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GEOPHYSICS

REPORT ON A
SOIL GAS TEST SURVEY
ZEEHAN AREA, WESTERN TASMANIA
by
SEIGEL ASSOCIATES AUSTRALASIA PTY. LTD.

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ZEEHAN AREA, WESTERN TASMANIA
ON BEHALF OF
GEOPHOTO RESOURCES CONSULTANTS

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PRIVATE AND CONFIDENTIAL

REPORT ON A
SOIL GAS TEST SURVEY
ZEEHAN AREA, WESTERN TASMANIA
ON BEHALF OF
GEOPHOTO RESOURCES CONSULTANTS

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GEOPHYSICISTS

SYDNEY, N.S.W.

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GEOPHYSICAL CONSULTANTS AND CONTRACTORS

S U M M A R Y

Mercury vapour tests carried out on samples of mineralisation and in soils over known mineralisation yielded only minor indications of anomalous mercury. However, as the soil gas tests were carried out after prolonged rain the mercury vapour soil gas method test work cannot be considered to be conclusive.

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INTRODUCTION

During the period 15th to 17th January, 1973, a mercury vapour soil gas test survey was conducted under the direction of Mr. P. Robertshaw, M.Sc., of Seigel Associates Australasia Pty. Ltd. on behalf of Geophoto Resources Consultants in the Zeehan area of Western Tasmania.

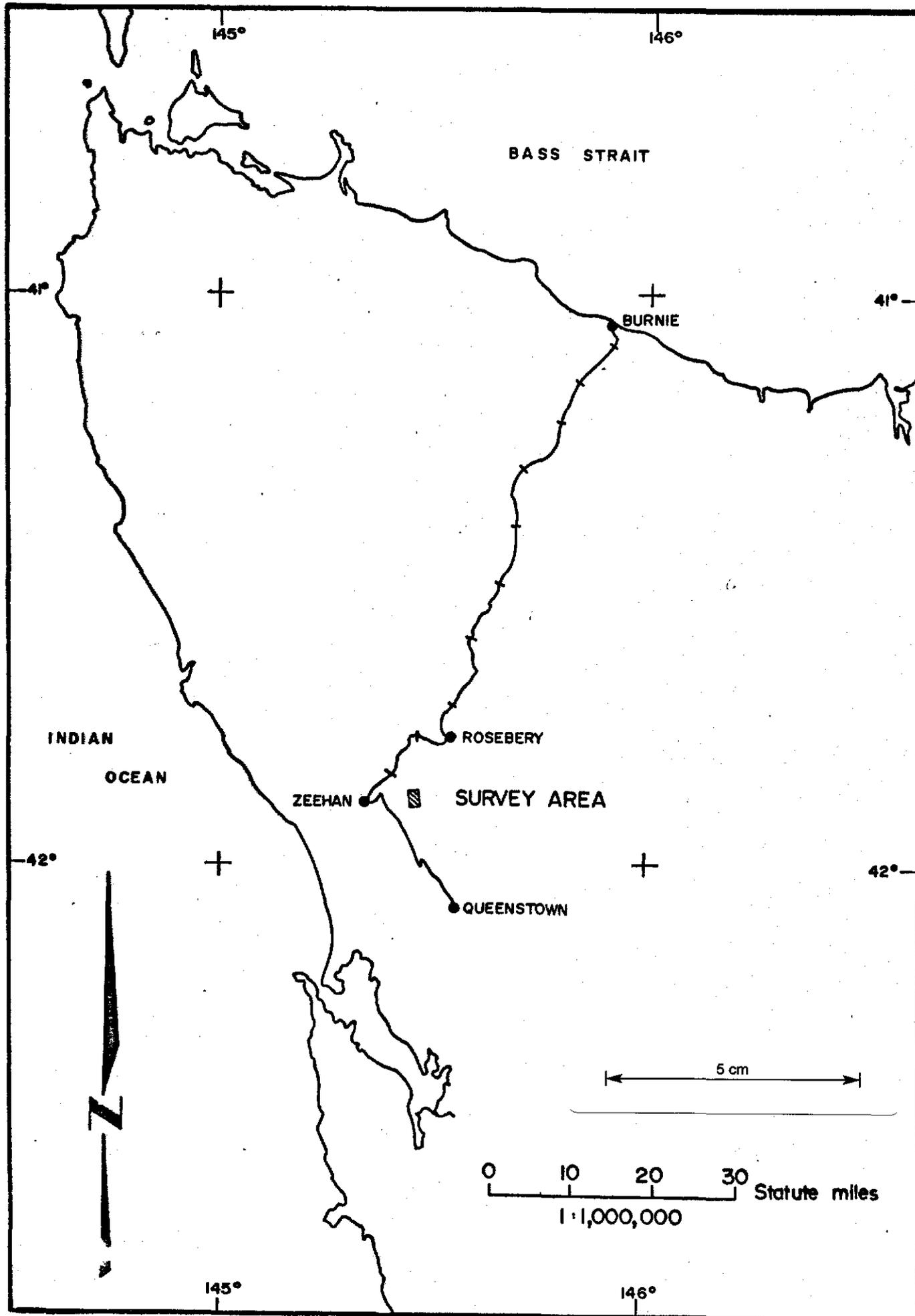
The location of the test area, approximately 6 miles east of Zeehan on exploration lease 7/68, Dundas district, is shown on Figure 1. The property is largely heavily timbered with temperate rain forest set in rugged terrain.

The programme consisted of over 1700 feet of traverses across known mineralised horizons. In addition a series of mineral samples from various locations within the lease were tested for free mercury content. The survey was intended to assess the applicability of the mercury vapour soil gas analysis technique in the search for further mineralisation of this type in this area.

EAST SOUTH COMET

LOCALITY PLAN

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The equipment used during the survey was a Scintrex HGG-3 mercury vapour soil gas spectrometer, the principles of operation and specifications of which are attached in Appendix HGG.

ECONOMIC GEOLOGY

The economic mineralisation under investigation in this area consists of fissure lodes along shear or fault zones within Cambrian sediments of the Dundas group. The mineralisation, considered to be of Devonian age, is mainly of galena and sphalerite in a gangue of siderite and appears at or near the surface as narrow discontinuous lodes. Numerous mines in the area have worked the lodes intermittently since 1890. (A.H. Blissett, Geological Survey Explanatory Report, 1962).

DISCUSSION OF RESULTS

The four traverses on the East South Comet grid are presented in profile form on Plate 1 at a horizontal scale of 1 inch = 100 feet.

The measurements are presented as an instrument readout in millivolts where 1 millivolt is approximately equivalent to a mercury vapour concentration of 10ng/m^3 in the gas inside the spectrometer sample cell. The vertical scale throughout

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the profile presentation is 1 inch = 100 m.v. At least two readings were taken at each location and the plotted values represent the averages of the measurements at each spot.

The survey was undertaken after several days of heavy rain and it was found that, despite the steep topography, much of the area was waterlogged, especially where the overburden consisted of dense clay. Measurements on line 50S had to be abandoned because of this, the extraction of soil gas not being feasible at that time.

The soil gas profiles show very little or no response in the proximity of most of the mineralised zones with maximum averaged values of 20 m.v. over a background of 5 to 15 m.v. Maximum individual readings of 20 m.v. were measured over the gossan on line 40S (at approximately 0 + 80E), and at a massive galena/sphalerite vein exposure on line 50S (at 3 + 00E). However, these values were equalled or exceeded in locations not obviously associated with the known mineralisation or fault structure, e.g. an individual reading of 25 m.v. was recorded at 3 + 60E on line 40S.

On line 54S, peak responses of 20 m.v. were measured at 4 + 20E and 7 + 00E, with a background level of approximately 10 m.v.

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These may indicate the true positions of mineralised faults mapped at 4 + 00E and 6 + 30E, as the lateral displacement of soil gas anomalies in this overburden is unlikely. However, the low amplitude of these "anomalies", only twice background, makes interpretation hazardous as they are close to the background noise level and could easily be caused by variations in overburden thickness (say from 3" to 3') or in soil porosity.

The free mercury content of eleven mineral samples from lodes within the lease was assessed by gently heating and agitating a finely crushed specimen and analysing the evolved vapour. A 1 gram sample of the -80 mesh fraction was used in each case. The results are shown in Table I. While these results are only semi-quantitative and cannot be expressed in p.p.b., all the responses are extremely low. Typical results from successfully detected lead/zinc ores elsewhere range from 1000 m.v. to over 3000 m.v., a factor of 100 greater than those obtained here.

CONCLUSIONS AND RECOMMENDATIONS

The mineral sample mercury assessments represent only the easily volatalised component of the total mercury content of the samples. From fresh, unweathered ore this is the component which would give rise to mercury vapour anomalies.

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Analysis by total chemical extraction may indicate that the lead/zinc veins do contain significant amounts of mercury, but it may be chemically bound or interstitially held in such a fashion as not to be released as a vapour under normal conditions. However, complete oxidation and destruction of the primary ore would be expected to release most of the total mercury content to the environment. It is considered significant that the gossan at 0 + 80E on line 40S did not give a high soil gas response, suggesting that, if the gossan represents typical oxidised ore, the lead/zinc mineralisation may be mercury deficient.

However, the lack of significant responses both from the crushed mineral samples and from the soil gas profiles over mineralised horizons indicate that the mercury vapour analysis technique may not be a viable exploration tool in the case of the mineralisation test. There is, however, one reservation, namely that it has been shown that after prolonged saturation by rain significant soil gas anomalies may be materially reduced or eliminated, only to be re-established after several days of dry weather. These tests were undertaken after several days of rain, hence the reservation.

Respectfully submitted on behalf of:

SEIGEL ASSOCIATES AUSTRALASIA PTY. LTD.


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TABLE I

Semi-quantitative analyses of the volatile mercury content of representative mineral samples

Freshly crushed samples, 1 gram specimen of -80 mesh fraction heated for 15 seconds over a propane flame

Sample	Location	Description	Spectrometer Response (m.v)
1	Montezuma Grid	Galena rich vein exposed along road.	10
2	South Comet Grid	Massive galena/sphalerite exposed in road.	20
3	Kosminski Grid	Semi-massive arsenopyrite/pyrite sample.	25
4	DDH SC-14 43.85 - 44.6 m	Massive galena/sphalerite	10
5	DDH SC-11 542'	" " "	15
6	DDH KH-15 178-180'	" " "	10
7	DDH KH-1 291-294'	" " "	10
8	DDH KHE 1A 245-246'	8.6% Pb, 19.2% Zn	10
9	DDH KHE 1A 303-305'	11.5%Pb, 13.2% Zn	10
10	DDH KH-9 501-503'	3.1% Pb, 7.5% Zn	10
11	DDH KH-9 515-517'	2.2% Pb, 6.1% Zn	20

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APPENDIX 'HGG'

HGG-3 MERCURY SPECTROMETER

PRINCIPLES OF OPERATION

AND

SOIL GAS SAMPLING PROCEDURES

GENERAL BACKGROUND AND PRINCIPLES

This note describes the principles design and construction of an electro-optical apparatus for the measurement of very small concentrations of mercury vapour in a gas. Such an instrument finds application in the mineral exploration field where mercury vapour is believed to act as a trace for both base and noble metal deposits.

Various mercury vapour detection systems have been described over the last 15 to 20 years, the earlier application being in the laboratory analysis of soil and soil samples. Later techniques have been described that are suitable for atmospheric measurements, but prior to the system described here no satisfactory instrument had existed that combined the necessary sensitivity, selectivity and fast response.

All of the published literature cites detection by the measurement of the attenuation of the intense mercury emission line at 2537°A . This radiation can be obtained by such sources as low pressure mercury discharge lamps, hollow cathode lamps resonance lamps etc. and is directed through a suitable sample cell onto a detector sensitive to the ultraviolet. The sensitivity of a simple detection system such as this is limited by the long term stability

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of the radiation source and the fact that many other substances absorb strongly in the ultraviolet. The history of the systems developed in the last few years, shows the various efforts made to improve the sensitivity and selectivity of the basic technique.

To obtain selectivity, it is necessary to measure the absorption in the sample cell due to mercury vapour alone, eliminating the effect of interfering gases, vapours and suspended particular matter. This can be carried out by measuring the total absorption and then selecting from that the absorption due to the interfering substances.

The total attenuation in the cell can be measured using the 2537⁰ A emission lines. However, to measure the attenuation due to the interference gases, a reference wavelength must be chosen, where the interfering gases absorb but the absorption due to the mercury vapour is much less.

This reference wavelength should, of course, be close to the "signal" wavelength, so that the absorption in either case due to interference can be regarded as identical. In one earlier system (Barringer 1963) this reference wavelength was obtained by passing the radiation from a warmed discharge lamp through a small cell containing

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saturated mercury vapour. This effectively removed the central portion of the 2537 radiation leaving the "wings". These "wings" served as the reference wavelength since the radiation could be little further absorbed by mercury vapour in the sample cell. One disadvantage of this system is that the signal line width has to be wide enough to include the wings, with consequent reduction in apparent gas absorption coefficient.

In the system described here, the reference wavelength is obtained by altering the nature of the discharge itself by means of the so-called Zeeman effect. When a suitable magnetic field, in this case some 15k gauss, is applied to the discharge, the emission line is partially split to give, as well as the original line, new lines on either side of the central wavelength.

The main ultraviolet emission in the low pressure discharge lamp is the result of electrons, excited by the discharge of a higher energy level, falling back to the ground state. These states are 6^3P , the excited state and 6^1S_0 , the ground state. The difference in energy levels is 4.86 eV, corresponding to $2537^{\circ}A$.

The splitting of the spectral line can be traced back to

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splitting of energy levels in a magnetic field. The orbit of an electron has associated with it a magnetic moment owing to the motion of the electron. When the atom is placed in a magnetic field, the total angular momentum vector is subject to a torque resulting from the interaction between the atomic magnet and the external field. The vector is caused to precess about the direction of the field. The frequency of the precession is given by $\frac{He}{4\pi mc}$ and is the well known Larmor frequency. Since the angular momentum is quantised, any energy level shift due to the applied field is also quantised. Thus discrete spectral lines are formed on either side of the original lines.

If the field is further increased the precession velocity increases. At a higher field the coupling between the angular and spin momenta starts to break down, and the Paschen-Back effect is observed, when a new set of displaced lines can be observed.

Naturally occurring mercury contains 5 isotopes, so that the 2537°A line, when investigated with high resolution, is seen to consist of 5 separate lines, each separated by between 10 and 15 mA° (one-thousandth $^{\circ}$ Angstrom unit). At the electron temperatures reached in the discharge, Doppler and collision effects will widen these hyperfine lines so that to some

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extent they will overlap. In the sample cell, at ambient temperatures and pressures, the overall width of the vapour absorption line is probably some $50 \text{ m}\text{\AA}$. Thus the shift required of the spectral lines to render them insensitive to absorption by mercury vapour is roughly of this order. The Zeeman shift is approximately $5 \times 10^{-5} \text{ cm}^{-1}/\text{gauss}$, so that the field required is about 15 - 16k gauss.

Implementation of this method is carried out by repetitive application of the magnetic field to the discharge tube. The radiation is directed through a sample cell onto a detector and the resultant radiation during the time the field is applied, is compared to that when there is no field. In a high sensitivity system, a small fraction of the radiation is split off prior to passing through the cell. By comparing the output of this reference detector with the signal detector, long term drifts of the magnetic field may be eliminated.

DESCRIPTION

The spectrometer is a dual beam, dual wavelength unit operating in accordance with the principles outlined above. An aluminium tube is used as an insert sample cell. This tube is readily removable for cleaning by releasing two clamps.

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The discharge lamp is located between the poles of the magnet assembly (see Sketch 2). The 2537°A radiation is directed by lense L1 to B.S.1 where it is split into two bundles. Half the light is directed to M1 and thence to the Reference Detector. The remainder of light is transmitted and passes through the sample cell to the Signal Detector.

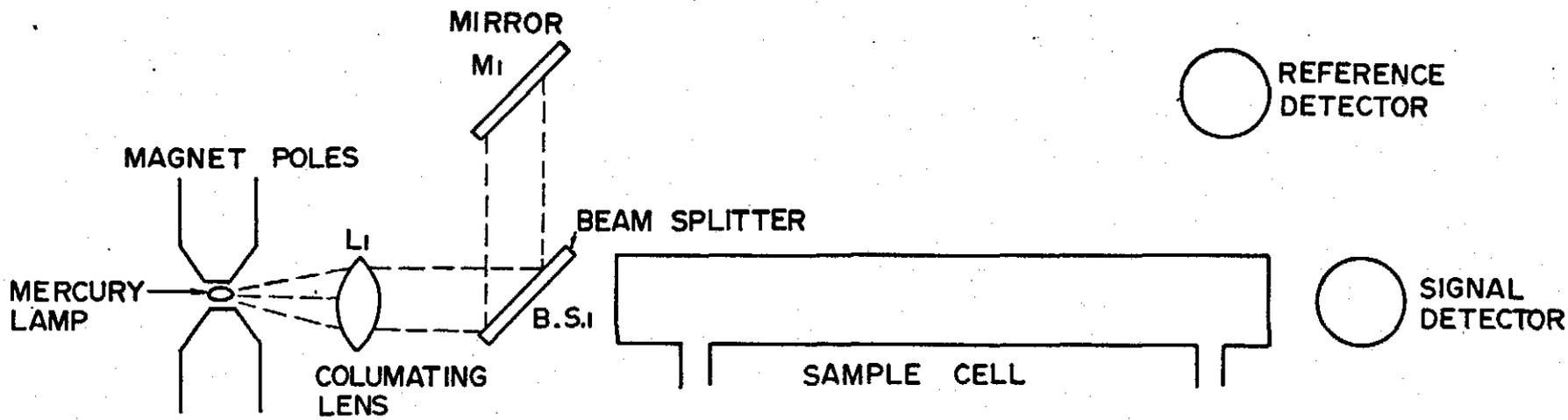
The magnet assembly is housed in C.R. steel to minimise magnetic coupling. The H.V. supply (100V) to the detectors and the 100kHz drive to the lamp are located in an aluminium box mounted next to the magnet housing.

The detectors in this unit are 935 photodiodes. Cathode load is $10\text{M}\Omega$ and coupled with each detector is a F.E.T. input unit gain voltage follower. Output impedance of the pre-amplifiers is less than 1Ω .

SIGNAL PROCESSING ELECTRONICS

The function of the electronics within this configuration is to convert the raw signals from the spectrometer into voltage levels proportional to the mercury concentration within the sample cell.

In most normal situations, the output signal to be proportional to its mercury concentration is of the form



SKETCH 2
OPTICAL PATH

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$$V_{out} \propto \frac{V_{SN} - V_{RN}}{V_{RN}} - \frac{V_{SF} - V_{RF}}{V_{RF}}$$

where V_{SN} , V_{RN} , V_{RF} are voltages proportional to the photocurrents measured by the signal and reference detectors during the "no field" and "field" periods respectively. Thus the expression assumes that the mercury concentration is low enough that the higher order terms in the expression e^{-kcl} are negligible. A further assumption is made with regard to the presence or absence of other absorbing gases.

In general, in the absence of mercury, it is preferable for optimum signal-to-noise ratio that the two halves of the above expression tend to zero, i.e. that $V_{SN} \rightarrow V_{RN}$ and $V_{SF} \rightarrow V_{RF}$. In the case where this is not exactly so, it is necessary that the flux difference between the "field" and "no field" condition be minimised, i.e. $V_{SN} \rightarrow V_{SF}$ and $V_{RN} \rightarrow V_{RF}$.

The raw signals from the spectrometer are fed to buffer amplifiers 1 and 2, the outputs of which feed the common mode amplifier. This block performs the function $V_{SN} - V_{RN}$ and $V_{SF} - V_{RF}$. Division by V_{RN} and V_{RF} is carried out by the scalar circuit.

The presence of mercury vapour is indicated by differential absorption between the periods "field" and "no field"

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appearing as an AC component. The effect of non-atomic absorbers appears as a DC offset at the output of the scaler and is blocked by a capacitor.

The AC component is detected by a shunt-gate synchronous detector, the resultant output having a mean DC output level proportional to the synchronous AC input component. This DC level is fed to a low pass filter and thence to the recorder. Further damping is provided at positions 1 and 2 of the Range switch. This position inserts a high value capacitance in the input circuit of the low pass filter.

The "field" and "no field" shunt gates operate at a 37.5% duty cycle. The remaining 25% is not sampled since the field is either growing or decaying and there are quite large transients which could otherwise saturate the synchronous detector.

The condition that $V_{SN} \rightarrow V_{RN}$ means that the optical and electronic gains in either channel should be equal. This balance is adjusted by operation of the gain balance control while the corresponding switch is in the Adjust position. In this position, one period of the synchronous detector is disabled and the input coupling capacitor shorted. Zero output indicates that the overall gain in both channels is equal.

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The second condition that $V_{SN} \rightarrow V_{SF}$ implies that the flux for either channel should be equal during the periods of "field" and "no field". In practice, when the magnetic field is applied to the lamp, the intensity is found to increase. This increase is compensated by reducing the lamp current for the duration of the "field" period. This decrease is performed automatically by a feedback control loop which senses any imbalance between the phases of the reference signal and corrects for it by altering the resistance of an active transistor in the voltage regulator circuit feeding the lamp drive.

The adjustment $V_{SN} \rightarrow V_{SF}$ implies that there should be no synchronous AC component in the signal. Accordingly, the Adjust position of the flux balance switch puts a high value capacitor across the feedback resistor of the signal buffer amplifier removing the AC component from the signal. The flux balance control is then adjusted until zero output is reached which indicates that the reference channel now also has no AC component.

Any residual errors are trimmed from the spectrometer using the zero control. This controls a set attenuation interposed during either the "field" or "no field" period in the input circuit of the signal amplifier. The phase of this correction is controlled by a panel mounted switch, and the extent of

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correction by the FINE and COARSE controls.

SAMPLE EQUIPMENT

The supplied sample equipment consists of a probe, the spike and wrench, and a hand pump.

The probe is essentially a stainless steel tube. Surrounding the tube is a wooden cone which seals the top of the test hole. On top of the probe a test tube water trap may be fitted.

The spike, of specially tempered steel, is driven into the ground and then turned and lifted out with the wrench.

The pump is a hand operated aluminium bodied piston type, with stirrup for ease of operation.

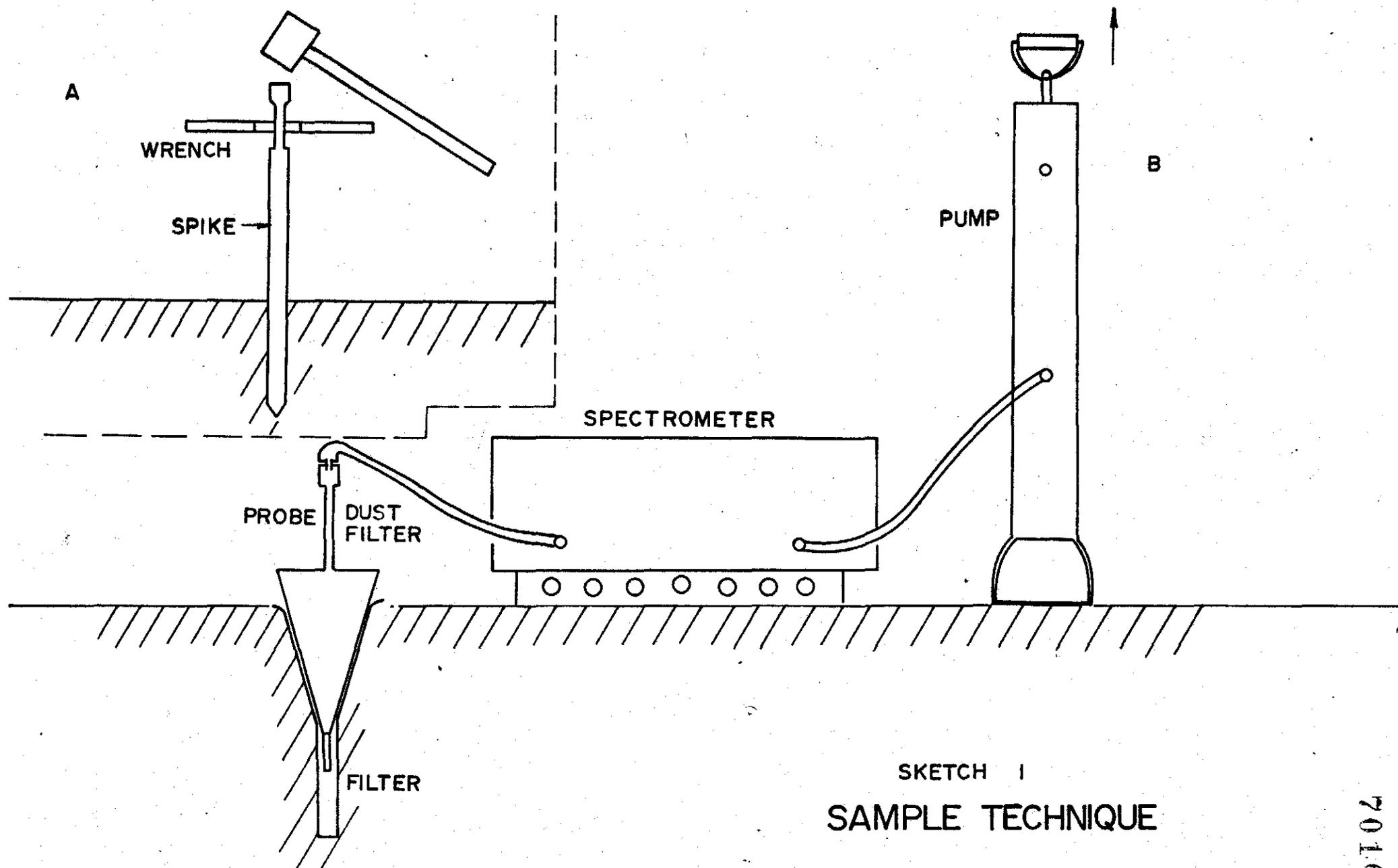
SOIL GAS SAMPLING PROCEDURE

The following procedure has been successfully used under a wide variety of climatic conditions.

1. At the desired test spot the first step is to drive the steel stake approximately $1\frac{1}{2}$ feet into the ground. Then with the wrench the spike is twisted and lifted out.

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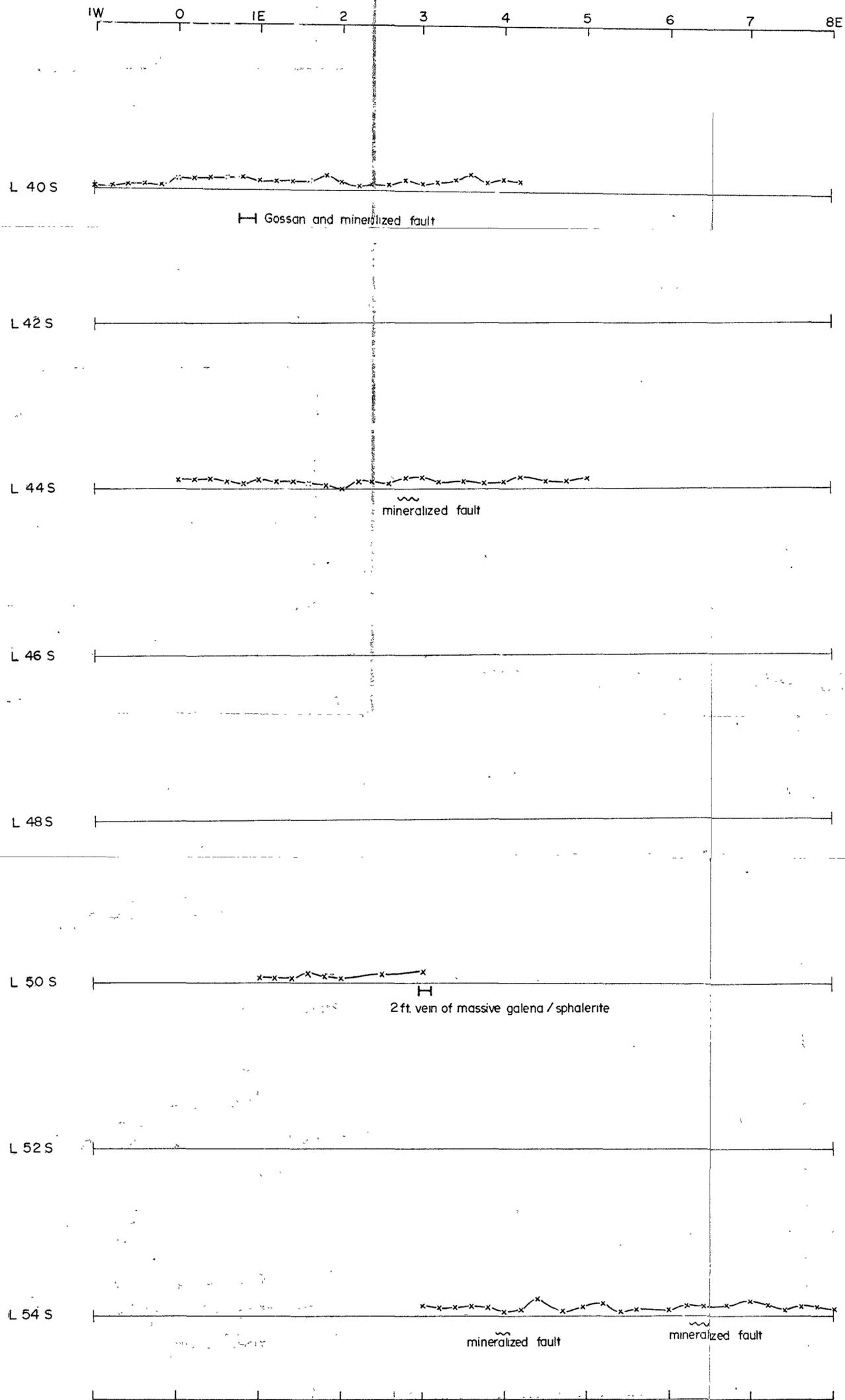
2. The stainless steel probe, fitted with a foam rubber dust filter and securely clamped to the sealing cone, is inserted immediately into the hole and forced well home to exclude atmospheric air.
3. With the hoses connected as shown in Sketch 1 the pump handle is slowly withdrawn to draw soil gas into the spectrometer. The optimum suction at the pump and the extent of the stroke depend to some extent on local ground conditions but can easily be recognised through experience and by watching the spectrometer meter for a peak.
4. After each sample the spectrometer cell should be flushed by drawing ambient air through it with two or three full strokes of the pump.
5. The required reading for each sample is the maximum steady displacement of the spectrometer meter from its initial ambient value. Flushing out the sample cell after the measurement should return the meter to its original value. Any small discrepancy due to drift during the measurement may be averaged out. The concentration of mercury vapour in the sample cell is proportional to the deflection in millivolts.



SKETCH I
SAMPLE TECHNIQUE

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6. In dry areas small plugs of cotton wool retained in sections of hose between the probe and the spectrometer inlet have proved effective in excluding dust.



Machine Reading m.v.

LEGEND

1 m.v. = 1 ng/m³ Hg vapour (approx)

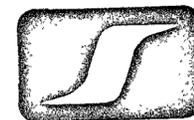
GEOPHOTO RESOURCES CONSULTANTS

**EAST SOUTH COMET GRID
EL. 7/68 DUNDAS DISTRICT**

**SOIL GAS TEST SURVEY
SCINTREX HGG-3
MERCURY VAPOUR SPECTROMETER**

SURVEYED AND COMPILED BY
SEIGEL ASSOCIATES AUSTRALASIA PTY. LTD.

JANUARY 1973



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SCALE IN FEET

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JOB No. T.A.S. 013 SHEET 1 of 1 PLATE 1

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