Rept.Bk. 706
G.S. 2914
S.R. 11/5/133

DEPARTMENT OF MINES
SOUTH AUSTRALIA

EXPLORATION GEOPHYSICS SECTION
GEOLOGICAL SURVEY

FIRST REPORT
ON
GIDGEALPA MAGNETIC SURVEY

by

J. McG. Hall,
Geophysicist.

9th July, 1964.

SR 11/5/133

RB 706

DEPARTMENT OF MINES
SOUTH AUSTRALIA

FIRST REPORT

ON

GIDGEALPA MAGNETIC SURVEY

by

J. McG. Hall,
Geophysicist,
EXPLORATION GEOPHYSICS SECTION
GEOLOGICAL SURVEY.

CONTENTS

PLAN REFERENCES

Title	Number
Locality Plan	64-494
Plan of Traverses, Northern Section	64-498
" " " , Grid	64-499
" " " , Southern Section	S3763
Total Magnetic Contours	L64-130
Total Magnetic Profiles - Grid	L64-131, L64-131A, L64-131B
" " " - Northern Section	L64-131C
" " " - Southern Section	L64-131D

Rept.Bk.No. 706
G.S.No. 2914
9.7.64. S.R. 11/5/133

DEPARTMENT OF MINES
SOUTH AUSTRALIA

FIRST REPORT

ON

GIDGEALPA MAGNETIC SURVEY.

ABSTRACT

A ground magnetic survey was carried out by the Department for Delhi (Aust.) Petroleum Limited at Gidgealpa from the 13th of March to the 15th of April, 1964. The total magnetic field of the earth was measured using the ~~using the~~ nuclear precession magnetometer and the results presented in contour and profile form. Due to a lack of adequate diurnal control and accurate station positioning, the accuracy of the results does not quite come up to the capability of the instrument. It is recommended that more attention be paid to navigation and diurnal control in future surveys over sedimentary basins.

INTRODUCTION

The survey was carried out by J. McG. Hall, R. S. Turner and J. M. Wauchope of the Exploration Geophysics Section, using the nuclear precession magnetometer mounted in a Departmental Land-Rover. (See Appendix). During the survey, the Delhi-Santos camp at Gidgealpa No. 1 Well was used as a base. See area plan 64-494. The area was covered in three sections - the grid around the wells numbers 1 to 3, the northern section between the grid and Coopers Creek, and the southern section to the south of the grid.

PREVIOUS GEOLOGICAL WORK

United Geophysical Corporation carried out a reflection seismic programme over the area in 1963, and Geophysical Service International carried out a regional magnetic survey in 1963 using some of the seismic lines as traverses. Stations were approximately at half mile intervals with traverses up to ten miles apart. A gravity survey has also been done over the seismic lines.

METHODS USED

a. Grid:

Seismic lines AR (from AR 100 to AR 130) and E were taken as the axes of the grid, which consisted of lines parallel to AR at half mile intervals and lines parallel to E at one mile intervals.

See plan 64-499.

Readings were recorded continuously along all lines, but were taken off the recording chart at .05 mile intervals and corrected and plotted at these intervals.

All distances were measured by a survey speedometer to .01 miles - on the seismic lines this amounted to an average error of less than .02 miles over a five mile traverse.

Traverses other than seismic lines were run on magnetic compass bearings and sky-line markers. This turned out to be rather inaccurate due to a lack of sky-line features and the roughness of the country which necessitated many detours and consequent uncertainty in distance and direction.

b. Northern and Southern Sections:

These were run mainly on seismic lines, with others put in by compass bearing to fill in large gaps between the seismic lines. See plans ~~S3763~~ 64-498. Because of the much greater length of these traverses, inaccuracies in direction and distances became greater and some of the traverses were omitted from the plotted results as it was felt that their positions were a little uncertain to be used for contouring.

For adequate diurnal control, it would have been necessary to either operate a continuous-recording magnetometer at a base station, or return to a base station for a reading about every hour. Unfortunately, there was no base instrument available, and the nature of the country and the distances covered on the survey made it impractical to return frequently to a base station. To get some diurnal control, the instrument was operated near the camp all day on the 12th April, and the readings, converted to gammas, plotted against time. This graph was used as a basis for diurnal control throughout the survey, as records from Gnangara observatory showed April 12th to be a quiet day magnetically.

CORRECTIONS

a. Geographical:

The variation of total magnetic intensity with latitude and longitude was measured from a chart of the total magnetic intensity over Australia. This variation was 8.3 gammas/mile in a north-south direction (+ve to the north, -ve to the south) and .32 gannas/mile in an east-west direction (+ve to the east, -ve to the west). Combining the two, a variation of +8.31 gammas/mile on a bearing of 2°12' was obtained and used as the geographical correction. Number 1 Well was taken as the base station for this correction.

b. Diurnal:

All readings were corrected to a time of 0500 hours, based on the graph of 12th April, 1964. These corrections were approximate due to two factors which were uncontrollable with this method.

(i) The variations for days other than April 12th, while generally similar, would certainly not have been identical and, in fact, if any strong magnetic storms had occurred during the period, this graph would have been useless during such storms.

(ii) In addition to diurnal variations, the earth's field varies irregularly from day to day, that is, even if a daily curve was nearly identical in shape to that of the 12th April it could be displaced an arbitrary number of gammas from it.

c. Heading:

It was known before the survey that the reading obtained by the instrument at any one position was dependent on the direction in which the vehicle and trailer were facing. Originally, it was thought sufficient to measure the earth's field at one place in the directions 0°, 90°, 180° and 270°, and correct readings on other bearings to the nearest cardinal point of the compass. However, once the survey had started, it soon became apparent that the corrections needed were so great in some directions that this approximation was not good enough; also, variations of even 10° from course caused appreciable differences in the heading correction to be applied. To enable accurate heading corrections to be made, a compass card was laid out with stakes on a stretch of flat, open ground and a series of measurements made at bearings from 0° to 360°. The readings were plotted against bearing (after diurnal corrections had been made) and corrections for readings between actually measured bearings interpolated from the graph so formed. This graph resembled a damped sine wave with period slightly less than 180°. All bearing measurements were taken with a magnetic compass. Corrections applied in this manner are considered accurate to within 1 gamma, although of course, no account can be taken of variations due to detours around bushes, water-courses, etc.

RESULTS

In the majority of the work, the readings were taken directly off the pen-recorder chart, the photographic films of the meters being used only for sections where the chart readings were uncertain or non-existent because of a breakdown.

The readings obtained were recorded on data sheets at .05 mile intervals for the grid and southern sections, and .1 mile intervals for the northern, and converted to gammas before the corrections described in the previous section were applied.
The conversion factor for this instrument is

$$\text{Total magnetic field} = {}^{24051.0}/_{\text{Reading}} \quad 10^{5} \quad \text{Gammas}$$

(1 Gamma = 10^{-5} gauss, and the approximate value of the earth's field at Gidgealpa is. .56 gauss or 56,000 gammas).
After corrections had been applied, the results were plotted in profile on plans L64-131, A to D, ~~e, f, and g~~, and also presented in plan form as the contour map L64-130 ~~h~~. Plans 64-498, 499, & 53763 ~~b, c and d~~ show the traverses along which readings were taken and which formed the basis for the contour plan. In addition, the traverses appear on the contour map as broken lines.

ACCURACY OF THE RESULTS

On smooth ground where vibrations and bumps do not cause scatter of the readings, the instrument is capable of being read exactly. If read continuously in the same place, the instrument will repeat its reading to within 1 unit (subject to corrections for diurnal draft), thus the precision can be taken as $\pm$ 1.3 gammas. Because of this, it is necessary to be able to make corrections to within 1 gamma in order to make best use of the high precision attainable by the instrument. Due to limitations previously described, this accuracy was not obtained.

Under the method of navigation used, the position of any individual station (other than those on seismic lines) can be considered uncertain to a degree of approximately 1000 feet on the grid, and 2000 feet on the northern and southern sections. This uncertainty in position is more likely to be due to uncertainty in direction rather than distance so that on the northern and southern sections where most of the non-seismic lines are roughly north-south, the major part of the error will be in longitude which has a minimum effect on the geographical correction. Over the grid the reverse is true, but here, due to the shorter distances between tie points, the uncertainty of position is only half as great and the geographical correction probably has a comparable accuracy of about $\pm$ 2 gammas over all sections.

Because of the lack of daily diurnal records, it is difficult to assess the accuracy of the diurnal correction. However, the various arbitrary adjustments which were needed to bring the values at stations read several times on different days into agreement, can probably be regarded as diurnal adjustments; these adjustments have an average accuracy of $\pm$ 5 gammas - this can probably be regarded as the overall accuracy of the diurnal corrections.

At any individual station, the bearing of the vehicle at the time of reading would normally have been within $\pm 5^{\circ}$ of the correct bearing (excluding points where definite detours were made - these places were noted on the data sheet and can be allowed for in the evaluation of the results). This would cause a maximum error of $\pm$ 4 gammas, the error being a minimum near the four cardinal points of the compass.

Thus, for those traverses not run along seismic lines, the total accuracy of any value would be approximately ± 12 gammas. On the seismic lines, the geographical and heading corrections have an accuracy of ± 1 gamma with the other corrections as above, giving a final accuracy of approximately ± 8 gammas.

RECOMMENDATIONS

It has been suggested that a second derivative map be made from plan LG4-130 with a view to delineating anomalous features more clearly. However, due to the fact that the spacing between the traverses is comparable to the areal extent of the anomalies, it is felt that an accurate and useful second derivative map would not be a feasible proposition. In addition, the size of the anomalies is of an order comparable to the possible errors in the value of the magnetic field - under these conditions the accuracy of second derivative values could not be much within the size of the anomalies expected.

As an alternative, I suggest that a residual magnetic map formed by removing the regional effect in plan LG4-130 would be practicable and would make the present anomalies clearer.

Regarding future work with the mobile magnetometer, several recommendations are made based on the experiences of the present survey.

a. In areas, such as Gidgealpa, of little or no surface relief or features, navigation by hand compass and sky-line markers is not accurate enough for the precision attainable by the instrument. However, an accurate mounted compass (compensated for the effect of the vehicle and calibrated to show true rather than magnetic bearings) would be accurate enough in the absence of detours. For this method to be successful, obstructions would have to be surmounted or removed rather than avoided. Another method of ensuring accurate navigation would be to have traverses surveyed from known points (on seismic lines, say) on a known bearing and flagged at intervals sufficient to enable the driver of the vehicle to keep to within 1° of the bearing. Providing obstructions are cleared so that detours are unnecessary, there would be no need for distances to be chained as long as the positions of both ends of the traverse are known and not more than about 5 miles apart. There would be no need for any levelling to be done. In addition to ensuring accuracy in the geographical corrections, this would enable heading corrections to be made with certainty. Where the country has considerable surface relief and features, the identification of stations and the position of traverses can be marked on aerial photographs accurately enough for a correction to be made for position to within 1 gamma. Heading corrections, while more complicated due to the possibility of more changes in direction, would not be much less accurate than with surveyed lines.

b. To ensure adequate diurnal control it is necessary to have a recording magnetometer (measuring total field) at a base so that the daily fluctuations can be accurately accounted for. For this purpose the construction or purchase of a second nuclear precession magnetometer is recommended. A chart recorder is needed, also the recording dials but not the photographic unit. Where the survey is in a mineral area rather than a sedimentary basin, anomalies are usually so great that diurnal corrections are unnecessary and the second instrument would be available to halve the field work for the project. (It will often be found in a mineral survey that anomalies of the order of 10,000 gammas are found and no corrections at all may be needed).

c. In areas where traverses are surveyed, a field party of three is suggested viz. a driver, a technician to operate the instrument, and a geophysicist or geophysical assistant to evaluate results while the party is in the field; he would also be responsible for the operation of the recording base magnetometer. It must be borne in mind that the mobile magnetometer can produce at least three times as many line-miles of data per day as, say, a Jalander magnetometer. This will mean three times as much work in computing results so that it will be almost imperative to have computation proceeding as the data is being collected.

Where lines are not surveyed a fourth man may be needed to navigate from aerial photographs. A hand calculating machine is considered essential if any computing is to be done while the party is in the field. Without the cal culator, it will not be possible to apply the corrections which can completely change the character of the results; this would prevent the party leader from deciding on possible extra traverses on the spot.

J. McG. Hall

J. McG. HALL,
GEOPHYSICIST,
EXPLORATION GEOPHYSICS SECTION.

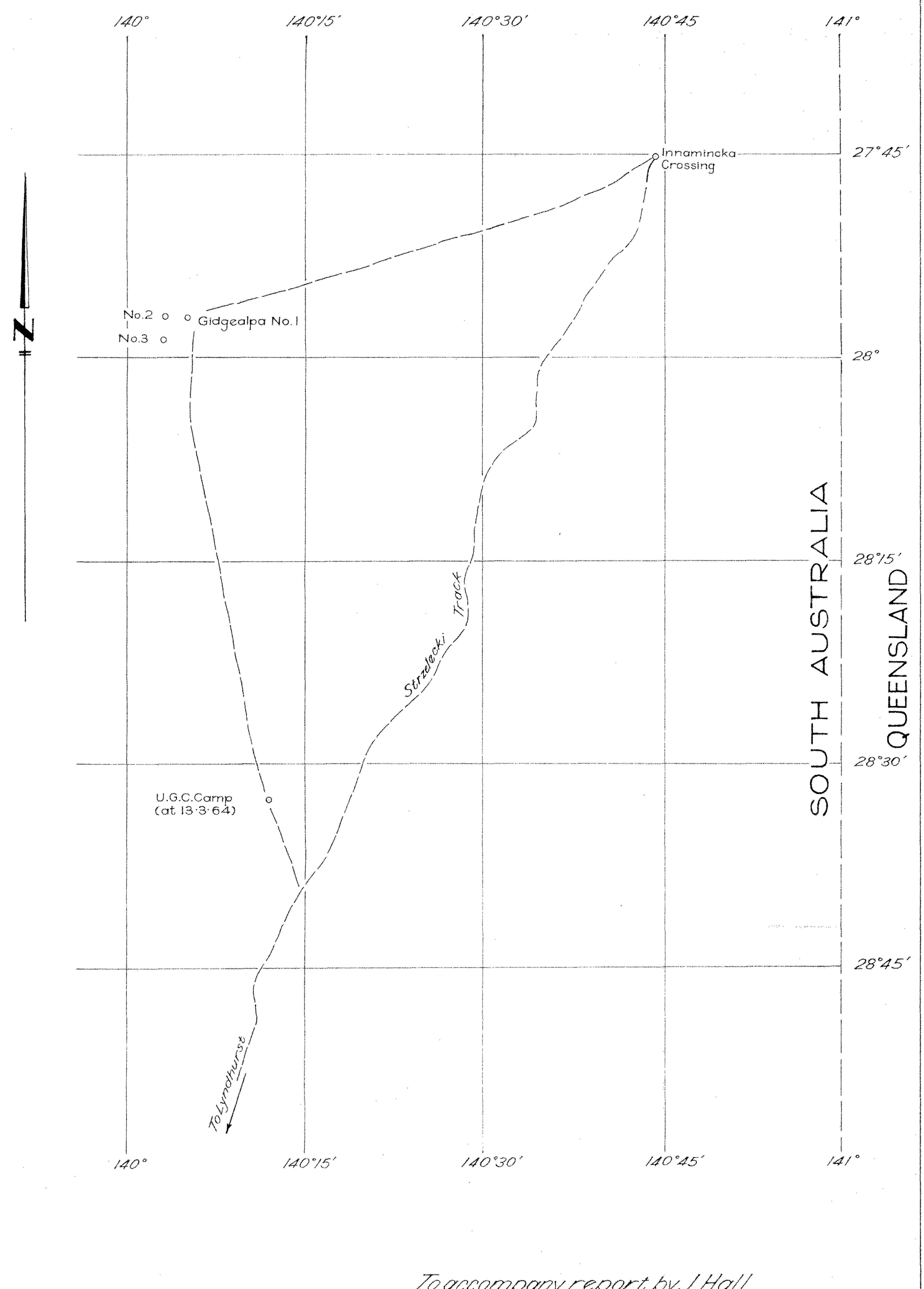
JMcGH:EMD
9.7.64.

APPENDIX: PRINCIPLE OF THE NUCLEAR PRECESSION MAGNETOMETER

Most atomic nuclei have a magnetic moment and can be considered as magnets spinning about their magnetic axes, and aligned with the earth's field. The simplest nucleus having this property is the proton, or hydrogen nucleus. Since oxygen has no magnetic moment, a bottle of water can be regarded as an assemblage of protons (so far as their magnetic properties are concerned) polarized in the direction of the earth's field. If a field far greater than the earth's and approximately perpendicular to it is applied to the bottle, the protons will move so they align themselves approximately in the direction of the new field. When this is cut off the nagmetic moment of the protons will return to its original direction and value in the earth's field H by precessing about H with an angular velocity $\omega = \gamma H$ where γ is a constant.

ω

This precession will induce an electrical potential in a coil wound about the bottle, the frequency of which is proportional to the earth's field. Thus, to find the earth's field it is necessary to measure this frequency which is best done by counting a predetermined number of cycles of the precessional voltage and timing these cycles electronically.



To accompany report by J.Hall

S.A. DEPARTMENT OF MINES

GIDGEALPA MAGNETIC SURVEY

LOCALITY PLAN

No.	Amendment	Exd.	Date

Approved

Director

Passed

Drn.
Tcd. G.M.
Ckd.
Exd.

Scale : 40,000' to 1"

64-494

Cb

Date 8·7·64

200—6.63 1423

To accompany a report by J. Hall.

S.A. DEPT. OF MINES

GIDGEALPA MAGNETIC SURVEY

PLAN OF TRAVERSES — NORTHERN SECTION

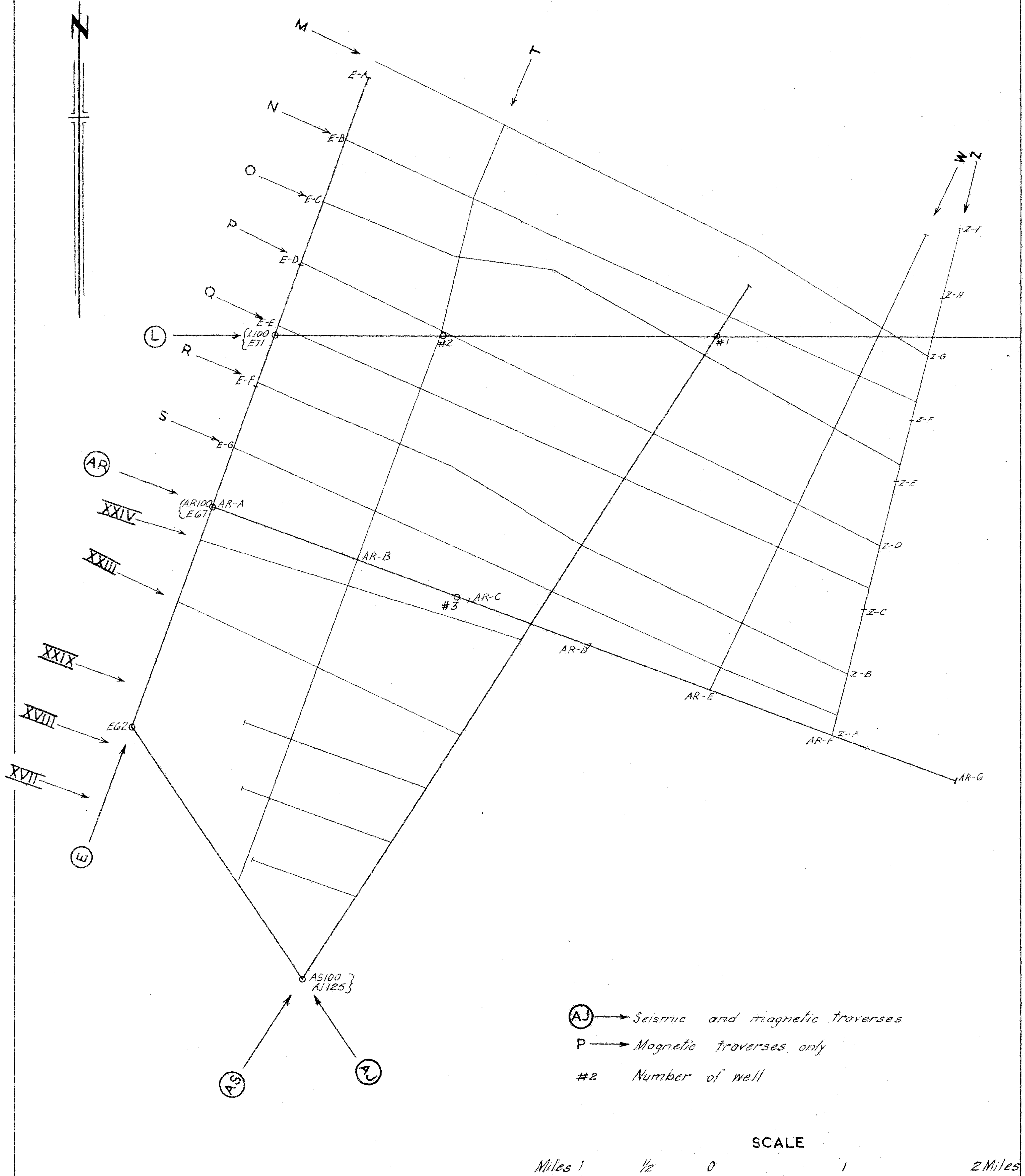
Associated Drawing	No.	No.	Amendment	Exd.	Date

Req. No.
D.M.
Compiled from

Approved | Passed
Director of Mines

Drn.
Tcd. B.L.S.
Ckd.
Exd.

Scale: 1" to 1 mile
64-~~489~~ 498
Date 10-7-64.



To accompany report by J. Hall

S.A. DEPARTMENT OF MINES

GIDGEALPA MAGNETIC SURVEY

PLAN OF TRAVERSES

MAIN GRID

No.	Amendment	Exd.	Date

Approved | Passed | Director

Drn.
Tcd. B.L.S.
Ckd.
Exd.

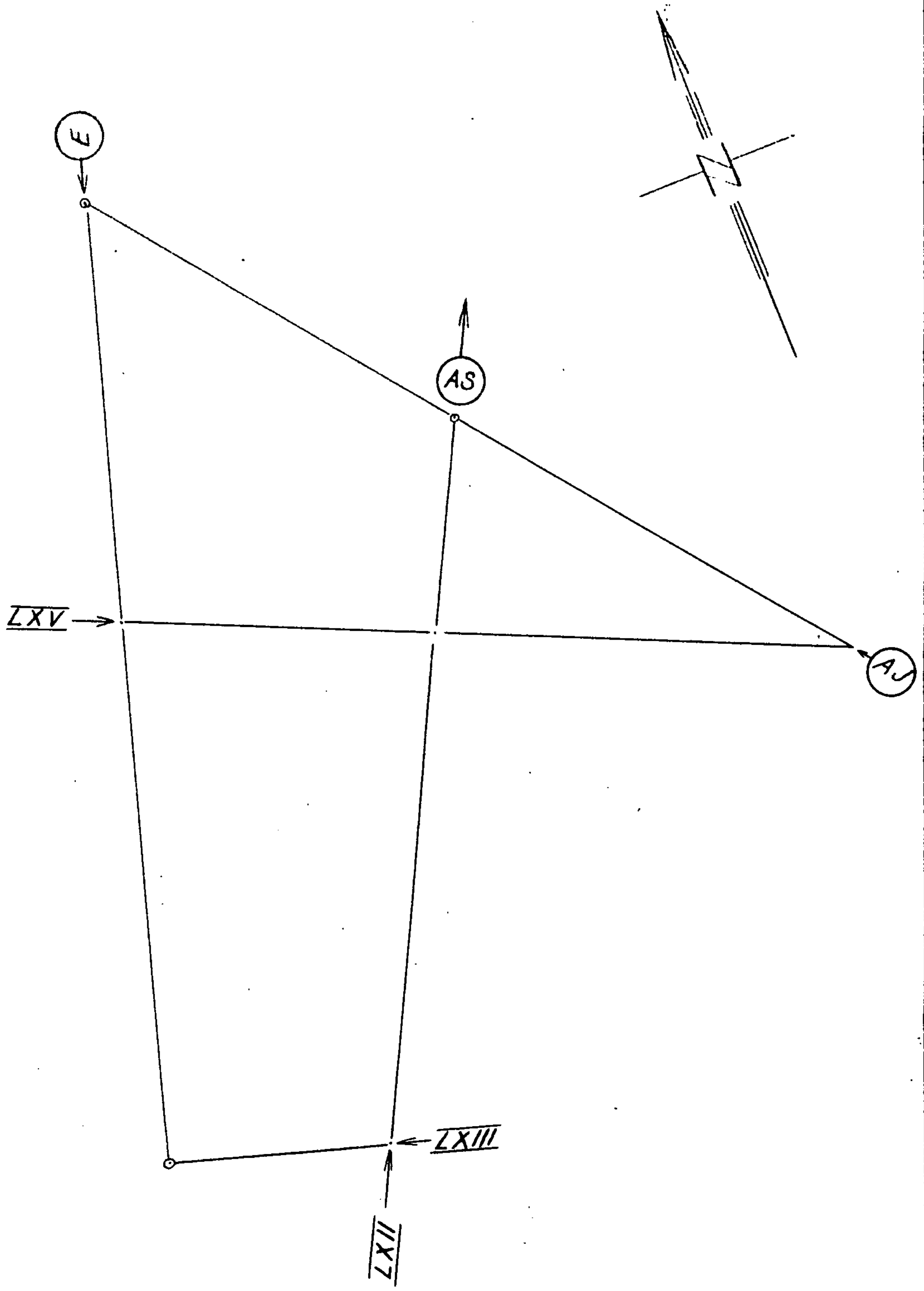
Scale: As above

64-499

Cb 1

Date 8-7-64

200—6.53 1423



LEGEND

(AJ) ⟶ *Seismic and Magnetic Traverse.*

LXIII ⟶ *Magnetic Traverse only.*

S.A. DEPARTMENT OF MINES

Approved	Passed	Drn.	GIDGEALPA MAGNETIC SURVEY	D.M.	Scale 1 Mile to 1 inch
		Tcd. M.J.R.	PLAN OF TRAVERSES	Req.	S3763
		Ckd.	SOUTHERN SECTION		Cb.
Director		Exd.			Date 10-7-64

400— 6.63 1423


S.A. DEPT. OF MINES
GIDGEALPA MAGNETIC SURVEY
TOTAL MAGNETIC CONTOURS
[redacted]
LEGEND
Contours of total vertical magnetic intensity. (Interval 5 gammas.)
55830
55840
Seismic and Magnetic lines.
Magnetic lines.
Magnetic High.
Magnetic Low.
Horizontal Scale 1 mile to 5 centimetres (approx. ½ mile to 1 inch.)
SCALE
MILE 1 0 1 2 3 4 5 MILES
To accompany report by J. Hall
L 64-130
Cb.
DATE 10-7-64


M LINE
N LINE
O LINE
P LINE
Q LINE
R LINE
S LINE
AR LINE
XXIV LINE
XXIII LINE
XXIX LINE
XXVIII LINE
XXVII LINE
Gammas
S.A. DEPT OF MINES
GIDGEALPA MAGNETIC SURVEY
TOTAL MAGNETIC PROFILES-GRID
L64-131

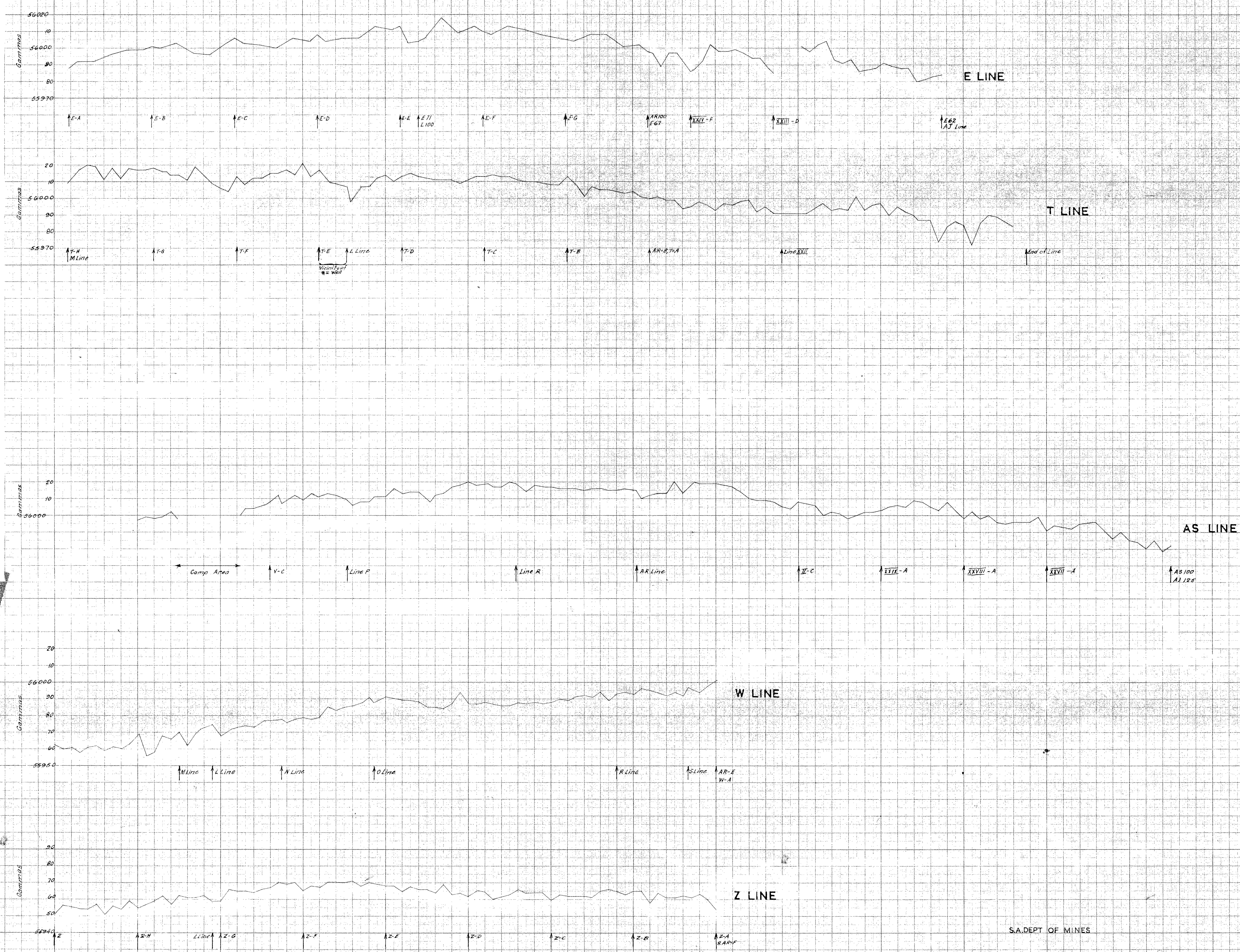
S.A DEPT. OF MINES

GIDGEALPA MAGNETIC SURVEY

TOTAL MAGNETIC PROFILES-GRID

Distance Scale : 1cm rep. 1/10 mile

L64-131A. cb.



S.A. DEPT OF MINES

GIDGEALPA MAGNETIC SURVEY

TOTAL MAGNETIC PROFILES-GRID

Distance Scale : 1cm. rep. 1/10 mile.

L64-131B

Gammas
B LINE
C LINE
G LINE
K LINE
F LINE
J LINE
E LINE
A LINE
S.A.DEPT. OF MINES
GIDGEALPA MAGNETIC SURVEY
TOTAL MAGNETIC PROFILES—NORTHERN SECTION
Horizontal Scales : 5cms rep. 1mile
2 inches rep. 1mile (approx)
L64-131C


GAMMAS
56000
90
80
56970
AJ LINE
E 62
AJ 112
Detour
Detour
AJ125
AS100
Detour
AJ 127
Start AJ
End LXV
20
10
56000
90
80
70
60
55950
LXV LINE
E Line
Detour
AJ Line
30
20
55910
LXIII LINE
End AS
E Line
S.A DEPT. OF MINES
GIDGEALPA MAGNETIC SURVEY
TOTAL MAGNETIC PROFILES –
SOUTHERN SECTION
Distance scale : 1cm rep 1/10 mile
90
80
70
60
50
40
30
55920
AS LINE
AS 100
AJ 125
Detour
End AS
90
80
70
60
50
40
30
55920
E LINE
Line LXIII
AT 100
Line LXV
E57
E 62
AJ Line
L64-131Dcb