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GEOLOGICAL AND GEOPHYSICAL INVESTIGATIONS

AT

TASMANIAN ELECTRO METALLURGICAL CO. PTY. LTD. PLANT AREA BELL BAY, TASMANIA.

N. McLaren

and

C. P. Taylor

Melbourne February, 1961.

AMG REFERENCE POINTS ADDED

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PLANS ACCOMPANYING REPORT.

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PART I - GEOLOGY.

I - INTRODUCTION

In April 1960, Soil Engineering Laboratories of Adelaide (Soilabs) drilled four bores to test the strata beneath the land at Bell Bay, Tasmania, purchased by The Tasmanian Electro Metallurgical Co. Pty. Ltd. (TEMCO) for the erection of a ferro-alloy plant.

These four bores intersected hard basalt at the following depths:-

Bore No. 1 from 28'2" to 58'0" - 29'10"
Bore No. 2 from 15'0" to 42'0" - 27'0"
Bore No. 3 from 33'0" to 72'6" - 39'6"
Bore No. 4 from 15'0" to 59'0" - 44'0"

Bores Nos. 1 and 3 were the only bores to intersect the full thickness of basalt, the other two holes being stopped in basalt. (In the Soilabs bores the basalt is called dolerite).

Bore No. 1, which proved a thickness of at least 29'10" of hard basalt was drilled only 40' from the proposed site of TEMCO No. 1 furnace.

The information from these four bores, together with that obtained from the previous drilling of the adjacent Australian Aluminium Production Commission's property indicated quite strongly that the TEMCO site was underlain by a layer of basalt approximately 40 feet thick and within reasonable piling distance from the surface.

The site was favoured by good shipping facilities and cheap electric power.

On 15th November 1960, Goldfields Diamond Drilling Co. Pty. Ltd. (Goldfields) commenced drilling TEMCO Bore No. 1 which was the first bore in a programme of six or seven bores designed to provide information for the piling contractors.

This bore was taken to a depth of 65'0", and although it intersected decomposed basalt and a 10 ft. section of weathered basalt, it did not show a satisfactory thickness of hard basalt.

The Broken Hill Pty. Co. Ltd.'s Raw Materials and Exploration Department was requested to assist in finding a more suitable site within the boundaries of TEMCO's area, and on 17th November geologist Mr. N. McLaren arrived at Bell Bay.

Mr. C.P. Taylor, the Department's geophysicist, arrived at Bell Bay on 24th November to carry out a ground magnetometer survey of the proposed furnace area.

Thirty-one bores were drilled by Goldfields, their aggregate length being 1,012 feet. These bores were put down primarily to probe for basalt and were not designed to produce geological information. Only two bores, Nos. 6 and 9, intersected the full thickness of basalt.

This report records the geological information that was gained from the drilling and makes certain observations which may be of assistance to the engineers concerned with the erection of the TEMCO plant.

All drill cores have been left at Bell Bay so that they may be referred to by the construction staff.

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II - FOUNDATIONS REQUIREMENTS

The specifications require that each furnace, weighing 1,200 tons, be founded on solid rock. The furnaces when in operation rotate on circular rails and these rails must not vary more than 1/50" from a horizontal plane, nor may the diameter of the rails vary more than 1/50".

It is the writer's opinion that normal earth movements would make it extremely difficult to provide foundations to meet these requirements, particularly in northern Tasmania where there has been regional faulting during the Tertiary period.

In the last six months there have been two earth tremors both of which have caused movement in parts of Tasmania, these movements being detectable by unaided human senses.

The foundation specifications also require that there be no differential movement at the furnace sites.

Each furnace occupies an area 41 ft. by 65.5 ft. and furnace centres are 90 ft. apart. TEMCO wish to make provision for four furnaces so it is necessary for the foundation area to be 311 ft. by 65.5 ft.

As a matter of interest the weight of a column of basalt 41 ft. by 65.5 ft. and 45 ft. thick is approximately 11,000 tons.

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III - GENERAL GEOLOGY AND LOCATION

Bell Bay is approximately six miles south of the northern coast of Tasmania on the eastern side of the Tamar River.

The oldest rock type outcropping in the Bell Bay area is a Jurassic dolerite which attains a thickness of approximately 300 ft. This dolerite, which is a similar rock type to basalt, outcrops along the eastern shore of the Tamar River over a length of five miles from a point one mile south of Bell Bay southerly to the East Arm. The width of this dolerite outcrop is three miles.

In the vicinity of Bell Bay the dolerite is overlain by Tertiary sediments with intraformational basalt flows.

At the TEMCO site the basalt is covered by Recent sediments consisting of clay and sand, and is underlain by unconsolidated Tertiary sediments. These sediments are of an estuarine nature and rapid variation in type can be expected.

The Tertiary sequence is virtually horizontal on a regional scale.

The basalt is a normal fine grained basalt with rectangular jointing. Some joint planes in the bore cores are polished indicating slight movement. An unusual feature in the basalt is the presence of pyrite along some joint planes.

The basalt is exposed in the cliffs bordering the Tamar River and here its thickness is approximately 50 feet. A similar thickness was shown by Soilabs Bore No. 3 and TEMCO Bores Nos. 6 and 9.

Mr. T.D. Hughes, Chief Geologist of the Tasmanian Mines Department has recognised at least four separate penecontemporaneous basalt flows in the Bell Bay area, and this has been verified to a limited extent by varying grain size in the basalt cores from our drilling and by the presence of vesicles in the core from below the top basalt surface.

The sediments underlying the basalt are unconsolidated and water saturated. The sand referred to in the logs is similar in every way to the sand on Melbourne beaches and the carbonaceous siltstone is virtually an ooze.

The Soilab bores and TEMCO bores Nos. 6 and 9 indicate that there has been no local post basalt faulting of any magnitude, (minor fault movement would not be discernible from the drilling), but the general area is a block down thrown by pre-basalt faulting and it is possible that post basalt movement has occurred along the pre-basalt faults. Such movement would not be detected by the boring at Bell Bay. The basalt exposed along the banks of the Tamar River is strongly jointed and it is possible that some of these joints intersect the full basalt thickness. It is thought that a recent land slip near the Aluminium Production Commission's wharf is attributable to such a joint.

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IV - DRILLING RESULTS.

With the exception of the four bores drilled by Soilabs, all bores were drilled by Goldfields using an English Drilling Equipment Co. Mark VI machine. The various ancillary equipment used during the drilling is shown on the descriptive bore logs.

Under the drilling contract no core was required from the surface to 18 feet. Below 18 feet 95% core recovery was stipulated but it became necessary to waive this clause in the interests of speed. However, core recovery was sufficient to enable positive identification of the rock types intersected.

Core recovery is shown on the descriptive logs which accompany the graphic logs in the Appendix.

Geologically speaking the only bores which gave unexpected results were Nos. 1, 4, 5 and 6.

Soilabs Bore No. 1 struck solid basalt from 31'6" to 56'0", and it was expected that TEMCO No. 1 Bore would give similar results. As can be seen from the Section 18A - Soilabs No. 1, this was not the case. Although TEMCO No. 1 Bore intersected 23'6" of decomposed basalt (blue clay) with a ten foot section of badly weathered basalt the bottom 14 feet of the basalt horizon in Soilabs No. 1 Bore was represented by unconsolidated sand in TEMCO No. 1 Bore.

Similar results were obtained in Bores 4 and 5, and the first 13 feet of Bore 6 cored sand and clay. Bore 6 was stopped at this depth but it was later continued to strike a good thickness of basalt.

In the absence of evidence of faulting Bores 1, 4, 5 and 6 (to 13') were interpreted by the writer as being drilled adjacent to the bank of an old stream or estuary with an easterly trend, and it was recommended that future drilling be to the south. Accordingly Bores 7, 8, 9, 10, 11 and 12 were drilled, all of them striking good basalt.

The preliminary results of the magnetometer survey were then received and they indicated a line of weakness coinciding with grid line 100W, making it necessary to drill west of this line. The order of drilling was then continuation of No. 6, 4A Bin north, 6A N.E., 6A S.W., 4A S.E., 4A N.E., 13, 14, 15, 17, 18, 18A, 17A, 19-26, all bores striking hard weathered or fresh basalt.

After a conference at Newcastle the site bounded by Bores 13, 7, 8, and 14, referred to as site 4A revised, was selected as the site for the first furnace. Bores 19, 20, 21 and 22 were then drilled for piling information on the furnace ring.

The eight bores at this site showed the following thickness of hard weathered and/or hard fresh basalt,

No. 13	19'0" - 34'0"	15'0"
7	25'4" - 49'6"	24'2"
8	27'3" - 42'5"	15'0"
14	21'0" - 30'0"	9'0"
19	19'4" - 22'6"	3'2"
20	20'9" - 23'10	3'1"
21	20'6" - 28'5"	7'11
22	21'10 - 24'10	3'0"

each bore being stopped in basalt.

In each of the eight bores the material immediately above the basalt is a soft clay either blue or brown in colour and resulting from the in situ decomposition of the basalt. It can also be expected that in the top few feet of the weathered basalt there will be patches of decomposed basalt erratically distributed and localised to small areas. This is illustrated by the poor core recovery in Bore 21 from 23'3" to 24'10", the loss of core being attributed to a small clay pocket.

Another feature shown by the drilling is the varying depths to which the basalt has been weathered. There is no constant parallelism between the top surface of the weathered basalt and the top surface of the fresh basalt, nor is the top of the weathered basalt a plane surface. This means that it is not possible to predict the depth to the weathered basalt by correlating between bores.

As previously indicated the TEMCO bores were not sited to give purely geological evidence nor were they taken to sufficient depth for this purpose. However, from the geological evidence that was obtained it would appear that the basalt "want" area has been caused by the formation of a southerly trending estuary during a lull in the effusion of the basalt, the estuary then being covered by a later basalt flow. This theory explains both the drilling and magnetometer results.

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Melbourne

N. McLaren.

PART II - GEOPHYSICS.

I - INTRODUCTION

The history of the previous work done at the TEMCO area together with the foundation requirements, general geology, and drilling results are included in Part I of this report.

Geologically, the area consists of a basalt flow both underlain and overlain by sediments. Basalt, because of its magnetite content, is normally more magnetic than sediments, and it was considered that a ground magnetometer survey of the area in conjunction with some drilling control would enable the depths to the top and bottom of the basalt flow to be calculated.

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II - METHOD

Readings of the vertical magnetic intensity (Z) were taken on a 100 foot grid with infill readings at 50 feet or 25 feet in the vicinity of the proposed furnace sites.

An arbitrary zero value for Z was chosen to simplify calculations, and no attempt was made to relate this to the absolute value for the area.

Diurnal corrections were made but, as the area being investigated was small, and no information on the local magnetism was available, regional variations were ignored.

Care was taken to read the magnetic intensity at such distances from extraneous magnetic material that their effects would be negligible. Occasionally this was not possible, especially when it was not visible or its magnetic properties difficult to evaluate. An example is the magnetic "low" near Bore 4, which was determined from readings which have probably been influenced by iron objects in the vicinity. There almost certainly is a large negative anomaly as shown but its magnitude may be smaller with a maximum of, say, -1000 gammas.

The survey commenced on 25th November, 1960, and was completed on 1st December, all grid lines having been previously pegged by Utah (Australia) Ltd. The instrument used for the survey was the Askania torsion magnetometer Gfz 582374.

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III - RESULTS.

The contours of Z at 250 gamma intervals, together with all bores and proposed furnace sites, are shown on Fig. 7.

The depths to the top of the weathered and unweathered basalt as intersected in each bore have been plotted against the corresponding value of Z in Fig. 8.

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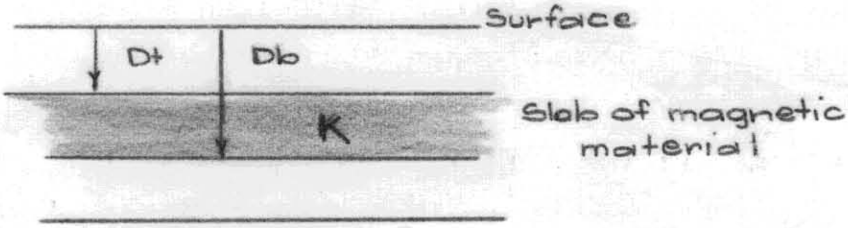
IV - INTERPRETATION

The basalt sheet at any point can be represented as follows:-



where Dt = depth to top of magnetic source
Db = depth to bottom of magnetic source
K = susceptibility of magnetic source.

The following assumptions are made:-

1. Within the area of the survey, the earth's magnetic field is constant. This is a reasonable assumption as the sediments above and below the basalt are probably non-magnetic. There are some slightly magnetic pebbles of laterite-bauxite (at 400N/500W) and ferruginous grit (at 900N/900E) but these are minor occurrences only.

2. The susceptibility (K) of the basalt is constant. There is no information available on this point and the susceptibility could vary considerably.

3. An empirical relationship exists between Z, Dt and Db of the form $Z = f(\frac{1}{Dt}, \frac{1}{Db})$.

It follows that:-

1. The variation in the vertical magnetic intensity in the area depends on Dt and Db. Since Db $\doteq$ 2 Dt, changes in Dt would produce greater variations than would identical changes in Db. Thus, to the first approximation, $Z = f(\frac{1}{Dt})$. This imperical relationship between Dt and Z is indicated on Fig. 8, and it can also be seen on the plans showing the geological cross-sections and all the corresponding magnetic profiles.

2. By measuring Z at the surface and using the graphs of Fig. 8, the depth to the top of the basalt at any point can be estimated.

3. The depth to the bottom surface of the basalt flow is virtually impossible to estimate using the magnetic results alone. For the particular case when Dt $\doteq$ Db, that is when the basalt sheet is very thin, Z approaches zero.

The graphs of Fig. 8 show that Dt probably corresponds to a horizon in the weathered basalt. As there is no sharp dividing line between the weathered and unweathered basalt, but a gradual change from one to the other, the values used for drawing these graphs would depend on the observer. This could account for some of the irregular readings. The fact that the weathered basalt can still be moderately magnetic explains why Z is much higher over Bore 1 than Bores 4 and 5.

Fig. 8 shows that Dt is generally in the range 10 feet to 40 feet, but within these limits it can vary considerably. This variation is probably caused by differential weathering of the basalt.

Bores 4 and 5, which did not intersect basalt, are within the -500 gamma contour, and from the empirical relationship between Dt and Z this value indicates either no basalt or basalt over 35 feet from the surface.

As shown on the geological section from Bore 18A to Bore SL1, there is an abrupt change in the basalt sheet between Bores 5 and 6; within a horizontal distance of 95 feet the thickness of the basalt flow changes from 36 feet to zero. The effect of this on Z is clearly shown on the magnetic profile along this section. It is an "edge effect" with the edge at 150W.

The distinctive magnetic variation between Bores 5 and 6 is not restricted to this section but continues in an approximate grid north-south line at least to 1300N and, to the south, to approximately 400N. This structure is distinctive on Fig. 7. Any Z profile across this line is similar to that between Bores 5 and 6 and represents a continuation of the break in the basalt sheet. There has been no drilling to confirm this although Bore 4A Bin North intersected basalt as expected.

South of 400N the magnetic variation along the line described above is not so pronounced: the -500 gamma contour swings sharply to the grid east at about 400N as does the -250 gamma contour, although this forms a distinctive narrow "channel" from 100W to 150W. On the western side of the line the 500, 750 and 1,000 gamma contours do not follow the 0 and 250 gamma contours.

This indicates that the break in the basalt sheet swings sharply to the grid east at about 400N although there is a narrow "channel" in the top of the basalt along a line through Bores 12 and 4ASE. These structures are well shown on the corresponding geological sections.

The break in the basalt sheet swings to the north again on the eastern side and then probably continues to the grid north-west, following the -500 gamma contour. Bore 1 is probably on the basalt sheet proper but is very close to the edge and most of the basalt has either been weathered or decomposed to blue clay.

Bore SL1 intersected 30 feet of basalt compared with 39 feet in SL3 and 44 feet in SL4 (SL2 was still in basalt when drilling stopped). This apparent decrease in the thickness of the basalt at SL1 suggests that the bore is near the edge of the flow.

Another hole in the basalt near 900N/400E is indicated by the magnetic contours. It appears similar to that in which Bores 4 and 5 are located.

In the area covered by the survey it is almost certain that except for the areas described above (i.e. where Z is less than -500 gammas) there is a continuous basalt flow.

The proposed furnace sites are shown on Fig. 7. Bores have been drilled either on or very near each site and these provide information on the depth to the basalt within each site. The magnetic contours show more clearly than the drilling results, however, that all sites (1, 1A - 6A and 4A revised) are in areas in which the depth to basalt changes rapidly in distances which are short compared with the size of the furnace site. In the "A" site line between 400W and 700W the top surface of the basalt could be flatter, at a depth of about 15 feet.

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V - CONCLUSIONS

The ground magnetic survey shows that the depth to the basalt which underlies the TEMCO area is irregular and that from the corners of a 41 feet by 65.5 feet rectangle it could be expected to vary by several feet no matter where the rectangle is located.

The contour plan of the vertical magnetic intensity can be taken as an indication of the variation in the top surface of the basalt flow and, if used in conjunction with the drilling results, should provide valuable information for the engineers in their considerations of the foundations in the TEMCO area.

Along a grid north-south line at approximately 150W, and between 400N and 1300N, the magnetic results indicate a continuous break in the basalt sheet. It is considered that, while the nature of this break and the "hole" in the basalt near Bores 4 and 5 are not clearly understood, the furnaces should be as far away from these as economically possible.

Suitable alternative sites would be the equivalent of 7A, 8A and 9A where the depth to the basalt could be expected to be constant at about 15 feet.

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Melbourne

C.P. Taylor.

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FIG. 1.

PLAN SHOWING

LOCATION OF TEMCO AREA

BELL BAY, TASMANIA.

Scale : 1 Inch = 8 Chains

AMG REFERENCE POINTS ADDED

4·1·61 G.B.

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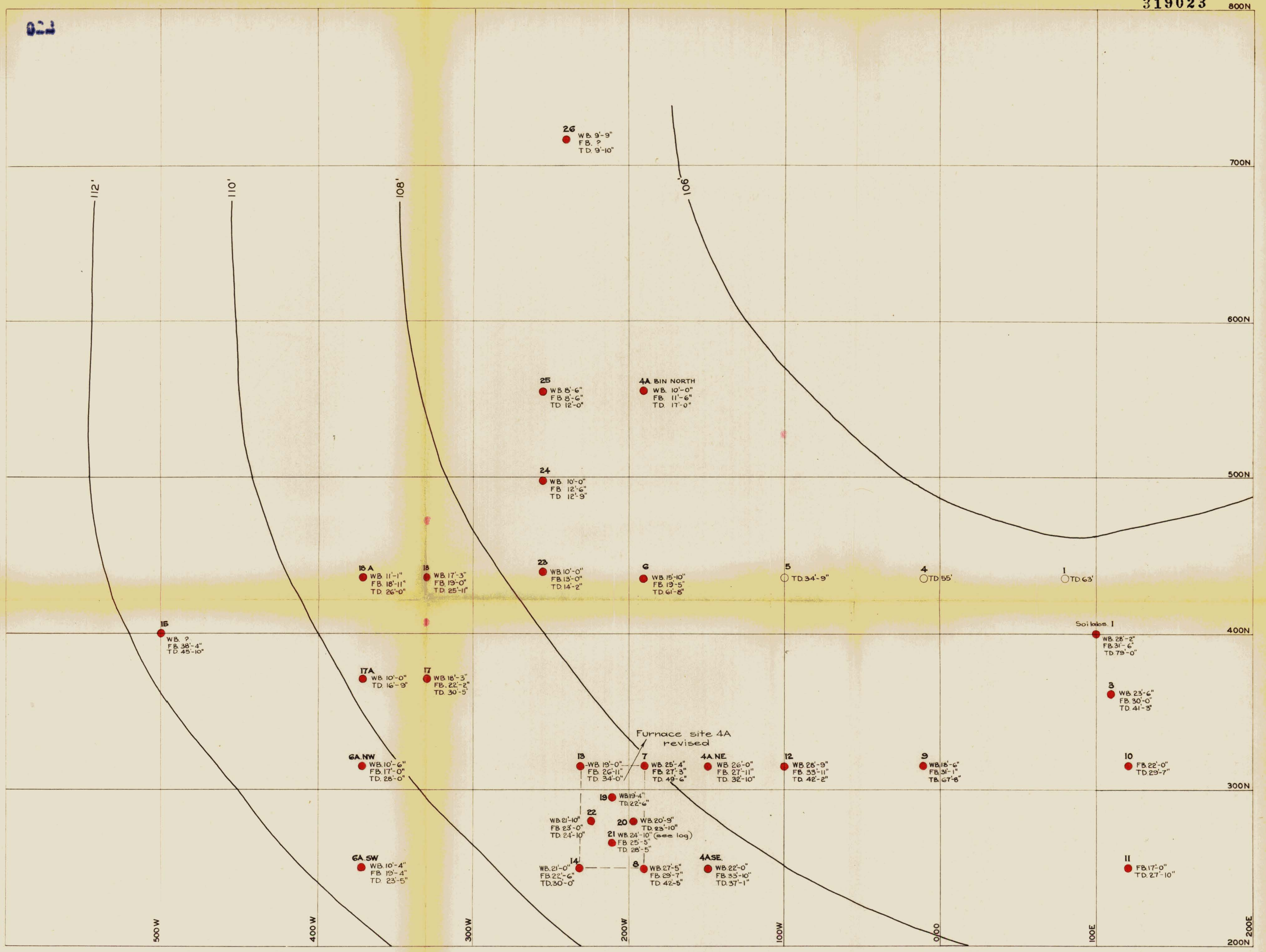

PLAN SHOWING LOCATION OF BORES
TEMCO AREA — BELL BAY, TASMANIA

SCALE 1" = 40 FEET

5 cm

LEGEND

WB 10'-6"	Depth to hard weathered basalt.
FB. 17'-0"	Depth to fresh basalt.
TD. 28'-0"	Total depth of hole.
106	Surface contours.
●	Bores which intersected or indicated full basalt thickness.

20 · 12 · 60 M.K.

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FIG. 3

923
6A.SW.
14
21 (Projected)
8
4A SE.
11
R.L. 106'
500
00
-500
VERTICAL MAGNETIC INTENSITY - GAMMAS
Top of basalt (unweathered)
SECTION 6A.SW - 11
1000
00
-1000
VERTICAL MAGNETIC INTENSITY GAMMAS
18A
18
23
6
5
4
1
Soilabs 1 (Projected.)
Top of basalt (unweathered)
LEGEND
Blue clay
Brown clay
Decomposed basalt.
Weathered basalt
Basalt
Sand
Carbonaceous siltstone
SECTION 18A - Soilabs 1.
TEMCO BORE SECTIONS & MAGNETIC PROFILES
BELL BAY, TASMANIA.
SCALES: Horizontal : 1 Inch = 20 Feet
Vertical : 1 Inch = 10 Feet
5 cm
22 · 12 · 60

319025

FIG. 4


SECTION 14 - 26
14
22 (Projected)
13
23 (Projected)
24 (Projected)
25 (Projected)
26
R.L. 106'
Top of basalt (unweathered)
500
00
-500
VERTICAL MAGNETIC INTENSITY GAMMAS
SECTION 12-5
12
5
SECTION 9-4
9
4
SECTION 11 - 1.
11
10 (Projected)
3 (Projected)
Soilabs 1. (Projected)
1.
LEGEND
Blue clay
Brown clay
Decomposed basalt.
Weathered basalt.
Basalt. (unweathered)
Sand
Carbonaceous siltstone.
TEMCO BORE SECTIONS & MAGNETIC PROFILES
BELL BAY, TASMANIA.
SCALES: Horizontal : 1 Inch = 20 Feet
Vertical : 1 Inch = 10 Feet
5 cm
4652
22. 12. 60


FIG. 5
VERTICAL MAGNETIC INTENSITY - GAMMAS
500
00
-500
R.L. 106'
6A. NW.
13
19
7
4A.NE.
12
9
10
Top of basalt (unweathered)
SECTION 6A.NW - 10.
1000
00
-1000
R.L. 106'
6A.SW
6A.NW
17A
18A
VERTICAL MAGNETIC INTENSITY GAMMAS
Top of basalt (unweathered)
LEGEND.
Blue clay
Brown clay
Decomposed basalt
Weathered basalt
Basalt (unweathered)
Sand
Carbonaceous siltstone
SECTION 6A.SW - 18A
TEMCO BORE SECTIONS & MAGNETIC PROFILES
BELL BAY, TASMANIA.
SCALES: Horizontal: 1 Inch = 20 Feet.
Vertical : 1 Inch = 10 Feet.
5 cm
4653
22.12.60

SECTION ALONG SOILAB BORES 1-4.
AND MAGNETIC PROFILES - TEMCO AREA
BELL BAY, TASMANIA.

SCALES : Vertical : 1 Inch = 10 Feet
Horizontal : 1 Inch = 100 Feet.

5 cm

4654

22 · 12 · 60

FIG. 7

CONTOURS OF THE VERTICAL MAGNETIC INTENSITY

GROUND MAGNETIC SURVEY

SITE OF TEMCO FERRO – ALLOY WORKS

BELL BAY. TASMANIA.

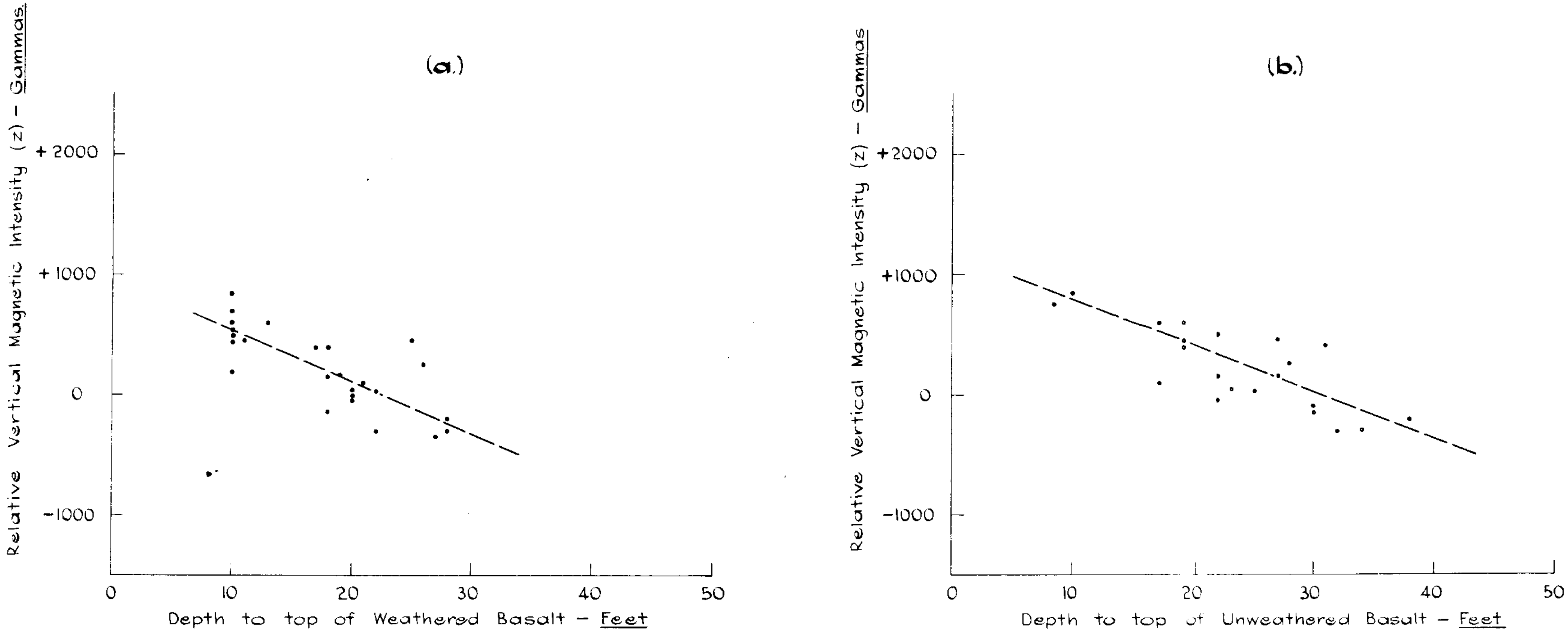
Scale : 1 Inch = 80 Feet.

4655

17.1.61 G.B.

319029 FIG. 8.

VARIATION OF MAGNETIC INTENSITY WITH DEPTH TO TOP OF BASALT FLOW TEMCO GROUND MAGNETIC SURVEY BELL BAY, TASMANIA.



4656

20·1·61 G.B.