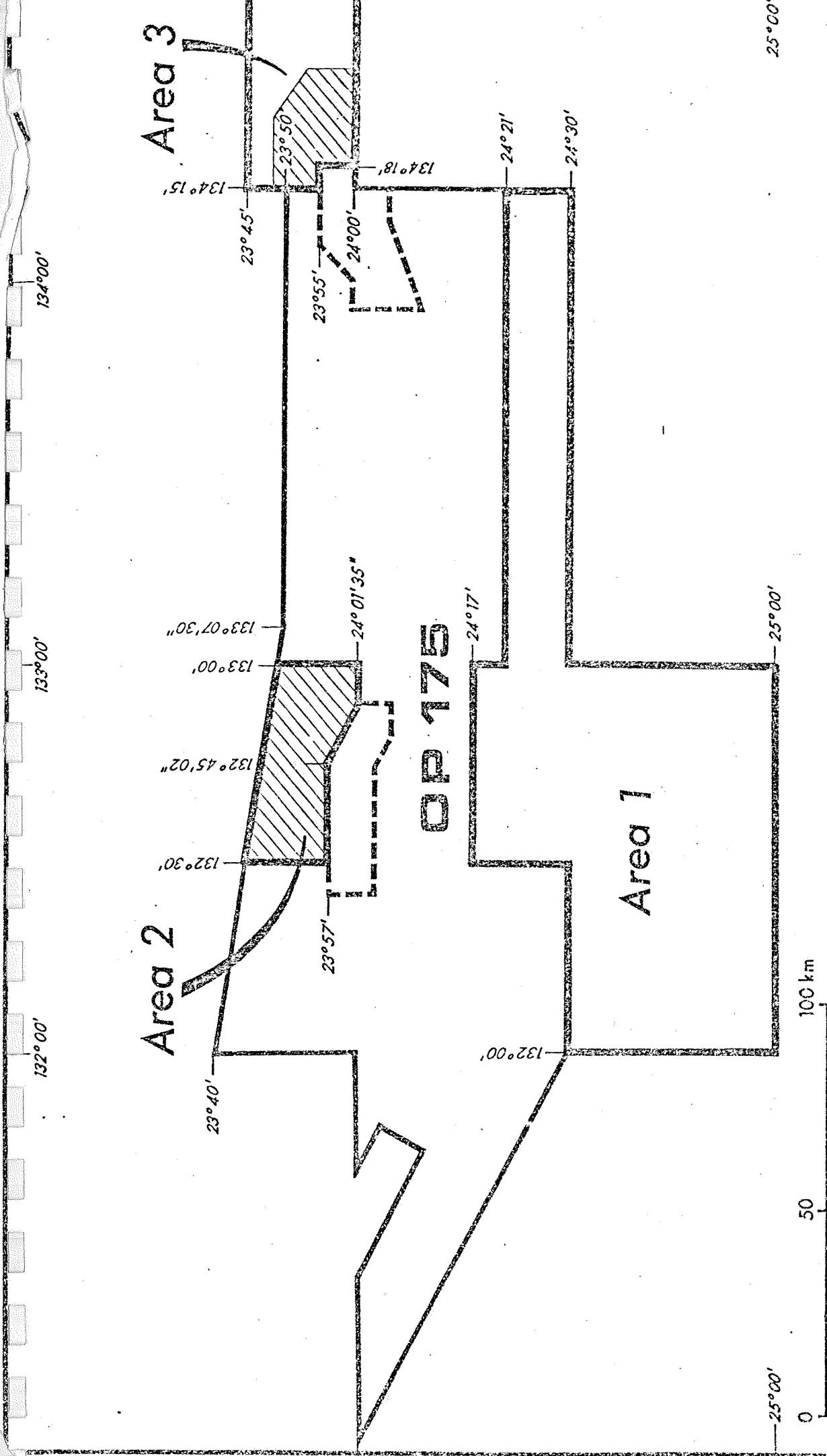
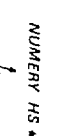
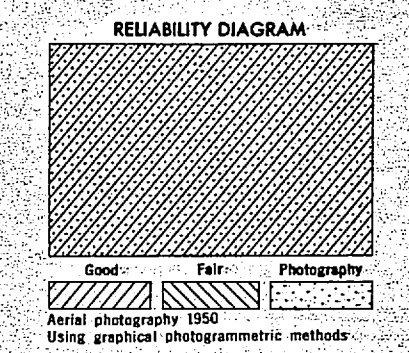


FIGURE 1: OP 175 showing three farm-in areas.



OP 175 Northern Territory



130° 30' LOCATION DIAGRAM 129°

Location	Species			
Mount Doree	Rappest	Alcatraz	Hickitt	Torenberry
Mount Loring	Fernknights	Alice Springs	Elwooda Creek	Rat River
Lake Anderson	Hermit	Redding	Rat River	Simpson Desert
Atter's Rock	Hermit	Fower	Elwooda Creek	Simpson Desert
Woodcove	Alcatraz	Alice Springs	Rat River	Woodcove

NORTHERN TERRITORY
SOUTH AUSTRALIA

LEGEND:

- Highway; built-up area
Road, sealed surface first class; route marker
Road/sealed surface second class, mileage
Road, loose surface oil weather first class
Road, loose surface oil weather second class
Road, loose surface dry weather
Road, unimproved earth
Bridge road, bridge railway
Railway multiple track
Railway single track
Light railway or tramway
Station; siding; station with siding
Telephone line; power transmission line
Ferry; stone wall
Lever or slide; quay
Mines; windmill; windmill
Building (g) church, school
Post office; wireless telegraphy; cemetery
Airport or aerodrome; landing ground
Control point major, mine; astronomical
Spot elevation in feet; accurate; approximate
Bench mark; mud, gravel
Sand; cliffs
Sand ridges; sand and dunes
Rail shed
Rail siding
Forest; forest; forest plantation
Forest continuous or pine plantation; scrub
Wetland; wetland or plantation
Wettable; water table; dam; dry lake
Lake; river or stream; peninsula
Lake; river or stream; peninsula
Dam or weir; falls; rapids
Drain or ditch perennial; intermittent
Spring perennial; intermittent; overflowed
Warm or swamp perennial; intermittent
Scaphoidae anachorae; scaphoidae
Breakwater; pier; dock or wharf
Fathom line; low water mark; light house
Wet; lagoon; exposed; vessel anchorage
Rock; submerged; bar or shoal

Legend

HYDROCARBON MICRO SEEPAGES

- Major
Moderate
Minor
Ground sample

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Revised from 1970 ground examination

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Scale 1:250,000

ELEVATIONS SHOWN IN FEET
VERTICAL DATUM IS BASED ON MEAN SEA LEVEL

TRANSVERSE MERCATOR PROJECTION
HORIZONTAL DATUM IS BASED ON MEAN ASTRONOMICAL DETERMINATIONS

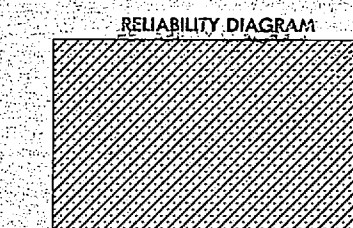
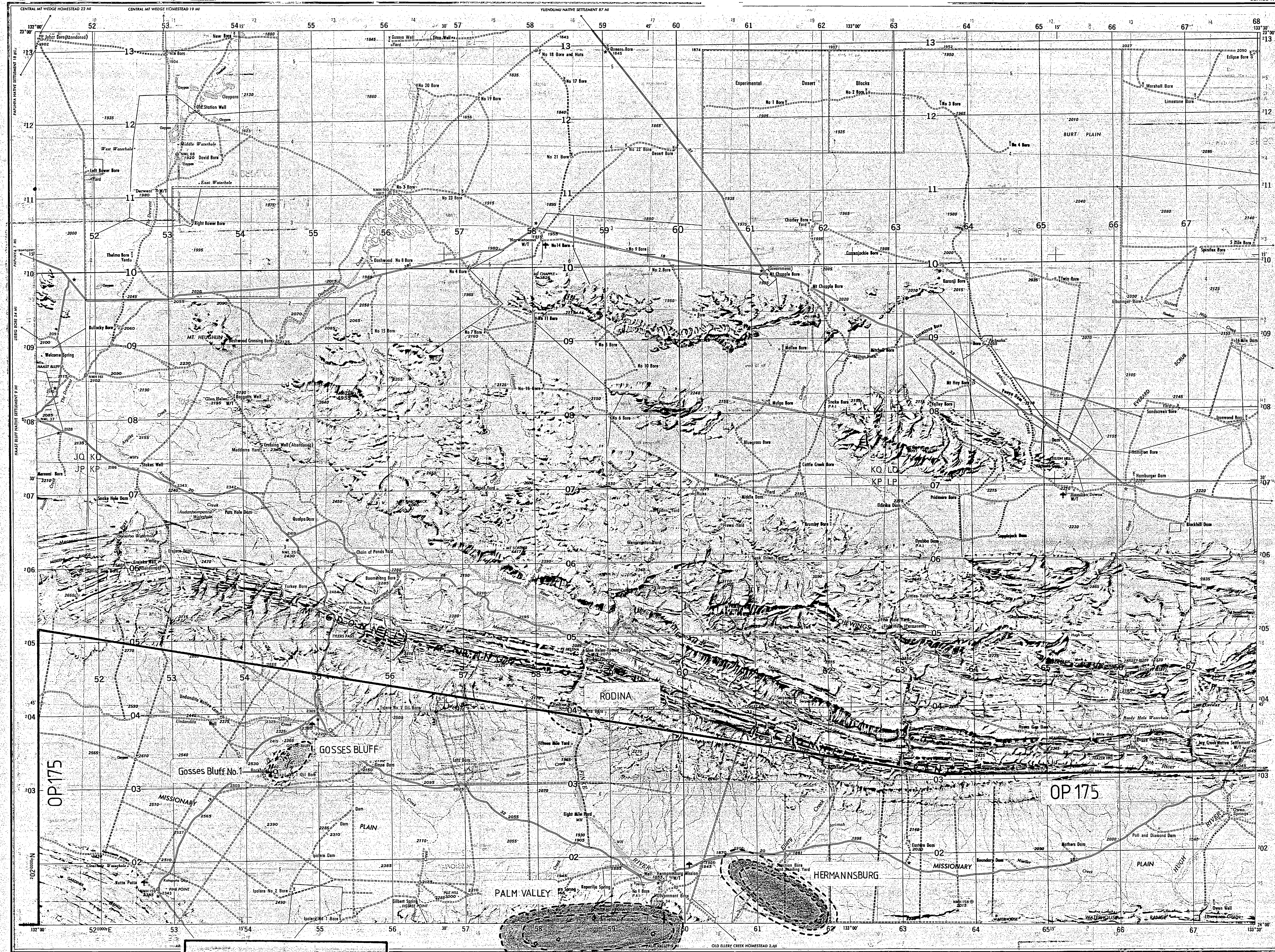
INDICATE THE 10,000-YARD TRANSVERSE MERCATOR GRID, ZONE 5 (AUSTRALIA SERIES) OF THE LAST FOUR DIGITS OF THE GRID NUMBERS ARE OMITTED

VAPORSEARCH PTY LTD

Airborne Hydrocarbon Survey

OP 175 Northern Territory

Fig. 3



Good Fair Photography
Aerial photography 1950-54
Using graphical photogrammetric methods.

LOCATION DIAGRAM

120°	121°	122°	123°	124°	125°	126°	127°	128°	129°	130°
10°	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°

- LEGEND
- Highway, built-up area.
 - Road, sealed surface first class, route marker.
 - Road, sealed surface second class, mileage.
 - Road, loose surface all weather first class.
 - Road, loose surface all weather second class.
 - Road, loose surface dry weather.
 - Road, unimproved earth.
 - Bridge, road, bridge railway.
 - Railway multiple track.
 - Railway single track.
 - Light railway or tramway.
 - Station, siding, station with siding.
 - Telephone line, power transmission line.
 - Fence, stone wall.
 - Levee or dyke, quarry.
 - Mine, windmill, yard.
 - Building (city, church, school).
 - Post office, wireless telegraph, wireless.
 - Airport or airfield, landing ground.
 - Control point major, minor, astronomical.
 - Spot elevation in feet, approximate.
 - Beach mark, mud, gravel.
 - Cliff, scarp.
 - Sand ridges, sand dunes.
 - Relief shading.
 - Forest dense, forest medium.
 - Forest deciduous or pine plantation, scrub.
 - Wetland, seasonal or permanent.
 - Wetland, water tank, dam, dry lake.
 - Lake, river or stream permanent.
 - Lake, river or stream intermittent.
 - Dam or weir, falls, rapids.
 - Drain or ditch perennial, intermittent.
 - Spring perennial, intermittent, reefed.
 - Marsh or swamp.
 - Seaplane anchorage, seaplane base.
 - Blackwater, pier, dock or wharf.
 - Fathom line, low water mark, light house.
 - Wreck, sunken, exposed, vessel, wreckage.
 - Rocks submerged, bare or awash.
 - Reef, rocky or coral.

SERIES R 502

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Legend

HYDROCARBON MICROSEEPAGES

- Major
- Moderate
- Minor
- Ground sample

Scale 1:250,000

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330 340 350 360 370 380 390 400 410 420 430 440 450 460 470 480 490 500 510 520 530 540 550 560 570 580 590 600 610 620 630 640 650 660 670 680 690 700 710 720 730 740 750 760 770 780 790 800 810 820 830 840 850 860 870 880 890 900 910 920 930 940 950 960 970 980 990 1000

ELEVATIONS SHOWN IN FEET
VERTICAL DATUM IS BASED ON MEAN SEA LEVEL

TRANSVERSE MERCATOR PROJECTION
HORIZONTAL DATUM IS BASED ON MEAN ASTRONOMICAL DETERMINATIONS

BLACK NUMBERED LINES INDICATE THE 10,000 YARD TRANSVERSE MERCATOR GRID, ZONE 4 (AUSTRALIA SERIES); CLARKE 1858 SPHEROID

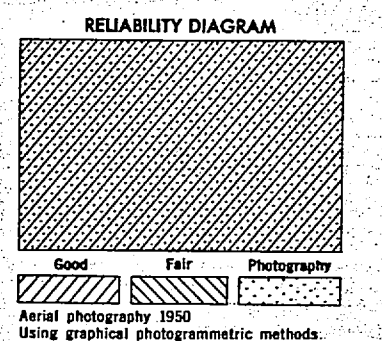
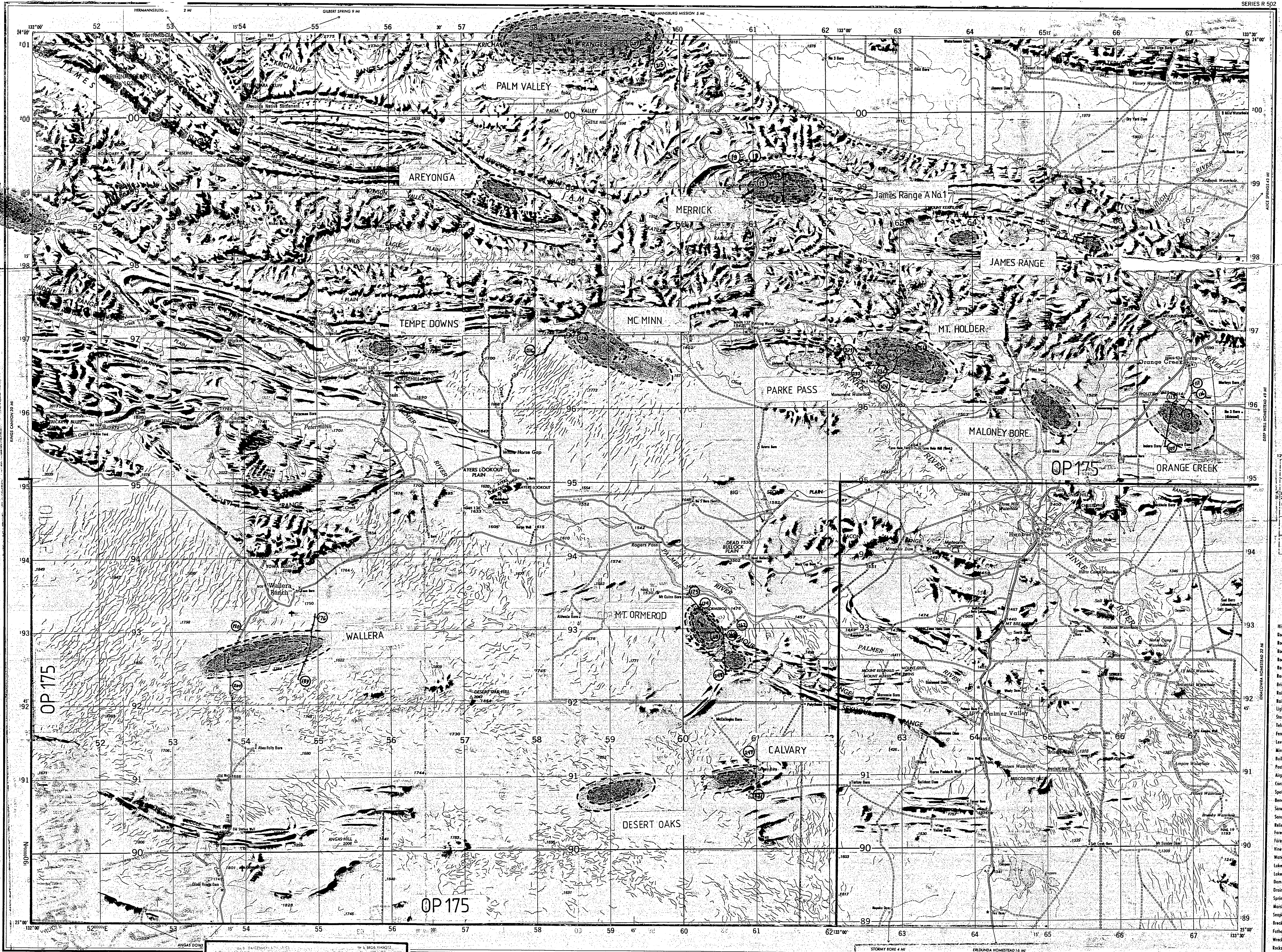
THE LAST FOUR DIGITS OF THE GRID NUMBERS ARE OMITTED

1965 MAGNETIC DECLINATION FOR THIS SHEET VARIES FROM 4°30' EASTERLY FOR THE CENTRE OF THE WEST EDGE TO 4°45' EASTERLY FOR THE CENTRE OF THE EAST EDGE; MEAN ANNUAL CHANGE IS 0°01' EASTERLY.

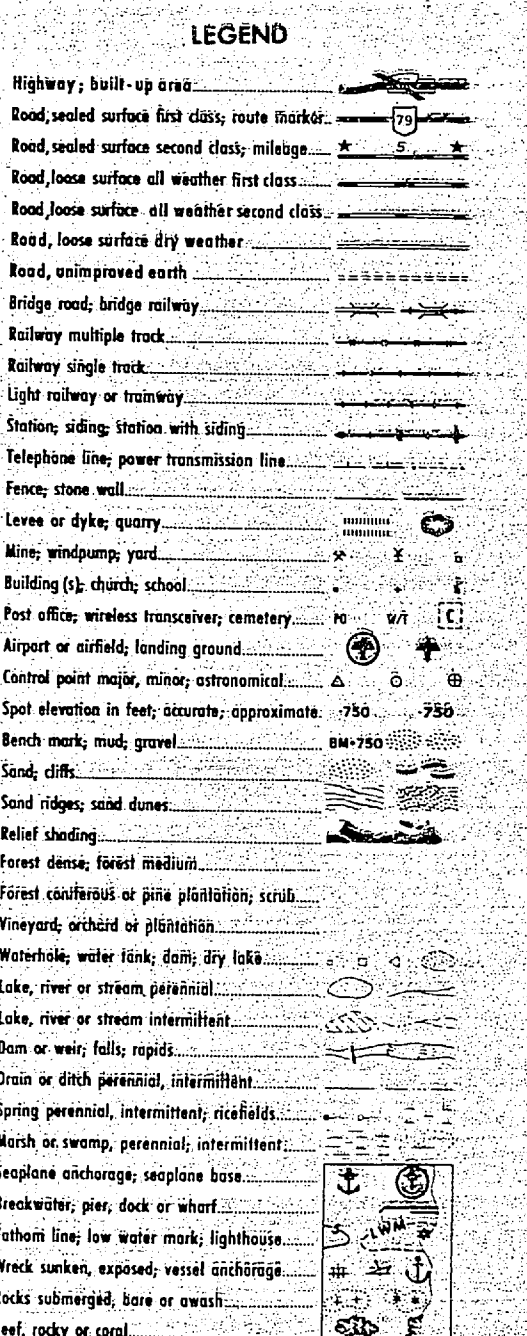
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Airborne Hydrocarbon Survey

OP 175 Northern Territory



LOCATION DIAGRAM									
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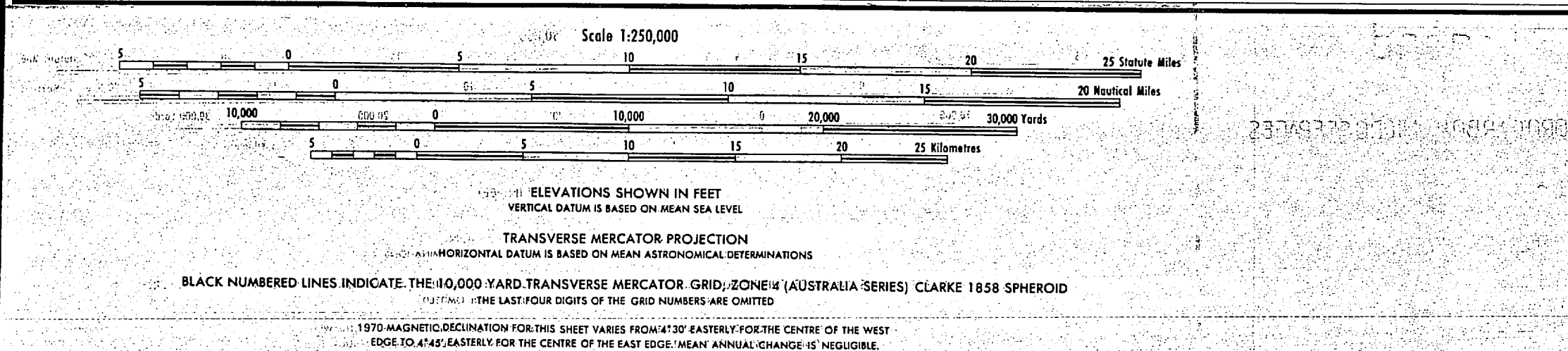
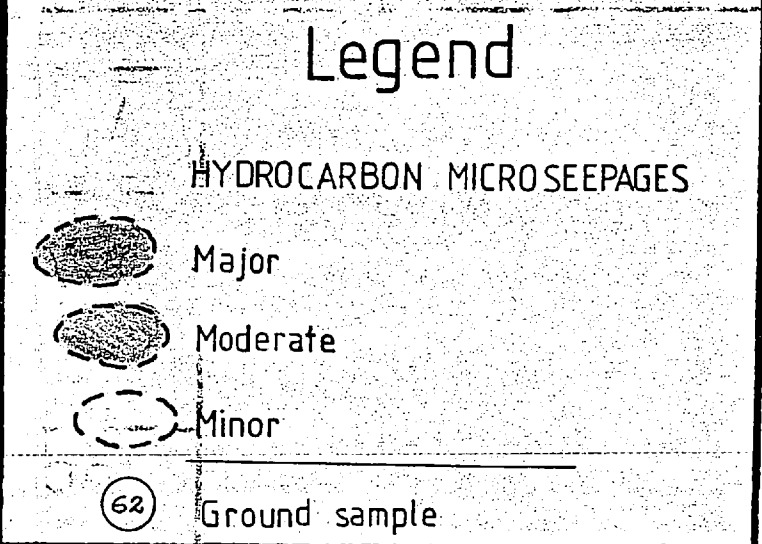
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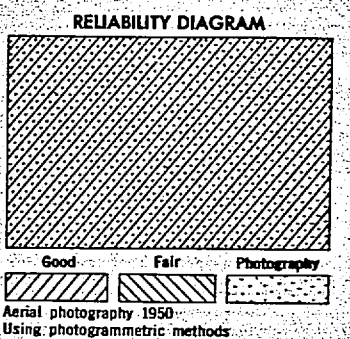
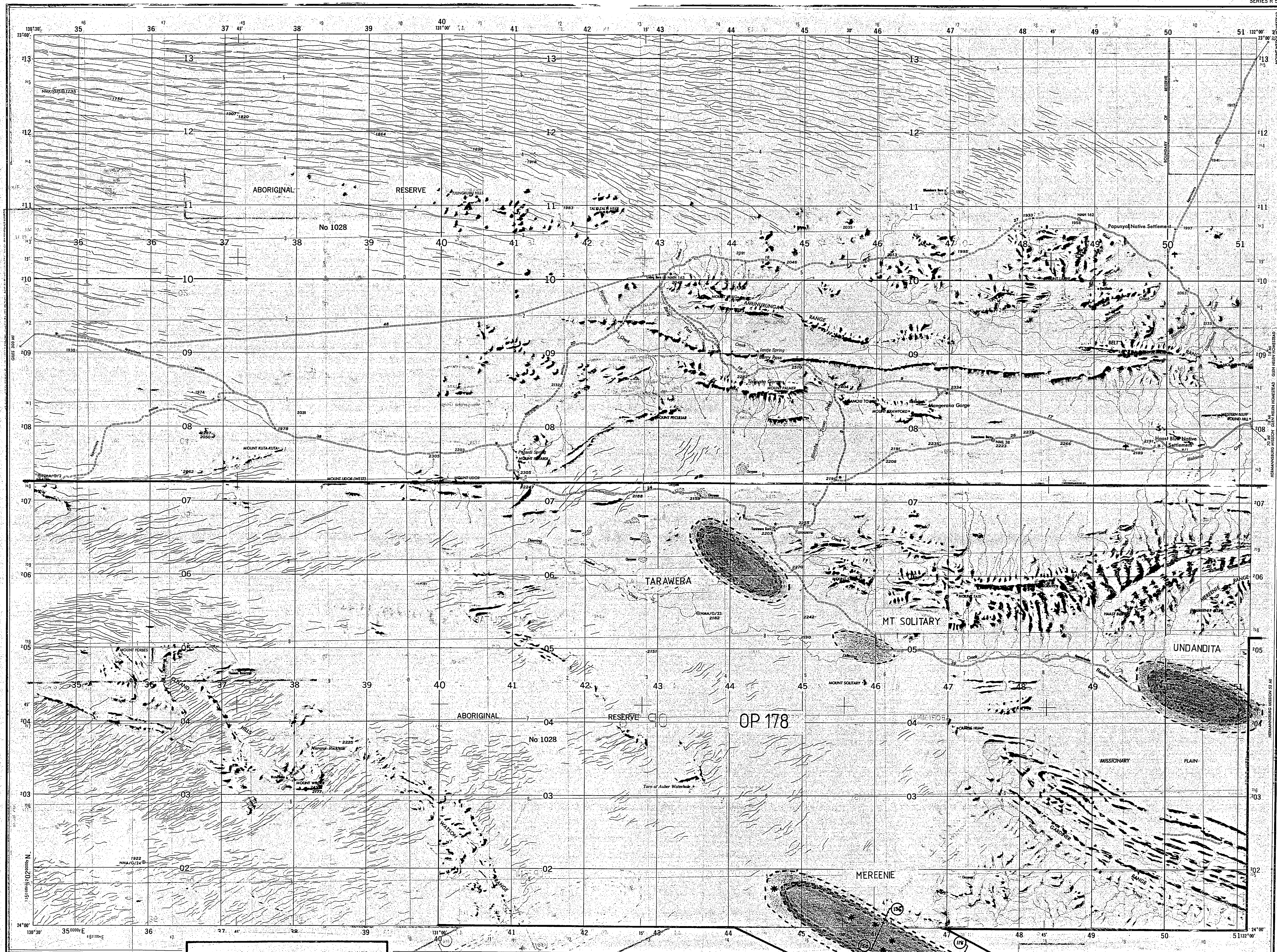
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Airborne Hydrocarbon Survey

OP 175 Northern Territory



LOCATION DIAGRAM

STATION	STATION	STATION	STATION	STATION
STATION 1	STATION 2	STATION 3	STATION 4	STATION 5
STATION 6	STATION 7	STATION 8	STATION 9	STATION 10
STATION 11	STATION 12	STATION 13	STATION 14	STATION 15
STATION 16	STATION 17	STATION 18	STATION 19	STATION 20
STATION 21	STATION 22	STATION 23	STATION 24	STATION 25
STATION 26	STATION 27	STATION 28	STATION 29	STATION 30
STATION 31	STATION 32	STATION 33	STATION 34	STATION 35
STATION 36	STATION 37	STATION 38	STATION 39	STATION 40
STATION 41	STATION 42	STATION 43	STATION 44	STATION 45
STATION 46	STATION 47	STATION 48	STATION 49	STATION 50
STATION 51	STATION 52	STATION 53	STATION 54	STATION 55
STATION 56	STATION 57	STATION 58	STATION 59	STATION 60
STATION 61	STATION 62	STATION 63	STATION 64	STATION 65
STATION 66	STATION 67	STATION 68	STATION 69	STATION 70
STATION 71	STATION 72	STATION 73	STATION 74	STATION 75
STATION 76	STATION 77	STATION 78	STATION 79	STATION 80
STATION 81	STATION 82	STATION 83	STATION 84	STATION 85
STATION 86	STATION 87	STATION 88	STATION 89	STATION 90
STATION 91	STATION 92	STATION 93	STATION 94	STATION 95
STATION 96	STATION 97	STATION 98	STATION 99	STATION 100

- LEGEND
- Features not positively identified on aerial photograph
 - Built-up area
 - Road sealed surface first class, single track
 - Road sealed surface second class, mileage
 - Road loose surface all weather
 - Road loose surface dry weather
 - Road unpaved earth
 - Track, foot or path, footbridge
 - Embankment, cutting
 - Gate, cattle grid
 - Bridge road, bridge railway
 - Railway multiple track
 - Railway single track
 - Light railway or tramway
 - Station siding, station with siding
 - Telephone line, power transmission line
 - Fence, stone wall
 - Levee or dyke, quarry
 - Mine, windpump, yard
 - Building (e.g. church, school)
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 - Forest coniferous, or pine plantation, scrub
 - Vineyard, orchard or plantation
 - Waterhole, water tank, dam, dry lake
 - Lake, river or stream, perennial
 - Lake, river or stream, intermittent
 - Dam or weir, falls, rapids
 - Drain or ditch, perennial, intermittent
 - Spring perennial, intermittent, intermittent
 - Marsh or swamp, perennial, intermittent
 - Sesuvium, anchorage, sesuvium base
 - Breakwater, pier, dock or wharf
 - Foreshore line, low water mark, lighthouse
 - Wreck, sunken, exposed, vessel, anchorage
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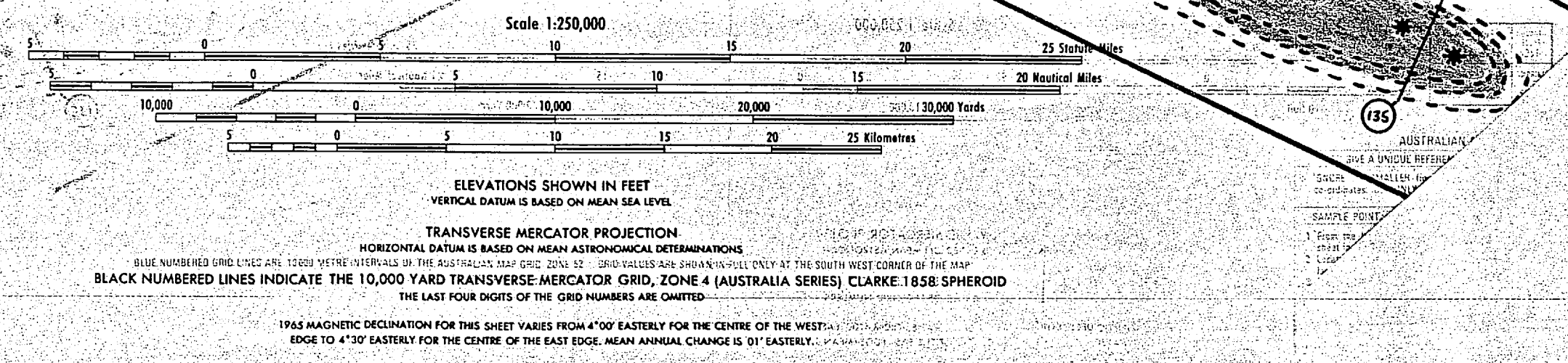
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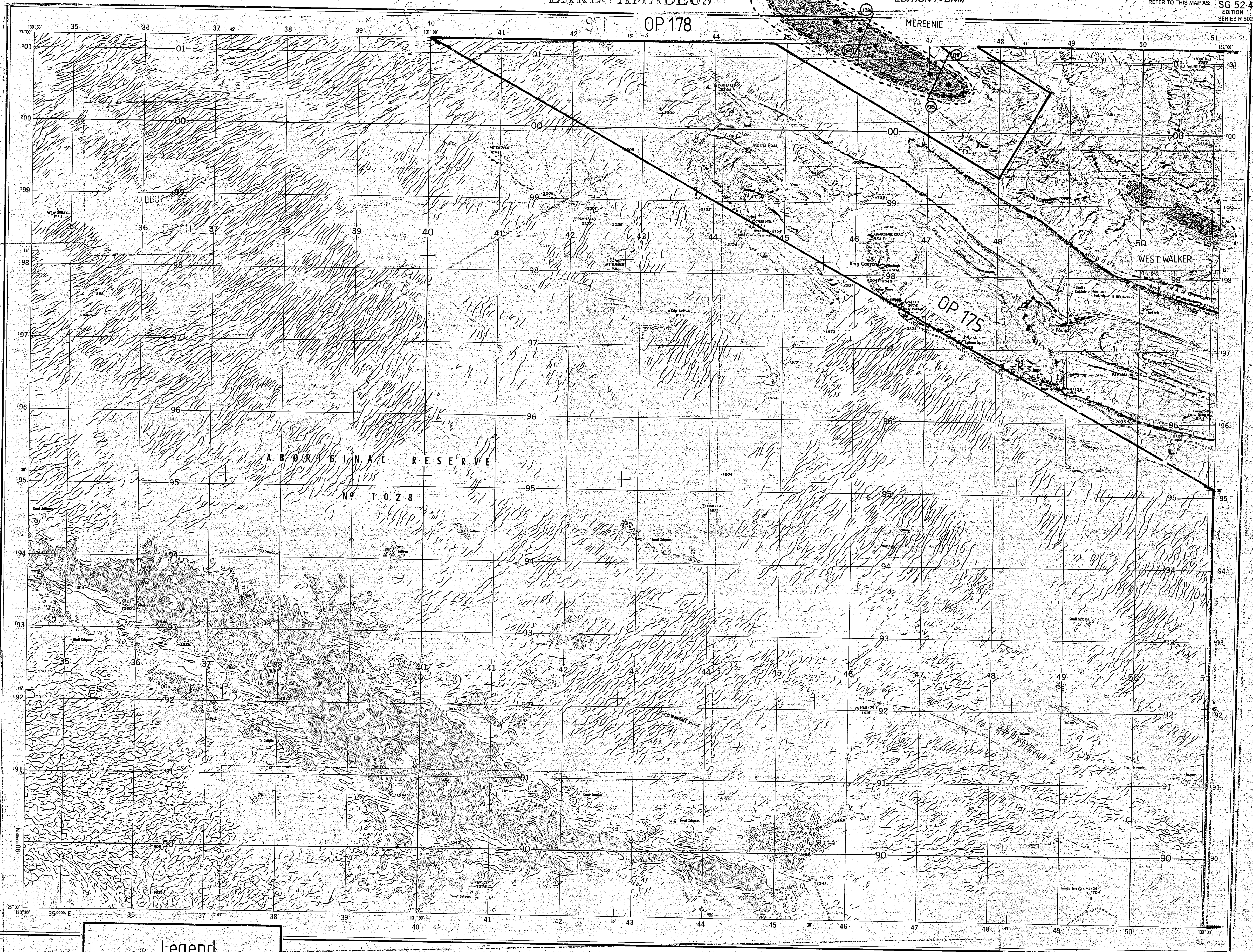
PRINTED BY authority of the Minister for National Resources.

Legend

HYDROCARBON MICROSEEPAGES

- Major
- Moderate
- Minor
- Ground sample



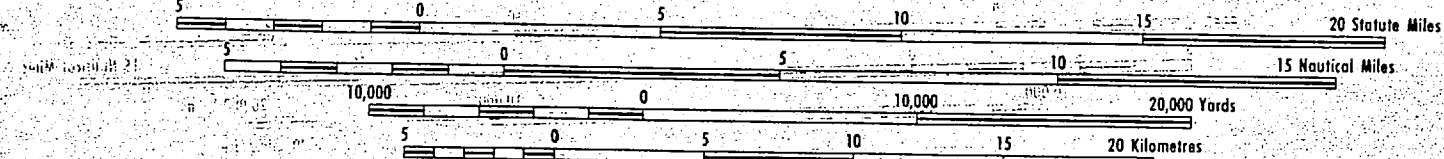


Legend

HYDROCARBON MICROSEEPAGES

- Major
- Moderate
- Minor
- Ground sample

Scale 1:250,000



ELEVATIONS SHOWN IN FEET

VERTICAL DATUM IS BASED ON MEAN SEA LEVEL

TRANSVERSE MERCATOR PROJECTION

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BLACK NUMBERED LINES INDICATE THE 10,000 YARD TRANSVERSE MERCATOR GRID, ZONE 4 (AUSTRALIA SERIES) CLARKE 1858 SPHEROID.

THE LAST FOUR DIGITS OF THE GRID NUMBERS ARE OMITTED

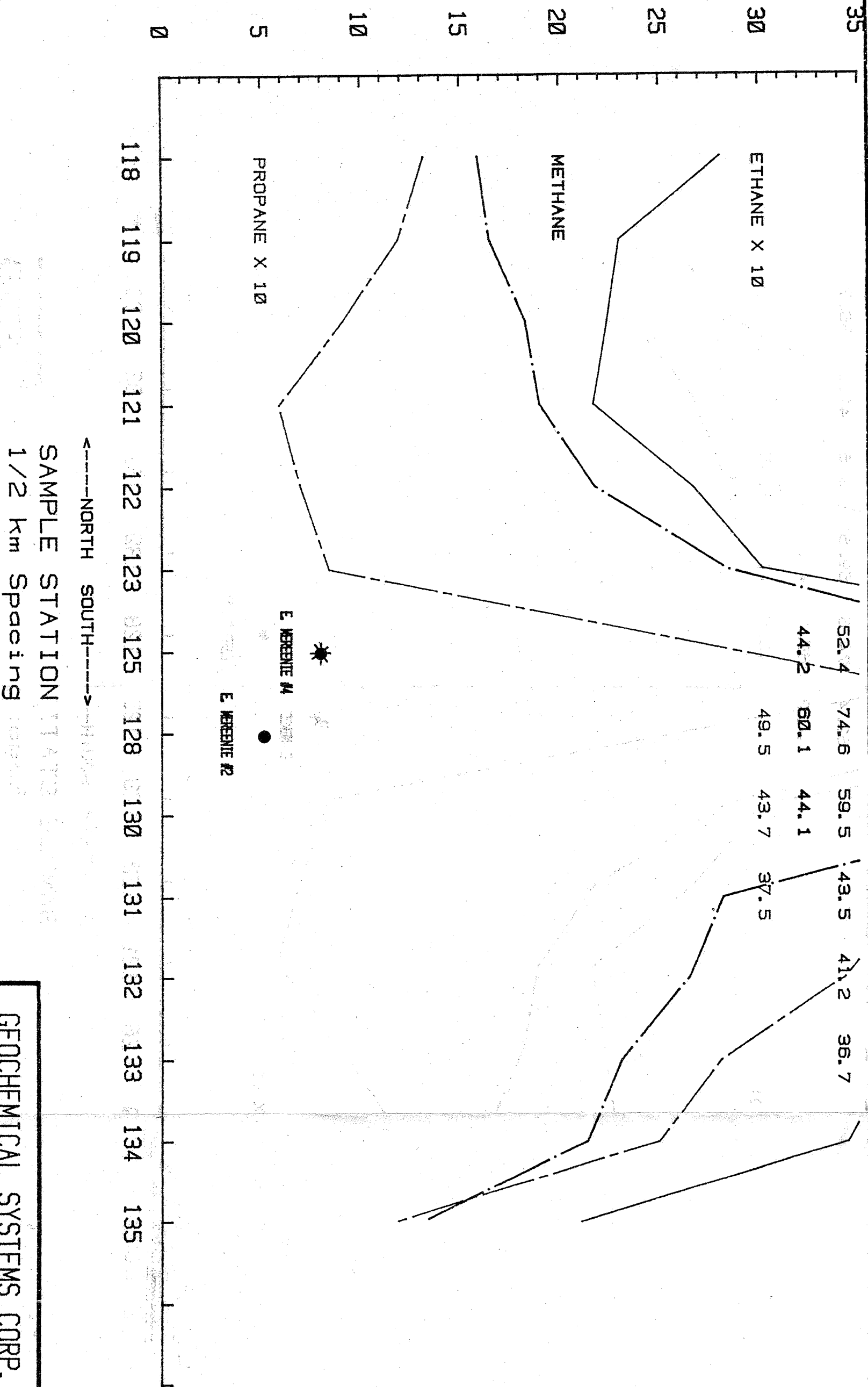
1960 MAGNETIC DECLINATION FOR THIS SHEET VARIES FROM 3° 45' EASTERLY FOR THE CENTRE OF THE WEST EDGE TO 4° 15' EASTERLY FOR THE CENTRE OF THE EAST EDGE; MEAN ANNUAL CHANGE IS 01' EASTERLY.

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Airborne Hydrocarbon
Survey

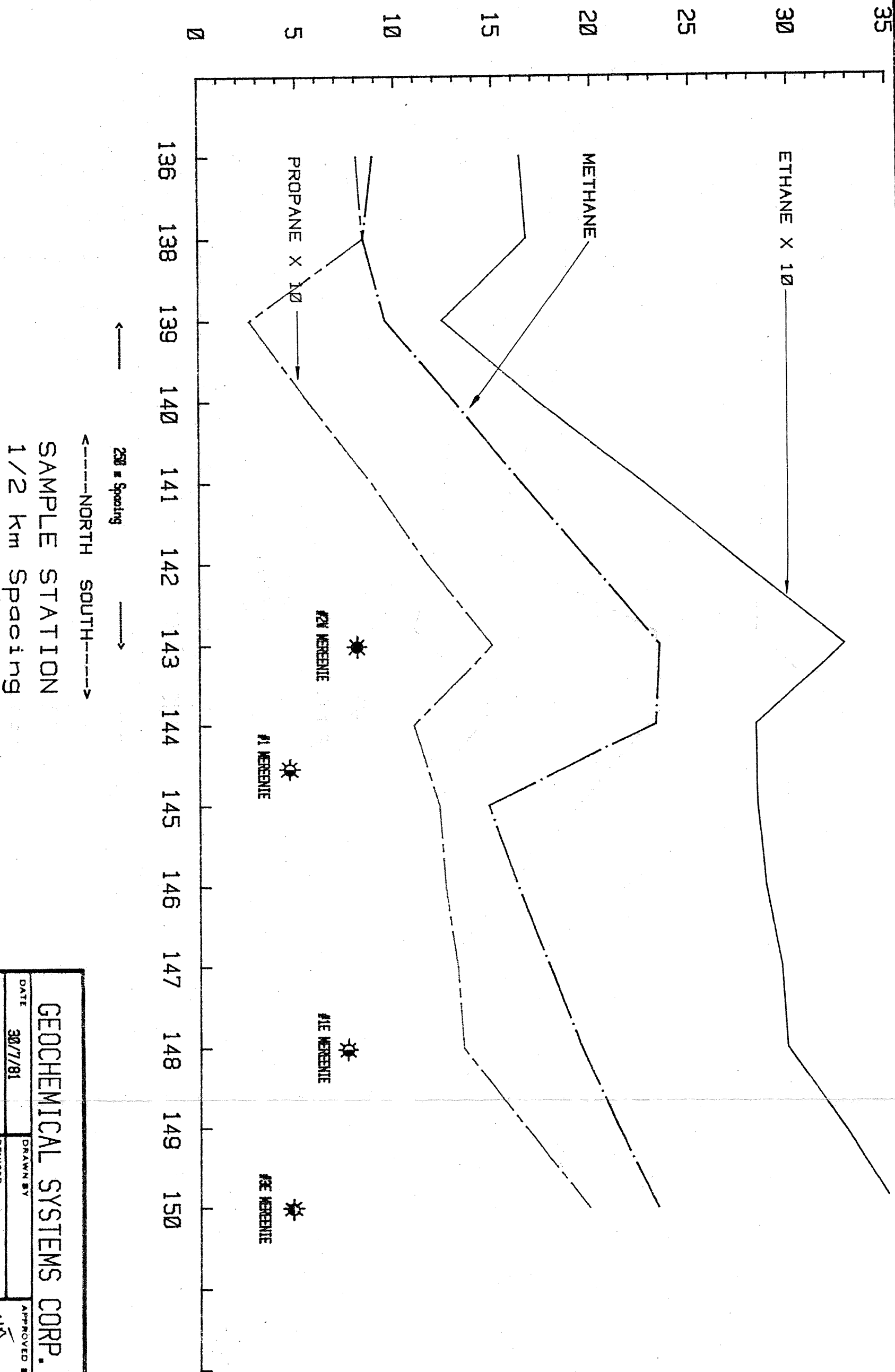
OP 175 Northern Territory

HYDROCARBON GAS -- PPM (VOLUME)



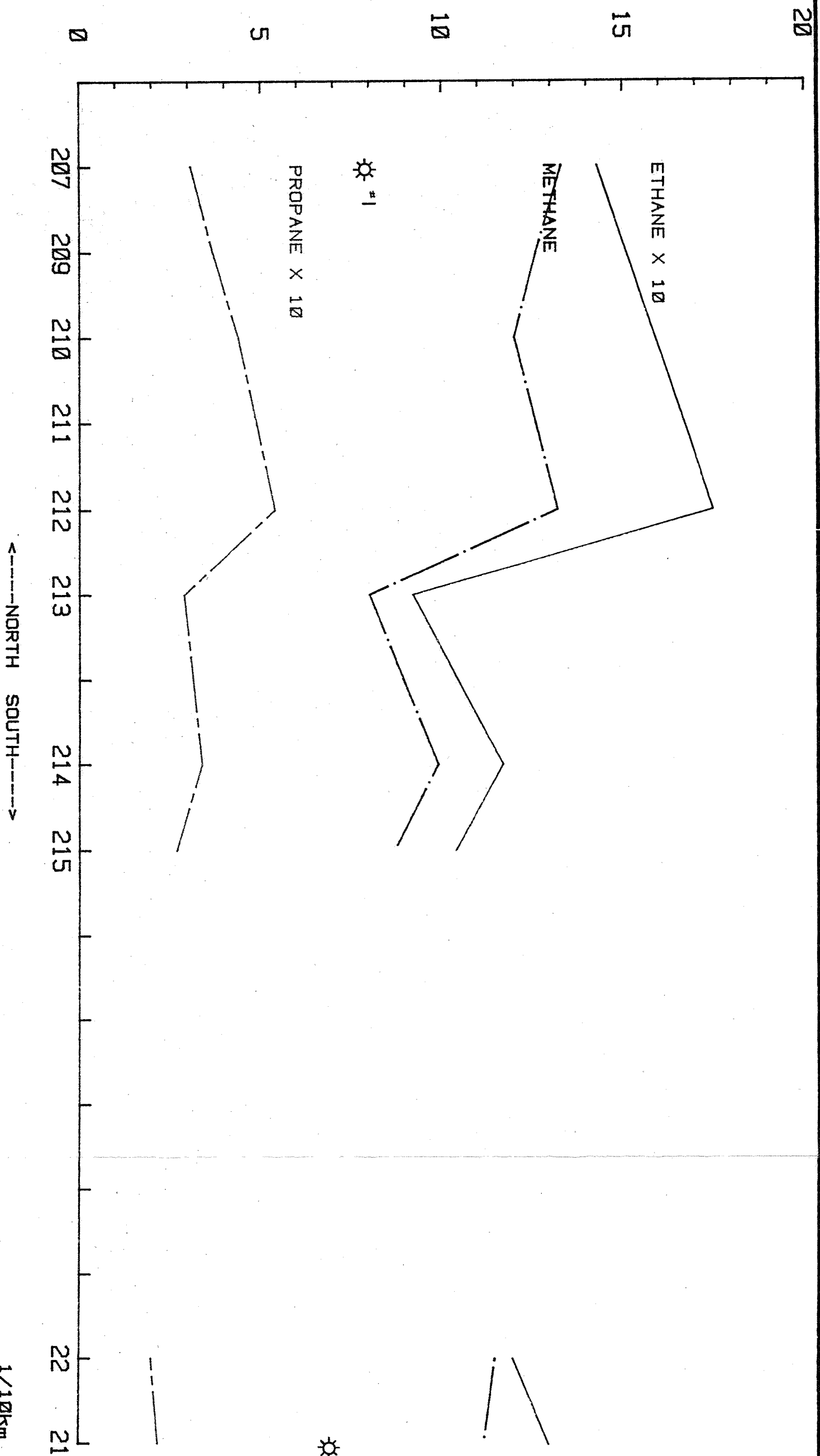
GEOCHEMICAL SYSTEMS CORP.			
DATE	30/7/81	DRAWN BY	
SCALE		REVISED	
VAPORSEARCH PTY., LTD.			
MERENIE FIELD - OP 175			
Fig. 8			

HYDROCARBON GAS -- PPM (VOLUME)



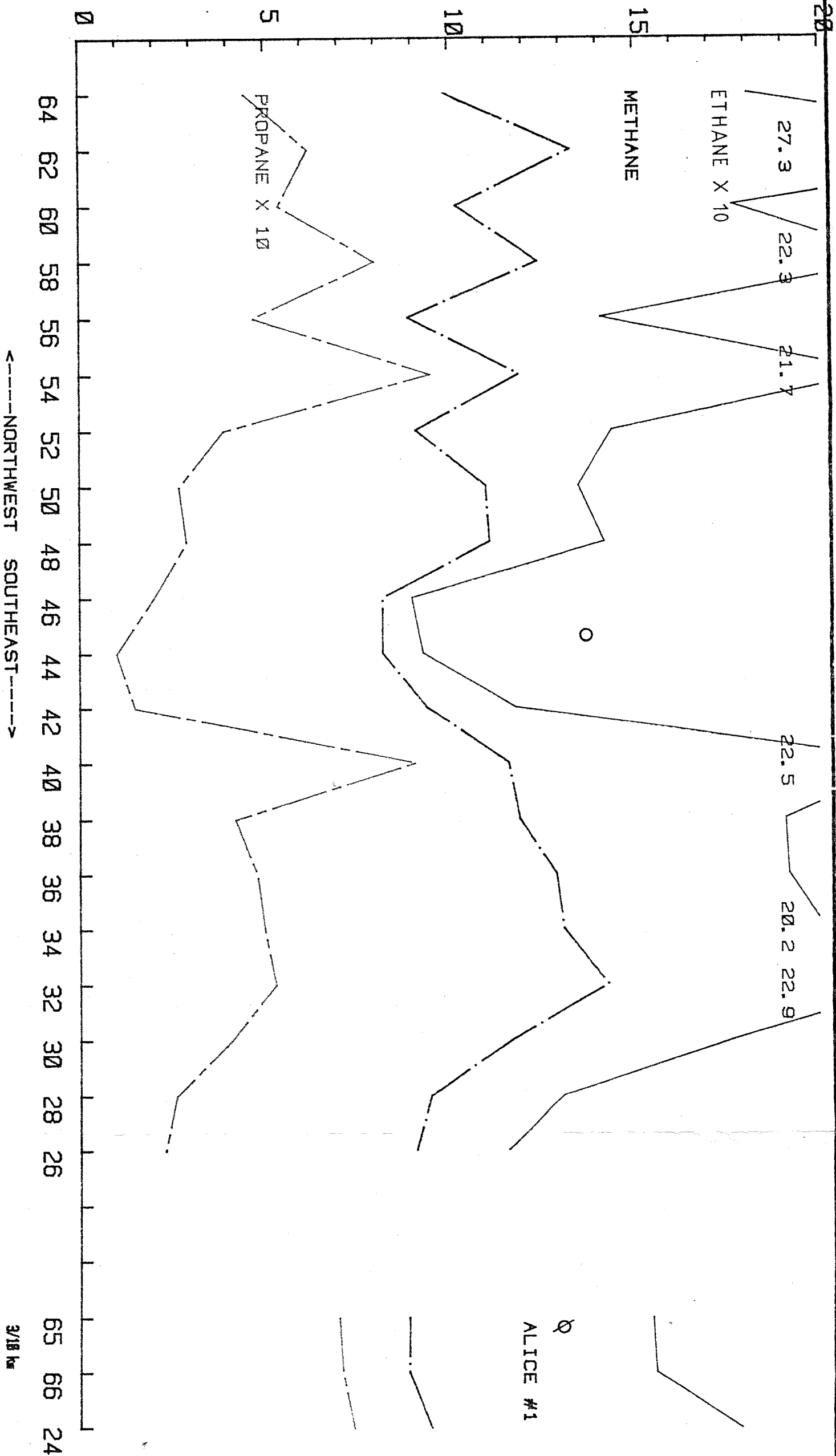
GEOCHEMICAL SYSTEMS CORP.			
DATE	30/7/81	DRAWN BY	
SCALE		REVISED	
VAPORSEARCH PTY., LTD.			
MERENIE FIELD - OP 1/5			
			Fig. 9

HYDROCARBON GAS -- PPM (VOLUME)



GEOCHEMICAL SYSTEMS CORP.			
DATE	30/7/81	DRAWN BY	
SCALE		REVISED	
VAPORSEARCH PTY., LTD.		APPROVED BY	
PALM VALLEY FIELD - OP 175		Fig. 10	

HYDROCARBON GAS -- PPM (VOLUME)

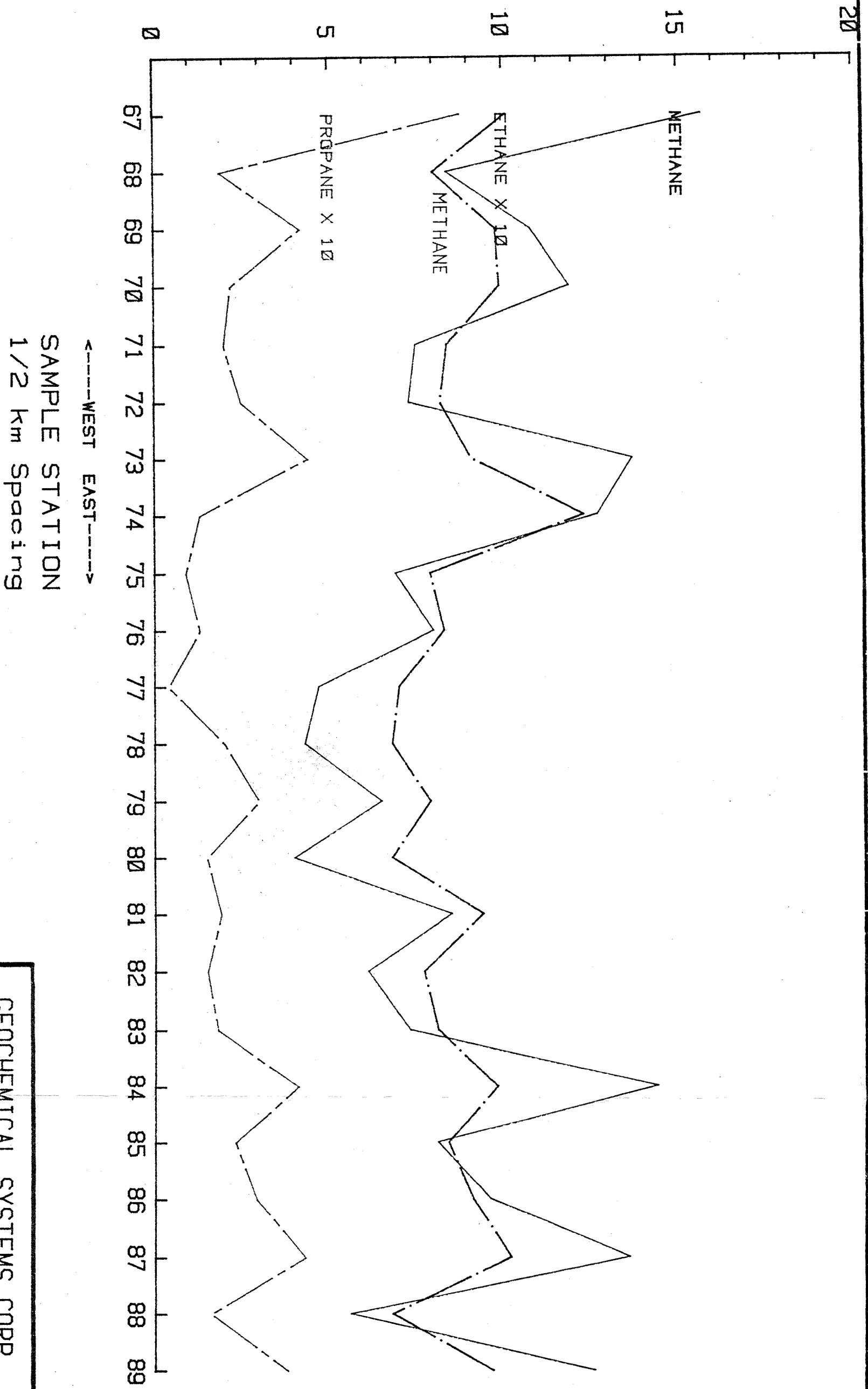


SAMPLE STATION
1/2 km Spacing

GEOCHEMICAL SYSTEMS CORP.			
DATE	30/7/81	DRAWN BY	
SCALE		REVISED	
VAPORSEARCH PTY., LTD.			
VALLABY PROSPECT - OP 175			
Fig. 11			

Ø
ALICE #1

HYDROCARBON GAS -- PPM (VOLUME)



GEOCHEMICAL SYSTEMS CORP.

DATE 30/7/81

DRAWN BY

APPROVED BY

SCALE

REVISED

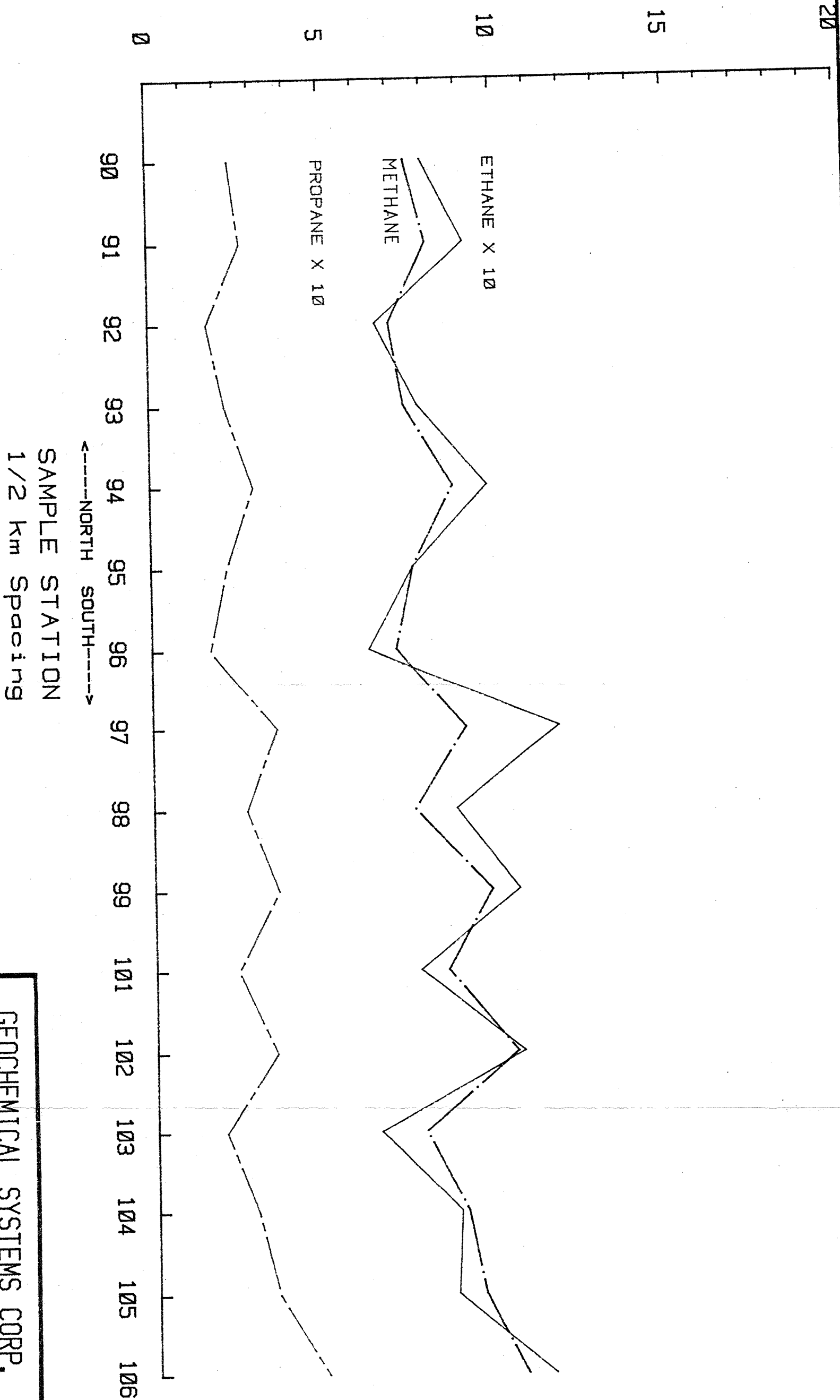
UK

VAPORSEARCH PTY., LTD.

ORANGE PROSPECT - OP 175

Fig. 12

HYDROCARBON GAS -- PPM (VOLUME)



GEOCHEMICAL SYSTEMS CORP.

DATE 30/7/81

DRAWN BY

APPROVED BY

SCALE

REVISED

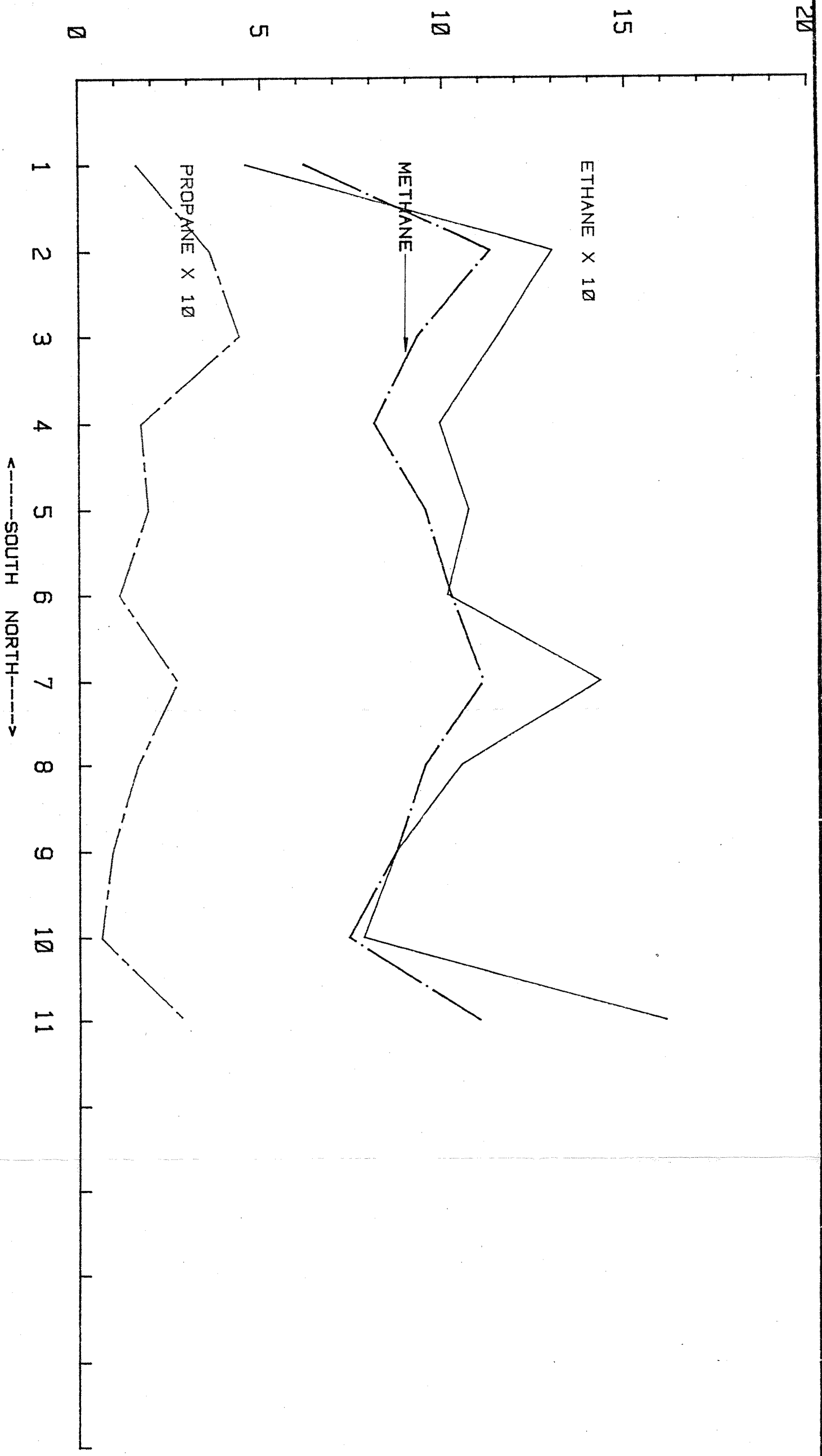
CUK

VAPORSEARCH PTY., LTD.

DINCO PROSPECT - DP 175

Fig. 13

HYDROCARBON GAS -- PPM (VOLUME)



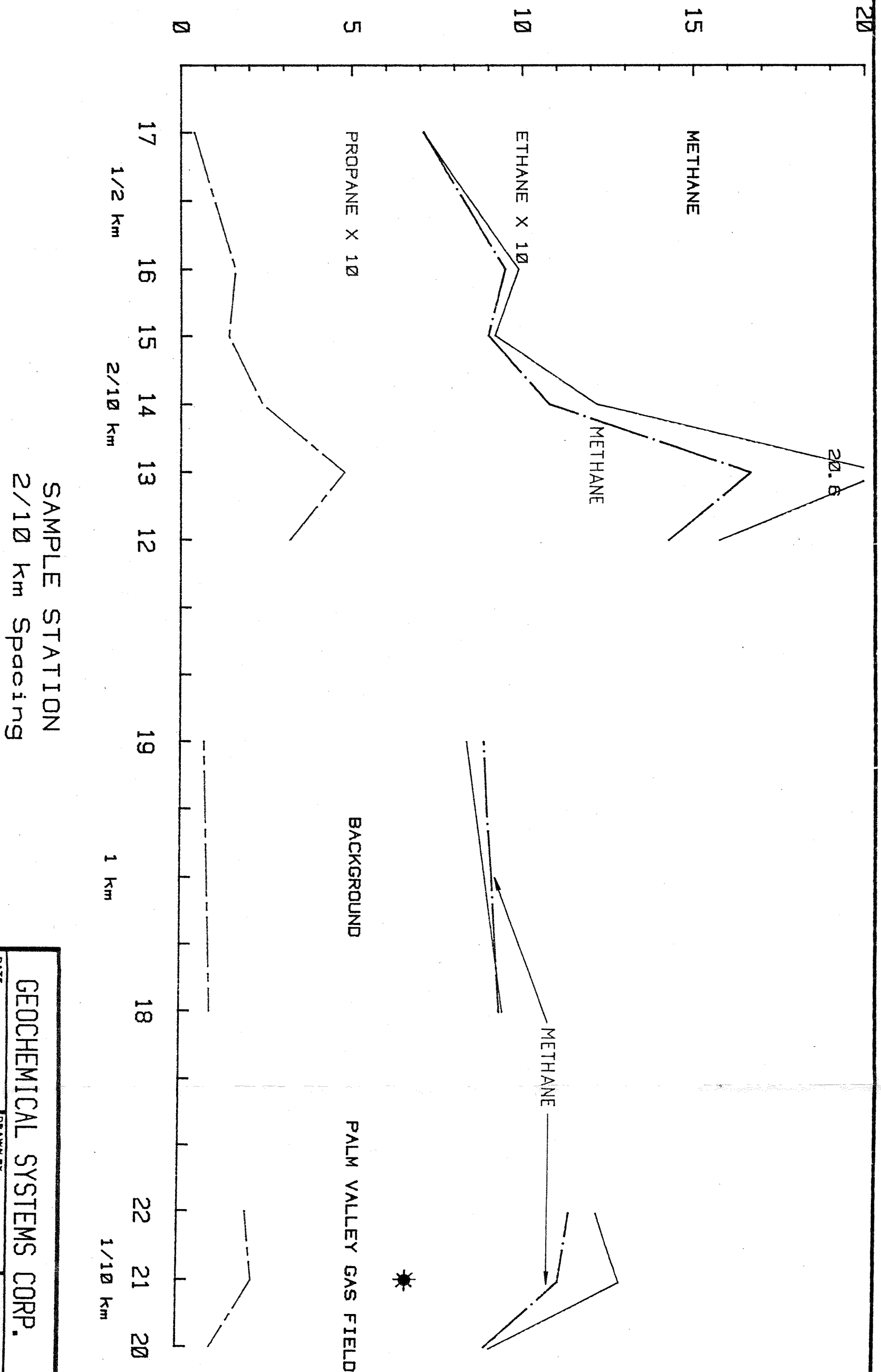
SAMPLE STATION
2/10 km Spacing

-----SOUTH NORTH----->

GEOCHEMICAL SYSTEMS CORP.			
DATE	30/7/81	DRAWN BY	
SCALE		REVISED	
VAPORSEARCH PTY., LTD.			
MERRICK PROSPECT - OP 175			
			APPROVED BY C.K.

Fig. 14a

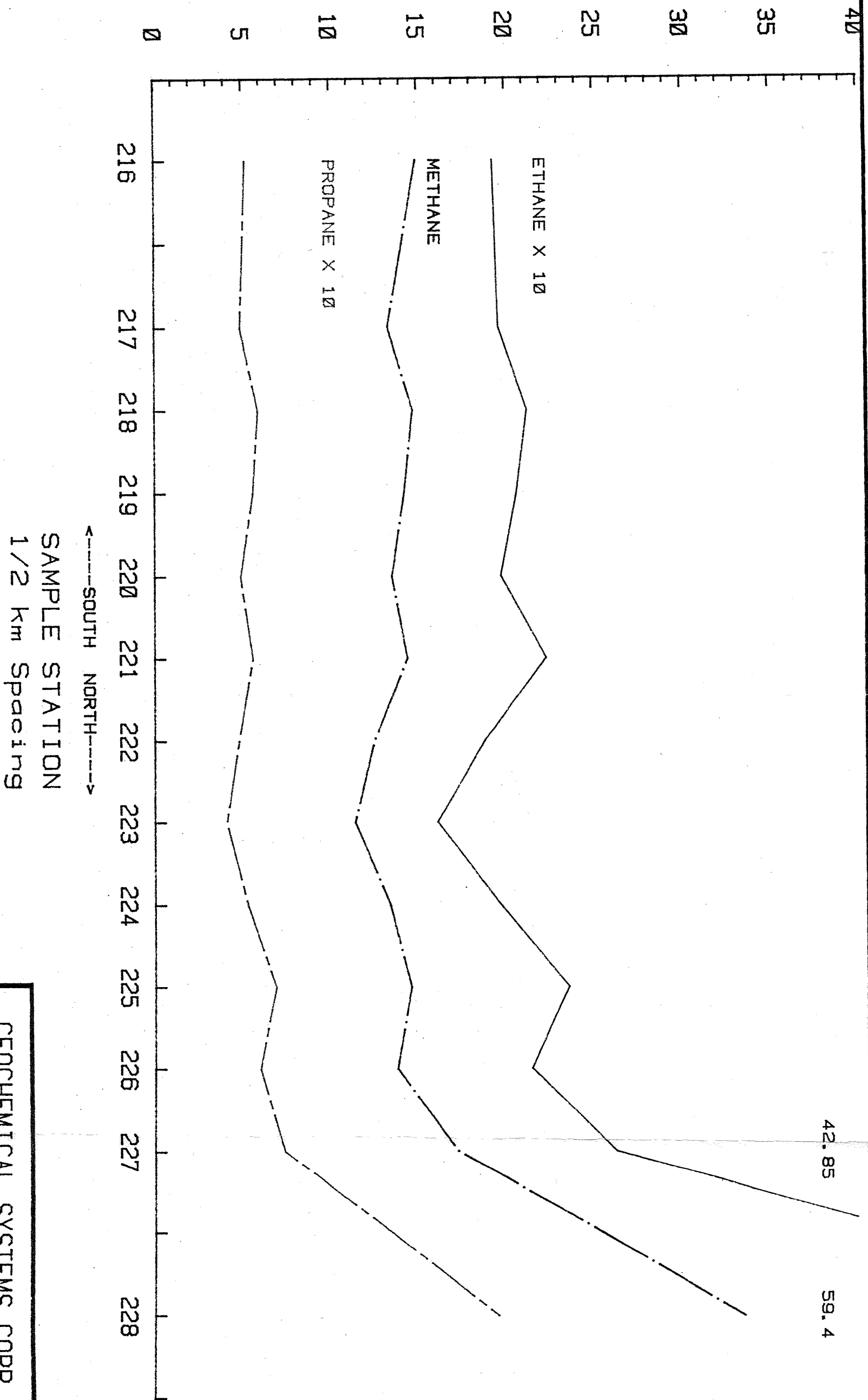
HYDROCARBON GAS -- PPM (VOLUME)



SAMPLE STATION
2/10 km Spacing

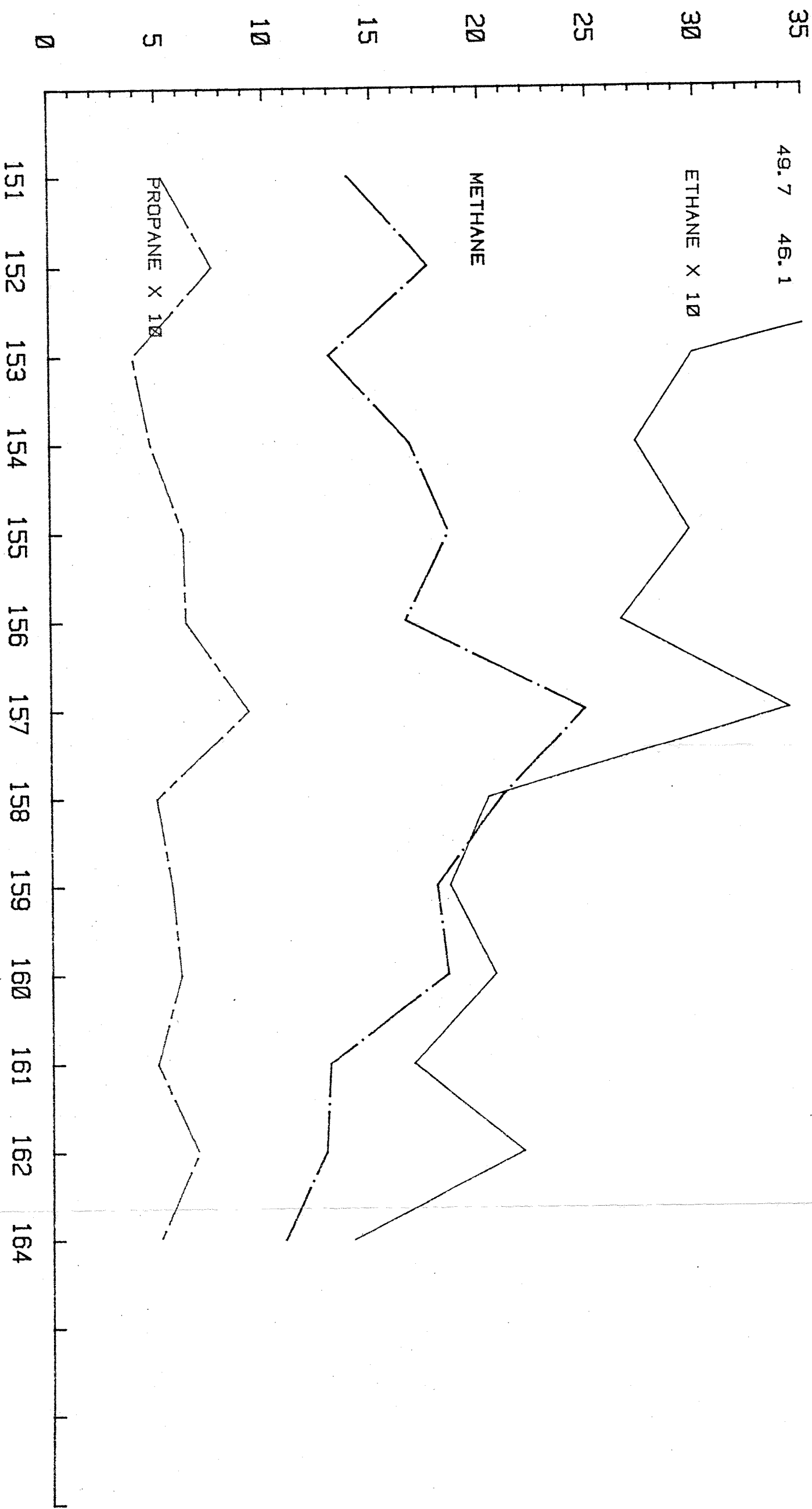
GEOCHEMICAL SYSTEMS CORP.			
DATE	30/7/81	DRAWN BY	
SCALE		REVISED	
VAPORSEARCH PTY., LTD.			
MERRICK PROSPECT - OP 175			
Fig. 14b			

HYDROCARBON GAS -- PPM (VOLUME)



GEOCHEMICAL SYSTEMS CORP.			
DATE	30/7/81	DRAWN BY	
SCALE		REVISED	
VAPORSEARCH PTY., LTD.			
McMINN PROSPECT - OP 175			
			Fig. 15

HYDROCARBON GAS -- PPM (VOLUME)



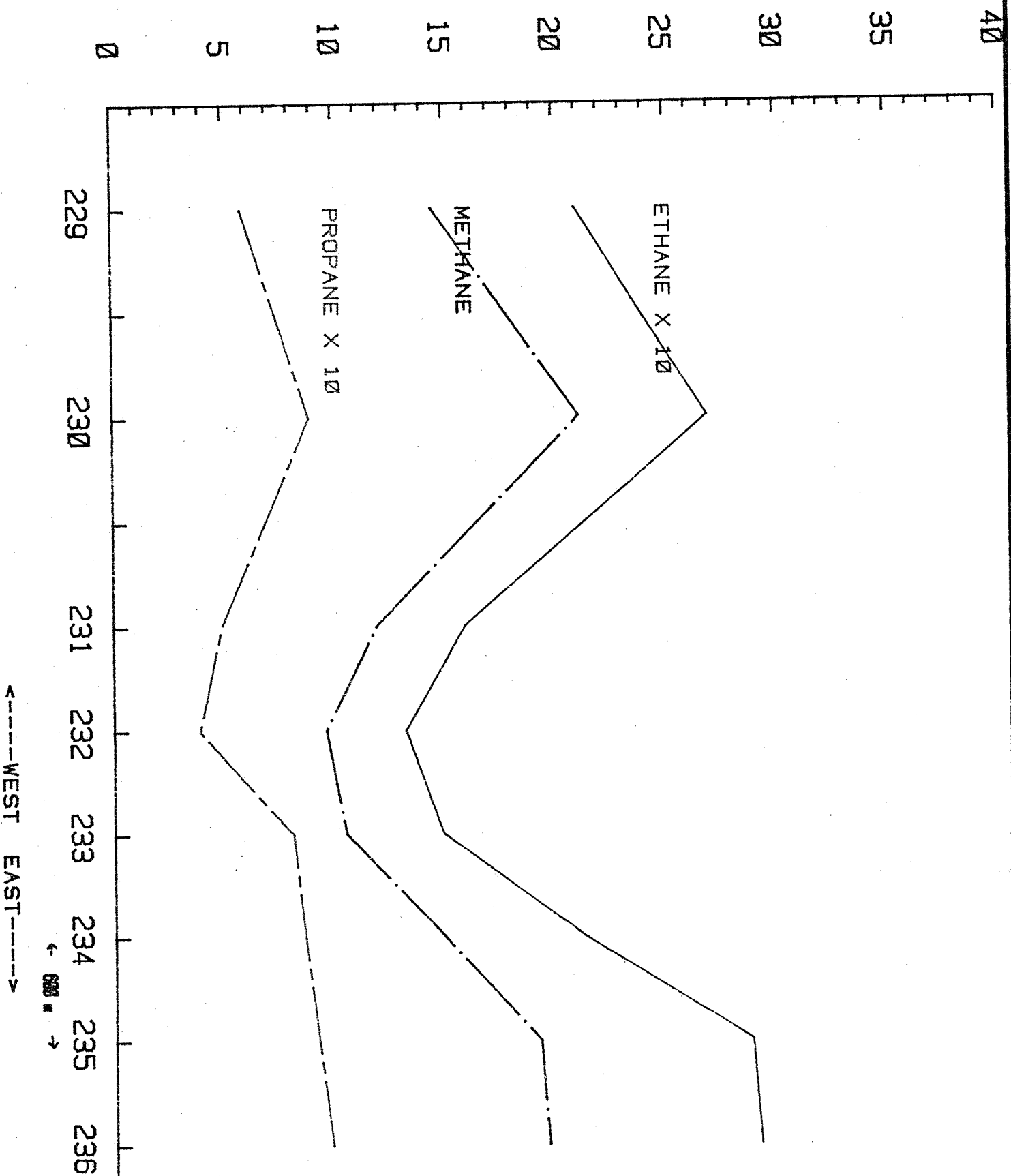
<-----NORTHEAST SOUTHWEST----->

SAMPLE STATION

1/2 km Spacing

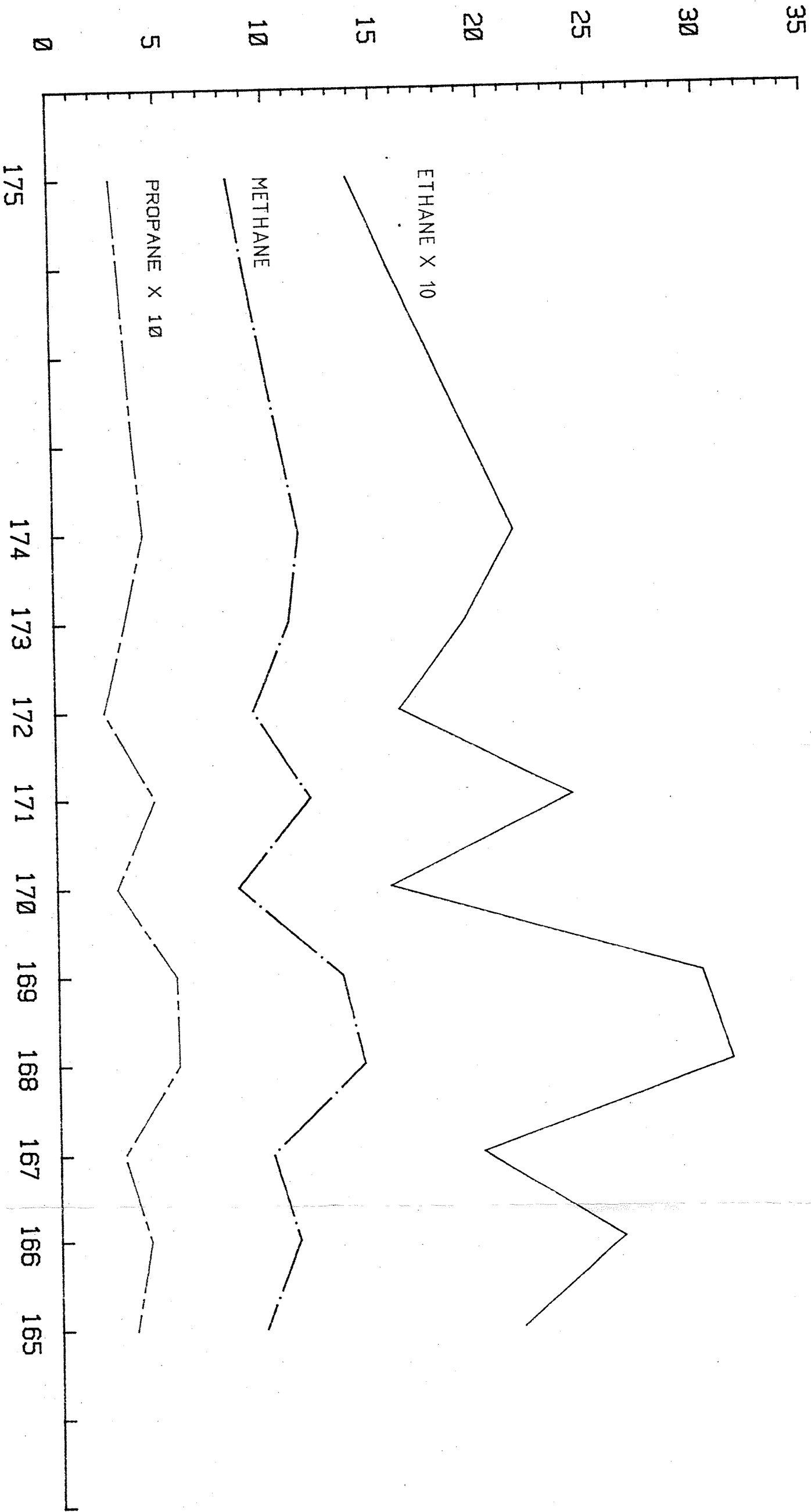
GEOCHEMICAL SYSTEMS CORP.			
DATE	08/7/01	DRAWN BY	
SCALE		REVISED	CAN
VAPORSEARCH PTY., LTD.			
MOUNT HOLDER PROSPECT - OP 175			Fig. 16a

HYDROCARBON GAS -- PPM (VOLUME)



GEOCHEMICAL SYSTEMS CORP.			
DATE	30/7/81	DRAWN BY	
SCALE		REVISED	
VAPORSEARCH PTY., LTD.			
MOUNT HOLDER PROSPECT - OP 175			Fig.16b

HYDROCARBON GAS -- PPM (VOLUME)

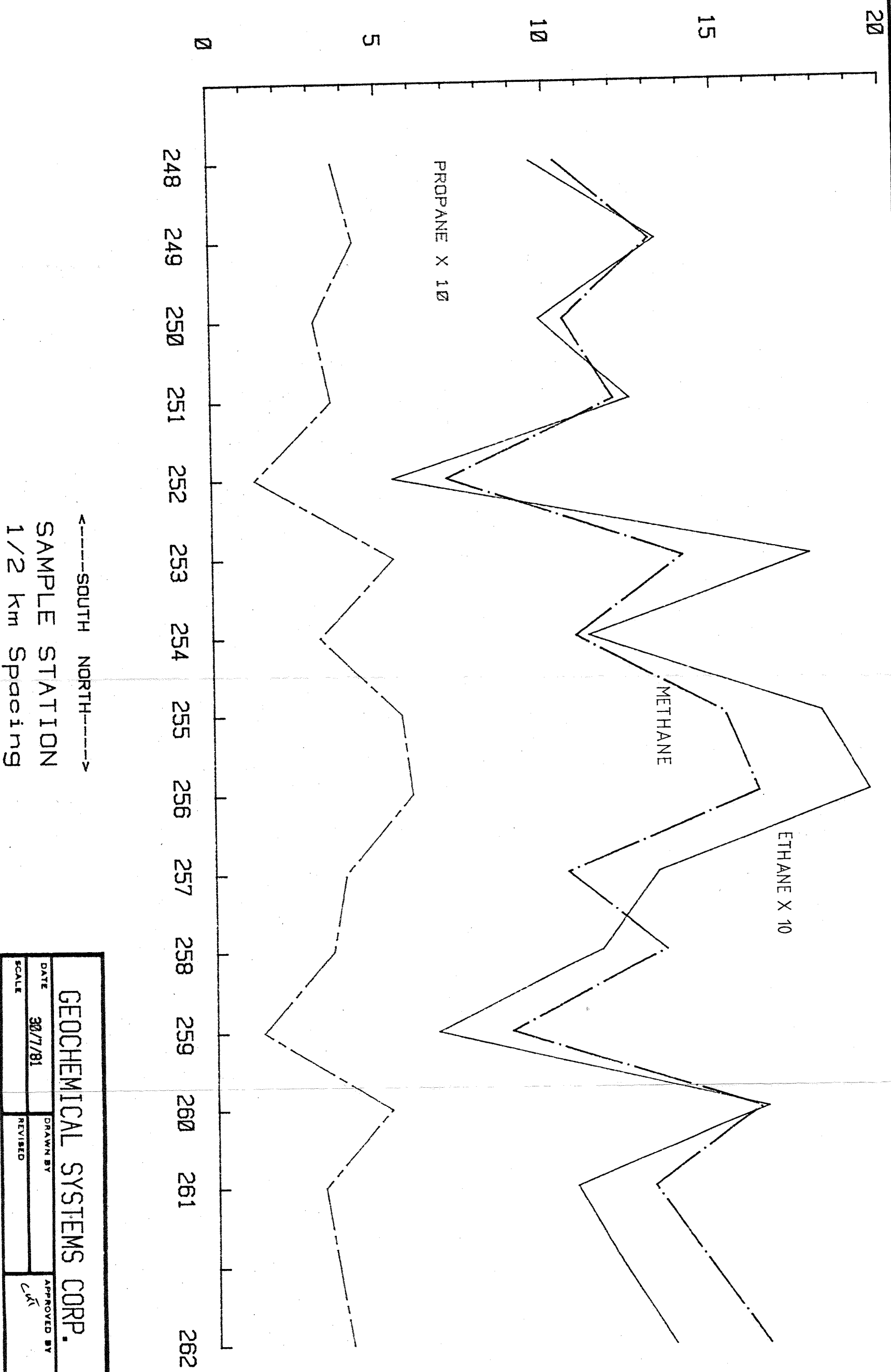


<----- NORTHWEST
 SAMPLE STATION
 1/2 km Spacing
 -----> SOUTHEAST

GEOCHEMICAL SYSTEMS CORP.			
DATE	30/7/81	DRAWN BY	
SCALE		REVISED	
VAPORSEARCH PTY., LTD.		APPROVED BY	
MOUNT ORMISTON PROSPECT - OP 175		CUT	

Fig.17a

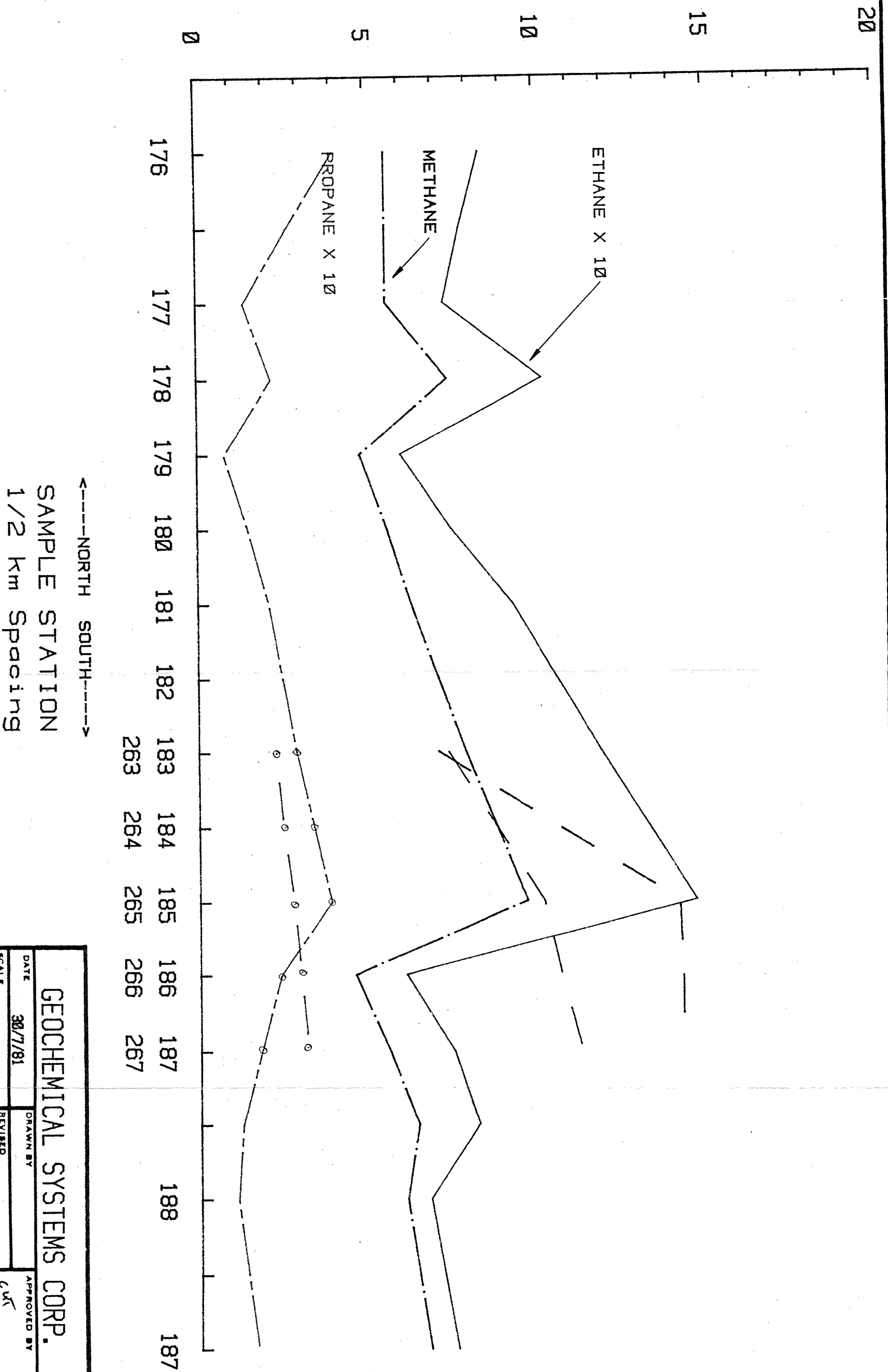
HYDROCARBON GAS -- PPM (VOLUME)



-----SOUTH NORTH-----
SAMPLE STATION
1/2 km Spacing

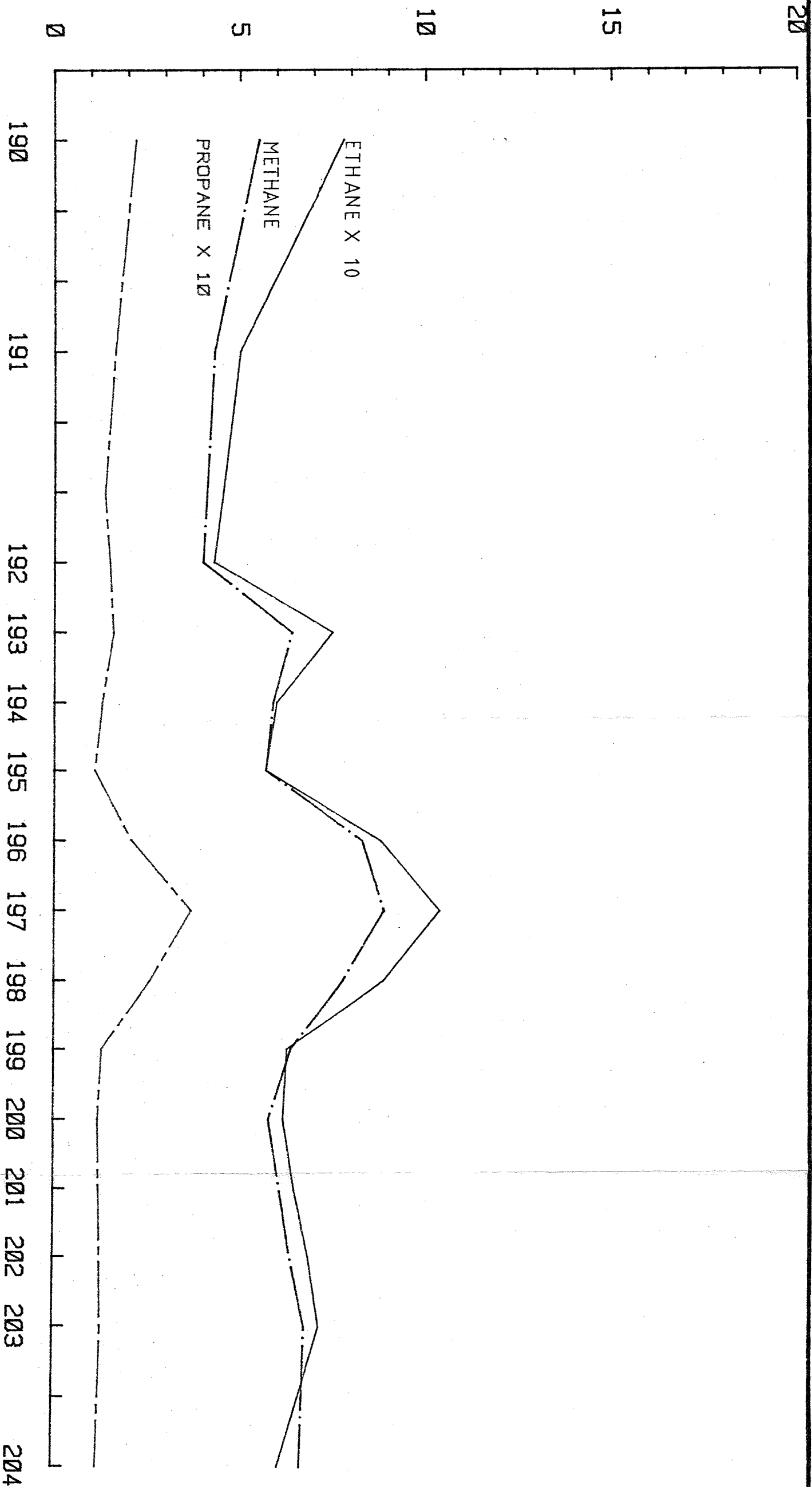
GEOCHEMICAL SYSTEMS CORP.			
DATE	30/7/81	DRAWN BY	
SCALE		REVISED	
VAPORSEARCH PTY., LTD.			
MOUNT ORMROD PROSPECT - OP 175			Fig. 17b

HYDROCARBON GAS -- PPM (VOLUME)



GEOCHEMICAL SYSTEMS CORP.			
DATE	30/7/81	DRAWN BY	
SCALE		REVISED	
VAPORSEARCH PTY., LTD.			
VALLERA PROSPECT - OP 175			Fig. 18a

HYDROCARBON GAS -- PPM (VOLUME)

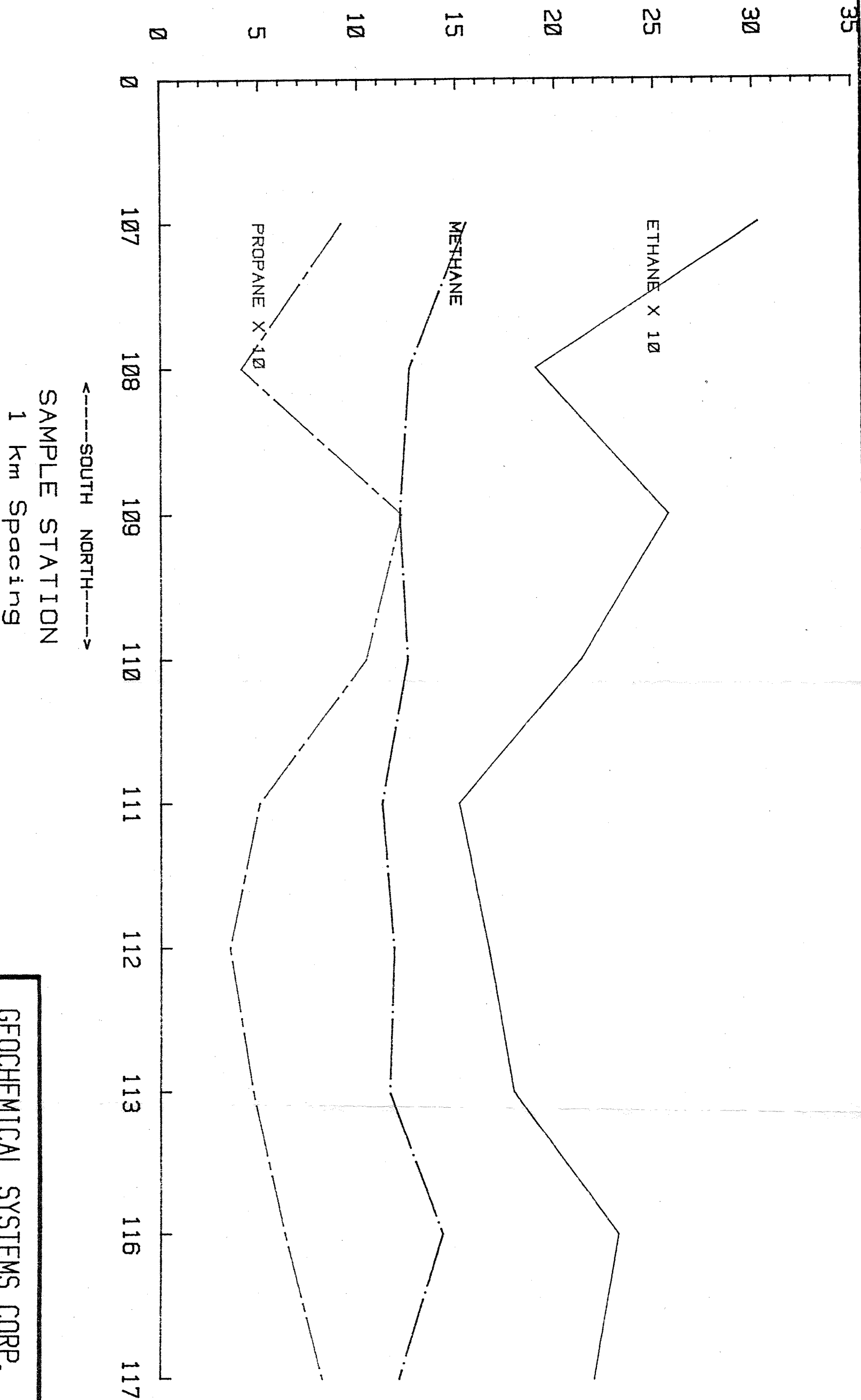


-----NORTH SOUTH----->
 SAMPLE STATION
 1/2 km Spacing

GEOCHEMICAL SYSTEMS CORP.			
DATE	30/7/81	DRAWN BY	
SCALE		REVISED	
VAPORSEARCH PTY., LTD.		APPROVED BY	
VALLERA PROSPECT - OP 175		C/K	

Fig.18b

HYDROCARBON GAS -- PPM (VOLUME)



GEOCHEMICAL SYSTEMS CORP.

DATE 30/7/81

DRAWN BY

APPROVED BY

SCALE

REVISED

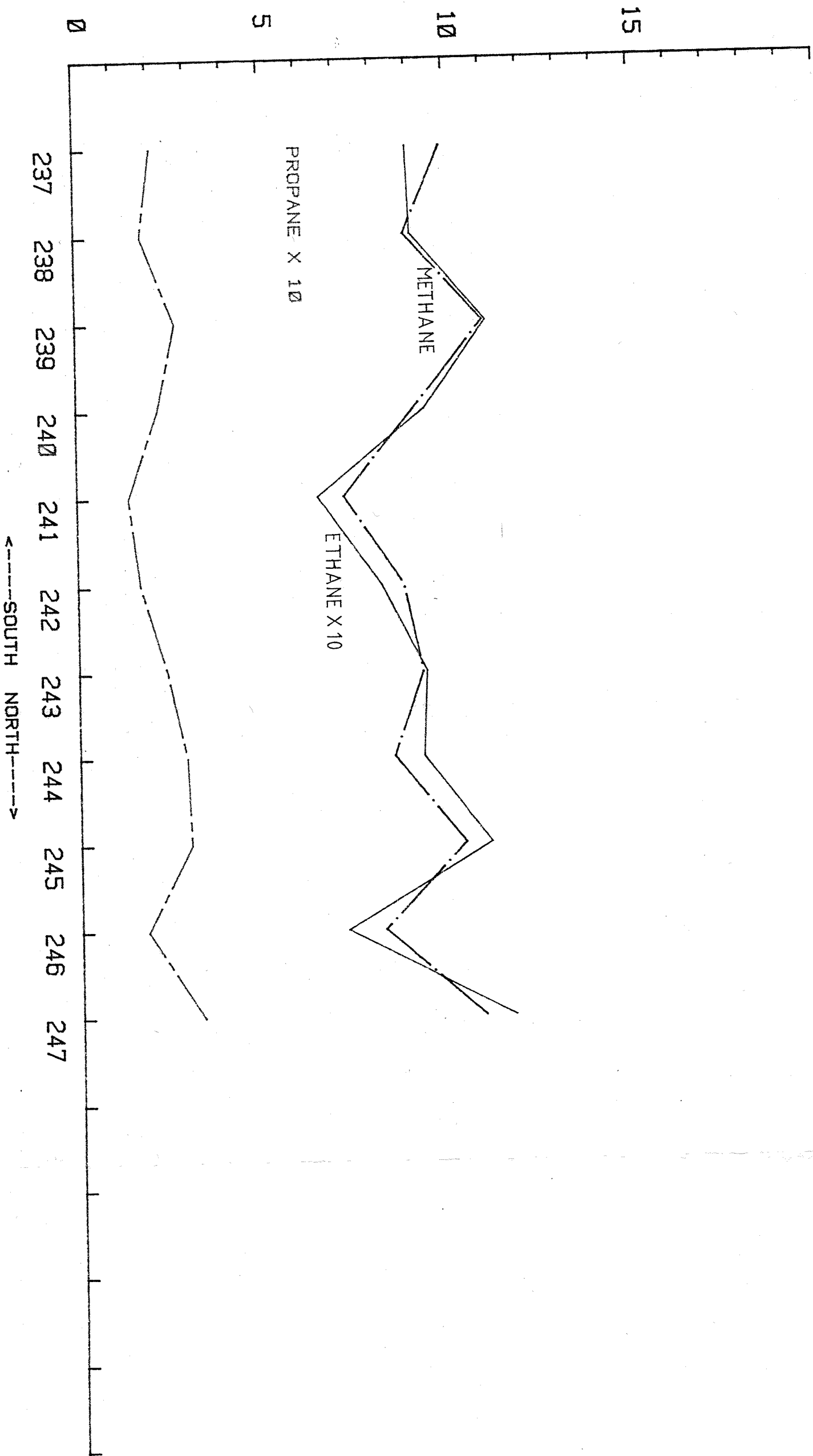
200

VAPORSEARCH PTY., LTD.

ORANGE CREEK STATION - OP 175

Fig. 19

HYDROCARBON GAS -- PPM (VOLUME)



SAMPLE STATION
1/2 km Spacing

GEOCHEMICAL SYSTEMS CORP.			
DATE	30/7/81	DRAWN BY	
SCALE		REVISED	
VAPORSEARCH PTY., LTD.			
CALVARY PROSPECT - OP 175			
			Fig. 20

APPROVED BY
CUT