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Mineral Reconnaissance Programme Report No. 1

The concealed granite roof in south-west Cornwall

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Summary

This report outlines the results of gravity surveys and drilling to locate cusps, possibly stanniferous, in the concealed granite roof north and west of the Carnmenellis granite outcrop. The results are plotted on the two maps of the complete Bouguer Anomaly (maps 4 and 5 at 1:10 560 scale) accompanying this report. Three other maps (numbered 1 to 3) are also presented showing the results of similar surveys in the area to the north of the St. Austell granite: these are not described in this text, but a full interpretation of all of the gravity results is in preparation.

The surveys around the Carnmenellis granite showed that shallower-depth prolongations of outcropping granites can be defined but that smaller or more deeply buried rises in the roof are not easily recognisable. The anomaly maps suggest that the granite roof exhibits less relief than expected from other geological indications and that relationships between mineralisation, porphyry intrusion and granite eminences are considerably more complex than postulated previously.

The Bosworgy borehole penetrated granite at 173.51 m at the intersection of the south-westwards extension of the Carn Brea - Carn Arthen - Pendarves granite ridge with the northern prolongation of the Tregonning - Godolphin ridge. The uppermost 20 m of granite at Bosworgy is greisenised with low-grade cassiterite, chalcopyrite and pyrite disseminations.

At Parbola, drilling on a postulated granite cusp reached 665.51 m without penetrating the steeply dipping southern flank of a granite ridge. Cassiterite was found in some narrow quartz-chlorite veins, the richest carrying about 1 per cent over 0.25 m. At 379-382 m there is a complex copper-lead-zinc lode with a thin stanniferous quartz-chlorite margin.

Generalised geological logs of the two boreholes form Appendix A. Appendix B provides details of geophysical logs (Gamma Ray, Neutron, Electric, Caliper, Density, Temperature, Differential Temperature) measured by British Plaster Board Limited.

The concealed granite roof in south-west Cornwall

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The following report is reproduced from the Transactions of the Institute of Mining and Metallurgy¹ by kind permission of the Editor.

This, the second brief report upon mineral reconnaissance investigations sponsored by the Department of Industry (Dunham, 1973), outlines the results of gravity surveys and drilling instigated to locate and examine cuspat elevations in the concealed granite roof to the north and west of the Carnmenellis Granite outcrop. A total area of 330 km² was surveyed, 1100 gravimeter readings being taken at an average density of 0.9 stations per km² - this being increased some tenfold in areas of indicated thin slate cover. Two boreholes were drilled to examine postulated granite cusps and abbreviated geological logs of these have been published (IGS, 1973). Gravity data maps and full borehole logs were placed on open file in the offices of the Institute in London, Exeter, Leeds and Edinburgh on the date of publication of this note.

A detailed account of the results obtained will be published in due course.

BACKGROUND

Hosking (1969) recently restated the belief that most of the economically important tin deposits of Cornwall occurred as vein swarms within, or close to, the apices of granitic cusps or in major vein structures flanking granite ridges. If this generalisation is true, it follows that the location of concealed granitic cusps and ridges could provide valuable guidance in exploration for hypothermal ore bodies.

The form of the batholith roof is imperfectly known. Widely spaced gravimetric observations (Bott, Day and Masson Smith, 1958) indicated the large-scale relief and small-amplitude ridges have been demonstrated in South Crofty mine (MacAlister, 1903) and in recent drilling north of Redruth. Circumstantial geological and mineralogical evidence prompted Hosking (1969) to postulate the positions of subsurface granite ridges; but, hitherto, there has been no attempt to verify or modify the model.

AIMS

Two economic aims were intrinsic to the investigation - the location of shallow-depth cuspat granite bodies likely to carry stanniferous vein swarms (as at Cligga, Hemerdon and St Michael's Mount) and the correlation of elvan and lode frequency with concealed granite ridges. Selection of the survey area was dictated by four major factors: (1) irregularity of roof surface, indicated by cusps and ridges cropping out at Carn Marth, Carn Brea, Tregonning and St Michael's Mount; (2) abundance of porphyry dykes and productive veins within the area; (3) intensity of mineralisation and concentration of emanative centres (Hosking, 1964, 1966) around and between granite outcrops; and (4) interpretative control afforded by underground and commercial drilling information.

In the structurally complex and lithologically variable setting of Cornwall detailed gravimetric surveys were considered to offer the speediest and least ambiguous method of defining the larger irregularities of the granite surface. Supporting regional geochemical studies were not attempted because of widespread surface contamination from former mining activities.

GEOPHYSICAL MEASUREMENTS

Gravity observations were made initially at Ordnance Survey benchmarks and spot heights at a density of approximately one station per km² by use of a vehicle-borne gravity meter. In two areas selected for detailed survey gravity and levelling traverses were made on foot along roads and tracks and, occasionally, fields to give the required density of cover. Worden and La Coste and Romberg gravity meters were used.

After correction for gravity meter drift and tides, observed gravity values were derived by the use of the existing IGS gravity base net and a value of 981.265 gal at Pendulum House, Cambridge. Combined elevation corrections to sea-level and a partial terrain correction were made with a density of 2.67 g cm⁻³, and the preliminary Bouguer anomaly was obtained by subtracting normal gravity according to the 1930 International Gravity Formula (recently compiled data now

¹Trans. Inst. Min. Metall. B., Vol. 84, pp. 1925.

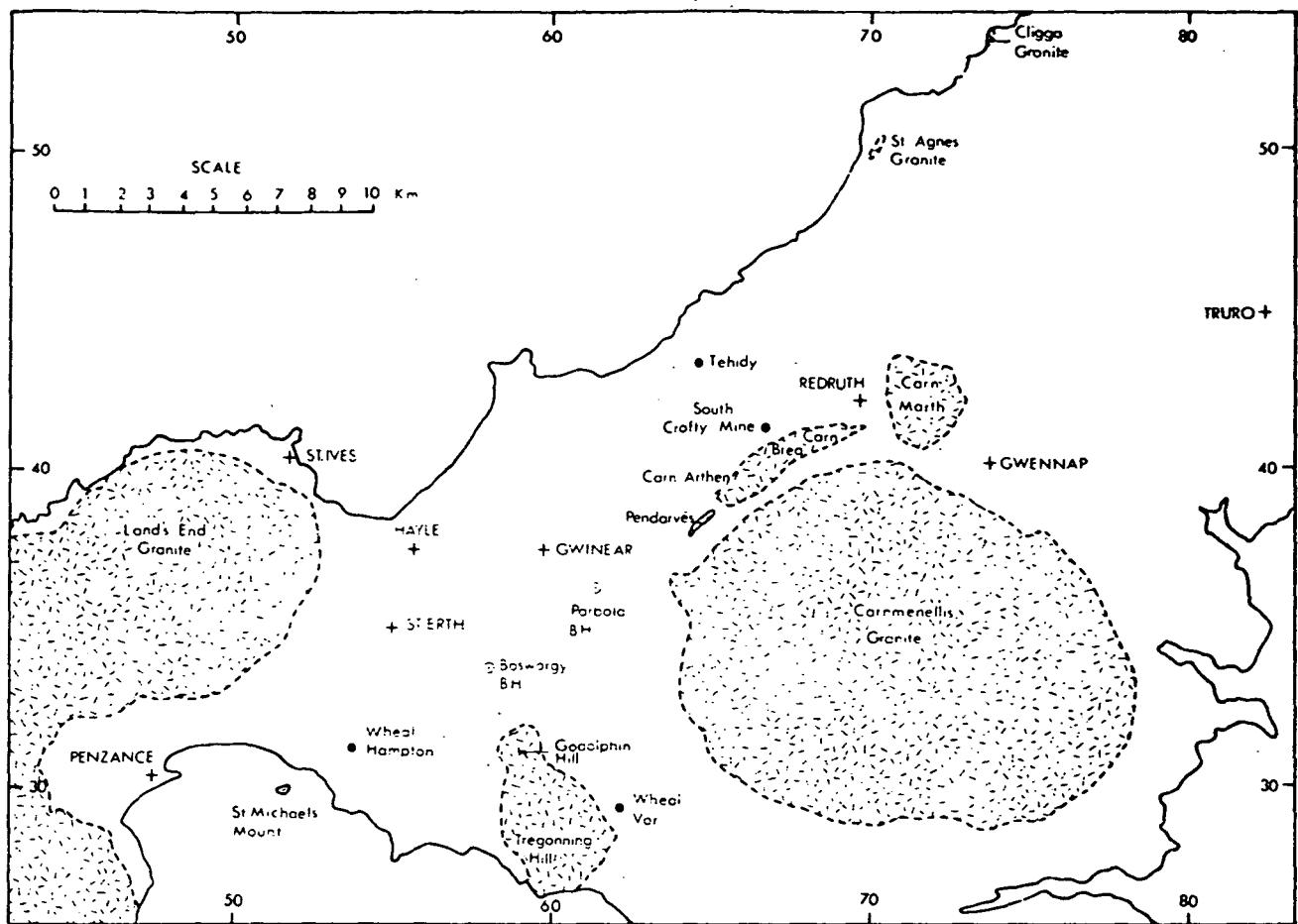


Fig. 1. Location map showing granite outcrops, SW England

obtainable from IGS incorporate a full terrain correction and the 1967 IGF). The Bouguer anomaly is dominated by the negative trough following the Cornubian granite chain, but where the granite is covered by killas, the anomaly becomes relatively positive because the killas has a higher average density than the underlying granite. Before the Bouguer anomaly can be used to determine killas thickness, the gravitational effect of the killas must be separated from that of the granite. To achieve this the Bouguer anomaly over areas of exposed granite is used to deduce the cross section of the batholith in these areas. The effect of a fictitious batholith, which reaches the surface everywhere and whose cross-section varies gradually between the known cross-sections at the areas of exposed granite, is then subtracted from the observed Bouguer anomaly. This yields a residual Bouguer anomaly that is roughly proportional to killas thickness. Modelling studies by use of three-dimensional computer techniques to obtain the depth to granite are continuing; after consideration of borehole and surface density measurements a density contrast of 0.1 g cm^{-3} between killas and granite has been chosen as representing a reasonable average for the area. Borehole derived depths to granite have not been used directly as control but only to provide a check for gross inconsistency. This is because undulations of the granite roof of short wavelength compared with their depth would be undetectable by gravity survey even if their amplitudes were moderately high; since gravity survey gives average rather than exact local depths, a single borehole would not necessarily provide a reliable control.

DRILLING

Two boreholes were drilled for the dual purpose of supplying interpretative control and examining indicated granitic cusps. At Bosworgy (NGR SW 5806 3367) the hole entered batholithic granite at a depth of 173.51 m, and at Parbola (SW 6157 3633) the borehole was drilled close to the steeply dipping southern flank of a granite ridge without penetrating the igneous body before termination at 665.51 m. The uppermost 20 m of granite at Bosworgy are greisenized and carry low-grade disseminations of cassiterite, chalcopyrite and pyrite. In the Parbola cores cassiterite occurs in some narrow quartz-chlorite veins (the richest about 1 per cent over 0.25 m), chalcopyrite is disseminated in greenstone over 1.3 m at 316 m depth and accompanies tourmaline in a 2 m lode cutting elvan at 290 m, and at 379-382 m there is a complex copper-lead zinc lode with one 10 cm selvage of stanniferous quartz-chlorite veinstuff.

PRELIMINARY RESULTS

A refined model of the subsurface granite form awaits detailed computer processing of all available geophysical and geological data, but semi-quantitative analysis of the Bouguer anomaly and residual Bouguer anomaly maps indicates a pattern of relief differing somewhat from published postulations.

An extension of the Carn Brea - Carn Arthen - Pendarves granite ridge can be traced south westwards to meet a northern prolongation of the Tregonning-Godolphin ridge. The Bosworgy borehole was sited in the vicinity of this intersection. The distribution and abundance of tin-copper veins and porphyry dykes in the Gwinear area may be related to this concealed granite ridge. There is no clear definition of a ridge linking the Godolphin and St Michael's Mount granites. Surprisingly, there is no suggestion of a shallow cuspatate granite near the emanative centre at Wheal Hampton (Hosking, 1964, 1966). A limited north-westerly extension of the Carn Marth mass is evident, but near-surface connexion with the Cligga - St Agnes ridge is uncertain. The latter trends roughly parallel to the coast, where sharp terrain effects confuse the gravity results, and it remains uncertain whether the ridge may continue westwards offshore (Hosking, 1969).

North of the Carn Brea - Bosworgy ridge the granite surface is presumed to dip gently northwards, and any irregularities on its surface are too deep or too small to be recognisable. Certainly, there is no indication of granite close enough to surface to account for the tin mineralisation and spotted slates recorded on the coast north of Tehidy (Hosking, 1949). Two unexplained gravity 'highs' are apparent near St Erth and southeast of Hayle; both lie immediately north of wide greenstone belts and may relate to locally thick developments of basic rocks. Formerly important copper lodes lie close to the north of both anomalies.

Postulated east-west granite ridges beneath the highly mineralised areas of Gwennap (Rayment, Davis and Wilson, 1971) and Wheal Vor do not give rise to recognisable gravity anomalies. In both areas the slate cover is known to be deep (in excess of 300 m), however, and this may mask relatively small-amplitude features. Perhaps more significant is the fact that both districts are located adjacent to granite cupola walls where steep gravity gradients suggest the possibility of major faulting.

CONCLUSIONS

This investigation has shown that regional gravity surveys with closely spaced stations can

outline, with reasonable certainty, the shallower-depth prolongations of outcropping granites, but the interaction of unresolved complex structure and unsuspected major lithological variations (eg the thick arenaceous succession of the Parbola borehole) prevents the recognition or definition of smaller or more deeply buried rises in the granite roof. In the present state of the science it seems doubtful whether this could be achieved without a large number of deep control boreholes.

Visual examination of the gravity anomaly maps suggests that the granite roof exhibits less relief than was hitherto expected from other geological indications, and it is clear that relationships between mineralisation, porphyry intrusion and granitic eminences are considerably more complex than were depicted by (Hosking, 1969). Nonetheless, hypothermal mineralisation in various structural patterns is associated spatially and presumably, genetically with all the known granite cusps and ridges, and the location of concealed major apical bodies is likely to define areas of future mineral potential. In the present investigation the occurrence of stanniferous greisenised granite in the Bosworgy cusp demonstrates the validity of this concept.

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APPENDIX A: GENERALISED GEOLOGICAL LOGS OF IGS BOREHOLES

1. Parbola Borehole

Location	Parbola Farm, Gwinear, Hayle, Cornwall Collar situated at G R SW 6157 3633, 640 m at 241° (T) from Cathebedron Cross. 1" Geol. Sheet NS 351/8.		
Driller	Drilling and Prospecting International Ltd		
Date	February - April 1973		
Surveys	Vertical to 149 m, below which the hole inclines at 85° towards 147° T. Collar height approx. 80.8 m above O. D.		
Sizes	0 - 9.14 m H size 9.14 - 149.35 m HQ size 149.35 - 665.51 m NQ size		
Classification	Description	Thickness	Depth
		m	m
Overburden	Soil and clayey subsoil	0.91	0.91
Head	Compacted clay with fragments of slate and vein quartz	3.71	4.65
Mylor Series	Weathered slates, fragmental recovery. Dark grey, smooth to lustrous slates, somewhat iron stained at the top. Locally very hematitic and lower down there are pyrrhotite flakes developed on cleavage surfaces. Major cleavage dips at 10-30°. Rare quartz veins and intercleavage bands, and some clay-filled joints. Well displayed tight folding disposed horizontally	6.63	11.28
		23.31	34.59
Quartz Vein	Massive white quartz stained by iron oxides. No ore minerals other than pyrite and hematite. Dips at 40°	1.01	35.60
Mylor Series	Soft, dark grey, vaguely spotted slates with pyrrhotite on cleavage which dips at 20°. Tight, near horizontal folds. Sporadic development of low angle quartz veining	14.83	50.54
Granite Vein	Dips at 30°, almost parallel to cleavage in host slates. Partly fine grained aplitic composition and partly very coarse grained and kaolinised. The basal 50 mm is brecciated slate cemented by ? aplitic material and may be an explosion breccia	0.25	50.68

Classification	Description	Thickness m	Depth m
Mylor Series	Darkish grey, soft, smooth slates	1.32	52.00
Intrusive Breccia	Granitic and aplitic material cementing partly rounded brecciated slate fragments	0.33	52.33
Mylor Series	Dark grey soft slates with a little pyrite	0.26	52.59
Intrusive Breccia	As body above, of which it may be a thin offshoot	0.10	52.69
Mylor Series	Darkish grey smooth slates with major cleavage dipping at 20°. Some low angle quartz veining. Slates vaguely spotted, sometimes knotted	13.76	66.45
Quartz Vein	Broken massive white quartz with some inclusions of baked slate. A little chlorite. Dips at 60°	0.88	67.33
Mylor Series	Grey slates, variably hematized. Well spotted and slightly indurated. Cleavage dips at 20 - 30°. Some tight folding with axial plane parallel to main cleavage. Clusters of low angle quartz veins	63.18	130.51
Quartz Vein	Broken recovery of massive white vein quartz with patchy chlorite and chloritised slate. Dips at 35°. Joints coated by chlorite with abundant sphalerite, some chalcopyrite, pyrite and a little arsenopyrite	2.43	132.94
Mylor Slates	Dark grey to near black, smooth, tough slates cleaved at 15° alternating with zones of striped siliceous slates banded at 20-25° dip. Some tight, near horizontal folding	10.42	142.75
Quartz Vein	Flat lying band of massive white quartz with a little chlorite	0.43	143.18
Mylor Slates	Grey slates interbedded with pale grey silty sandstone layers. Intensely sheared and folded. Bedding variable from 10° to 30° dip; cleavage less steep apparently	3.00	146.18
Quartz Vein	Dips at 55°. Cellular in uppermost 40 mm and thereafter massive. Some chlorite, little pyrite	0.86	147.04
Mylor Series	Grey to silvery grey, micaceous silty slates, finely banded with banding usually steeper dipping than the cleavage-inverted? Little chlorite and traces of pyrite. Some zones of low angle quartz veining. Vaguely spotted or knotted,		

Classification	Description	Thickness	Depth m
	rarely conspicuously so. Rare thin sandstone horizons below 157.53 m. Occasionally hornfelsed. Much shearing in parts	± 3.1	233.86
Mylor Series?	Dark grey to brownish grey somewhat hornfelsed striped sediments consisting of alternating slates and silty sandstones. Locally the slates are preponderant and the sandstones become more discrete and thicker. Scattered quartz veins. Sediments dip at 20-40°, cleavage generally is less steep. Generally spotted, locally intensely so	± 1.7	260.63
Elvan	Upper contact sharp and irregular, dipping about 30°. Slate above slightly brecciated. Fine grained throughout with slightly finer chilled margin. Very finely porphyritic and rich in tourmaline and dark chloritic spots. Abundant tourmaline veining below 282.17 m. Locally kaolinised	± 1.7	288.90
Lode	Upper part of shattered siliceous elvan cut by abundant tourmaline veins. Central zone essentially of quartz with tourmaline veining recut by massive chlorite carrying abundant chalcopyrite. Basal section of tough siliceous elvan with tourmaline veins and some later chlorite/chalcopyrite veining. Apparently sub-vertical	± 1.3	290.93
Elvan	Tough, fine grained equigranular elvan similar to that above vein. Locally kaolinised or hematitic	± 1.3	297.92
Explosion Breccia	Angular to rounded fragments of slaty rocks in a clastic granitic matrix. Contacts poorly cored	± 1.5	299.77
Elvan	Fine grained equigranular elvan, rich in tourmaline and rather siliceous	± 1.2	305.19
Explosion Breccia	Wedge shaped body similar to that above and with one fragment of granite	0.45	305.64
Elvan	Very fine grained grey siliceous elvan with glassy groundmass. Very finely porphyritic. No chilled margin. Lower contact dips at 10°	± 1.3	308.13
Portscatho Series?	Finely banded pale grey sandstones interbedded with darker grey micaceous slates. Tight flat folds cut by later shearing. Some irregular quartz veining	± 1.5	311.18

Classification	Description	Thickness m	Depth m
Elvan	Pale grey, tough, fresh, finely porphyritic elvan with narrow chilled margins. Dips at about 25°	0.76	311.94
Portscatho Series	Pale grey sandstones interbedded with darker grey micaceous hornfelsed slates. Flat, tight folding	0.33	312.27
Elvan	Coarsely porphyritic, pale, slightly greenish grey elvan with narrow fine grained chilled margins. Dip 50-60°. Very fresh	3.20	315.47
Greenstone	Dark greyish to brownish green, tough, compact, fairly fine grained igneous rock. Patchy development of quartz-chalcopyrite-sphalerite near the top. Chloritic near base	5.19	320.66
Elvan	Upper contact is irregular, stepped, at about 40° dip. Coarsely porphyritic generally pale grey rock with narrow chilled margins. Locally altered by kaolinisation or chloritisation; some streaky ferruginous discolouration. Locally intense tourmaline veining. Basal contact dips at 25°	8.86	329.52
Greenstone	Tough, hard, compact, fairly fine-grained dark greyish blue to greyish green igneous rock. Chloritic adjacent to elvan. Rare chalcopyrite in actinolitic veining	3.33	332.85
Elvan	Dips at 20-30°. Medium grey coloured porphyritic rock with much finely clustered chlorite and some tourmaline. Some chlorite veins carry traces of chalcopyrite	4.67	337.52
Greenslone	Dark green, brown and bluish, hard, fairly fine grained, compact igneous rock. Some chloritic veining. Some sediment at base. Dip 10°	2.10	339.62
Portscatho Series	Thin grey sandstone separated by very thin layers of brown biotitic hornfelsed slates. Banding dips at 10-20°. Rare thin quartz veins	3.46	343.08
Greenslone	Dark green and brown, tough, compact, fine grained rock. Some epidotic and sideritic veining. Dip 10°	0.30	343.38

Classification	Description	Thickness m	Depth m
Portscatho Series	Predominantly light grey, fine sandstones with thin greenish grey chloritic slates and brown biotitic slates. Banding dips at 0-20°. Tightly folded but disturbed by later shearing. Rare quartz veining. Quartz veinlet with cassiterite at 349.27 m and rare quartz-chlorite-sphalerite veining below this	12.55	355.93
Greenstone	Fine grained, tough, dark greyish green to bluish rock. Massive and poorly jointed. Both contacts ill-defined	3.07	359.00
Portscatho Series	Interbedded thin grey sandstone and bluish to greenish slates, becoming more arenaceous in depth. Bedding varies from 0° to 25° dip. Flat lying tight folding. Clusters of near horizontal quartz veins	8.49	367.49
	Essentially bluish grey smooth, spotted slates with thin sandstone bands. Intensely sheared in parts and frequently veined by low-angle quartz	5.71	373.20
	Interbedded sandstones and slates, intensely sheared and stretched. Bedding at 20° dip. Thin quartz banding. Chloritised below 378.10 m	5.69	378.89
Lode	Banded quartz/chlorite and white quartz vein complex with the basal 0.5 m of brecciated slate in a cement of siderite and quartz. Throughout there is a mixture of sulphides, mainly sphalerite, galena, chalcosite, chalcopyrite, pyrite and arsenopyrite. Neither contact is clear but banding suggests dip of about 70°	3.02	381.91
Portscatho Series?	Pale grey silty slates, highly sheared. Foliation at 25° dip. Spotted at base	1.99	383.90
Greenstone	Bluish to brownish green, hard, tough, fine grained, compact igneous rock. Near horizontal	1.32	385.22
Portscatho Series?	Pale grey silty slates with thin sandstones, dipping at 20-25°	0.53	385.75
Greenstone	Tough, compact, hard, fine grained dark green, brown or blue igneous rock, somewhat biotitic	0.76	386.51
Portscatho Series	Olive green silty slates with thin sandstone horizons. Cleavage dips at 20°, bedding variable. Tight folding evident	8.97	395.48

Classification	Description	Thickness m	Depth m
Greenstone?	Two bands of tough, fine grained highly biotitic rock, apparently altered green-stone; separated by pale grey sandstones and dark grey slates	0.68	396.16
Portscatho Series	Pale grey sandstones with thin interbedded darker grey slates. Banding dips at 30° or less and is often tightly folded	14.38	410.54
Greenstone	Dips at 20-25° and is tough, fine grained green to brown compact rock. Traces of sulphides	3.79	414.33
Portscatho Series	Alternating pale grey sandstones and thin micaceous and hornfelsed darker grey slates. Bedding usually dips at 25° or less and is frequently folded or sheared. The sandstone:slate ratio varies from 1:1 to 9:1		
	A probable altered greenstone - now a dark brown quartz-biotite-garnet rock, near horizontal extends from 434.17 to 434.32 m	31.22	445.55
	Grey and silvery micaceous slates, intensely folded	0.51	446.06
Quartz Vein	Massive milky white quartz with a little chlorite. Dip 65-70°	1.04	447.10
Portscatho Series	Dark grey and brownish grey spotted slates, soft and altered. Contorted and abundant zones of quartz veining. Small greisen veinlet at 448.73 m	2.57	449.67
	Pale grey sandstones with thin intercalations of sheared hornfelsed micaceous slates. Banding dips at 20-30° often highly folded. Occasional quartz veining and a 0.15 m greisen veinlet at 450.66 m	13.32	462.99
	Dark grey to near black spotted micaceous slates with scattered paler sandstone bands. Tightly folded with cleavage at 15-20° dip. Bedding dips at 30°	9.93	472.92
	Pale grey sandstones with interbedded darker grey micaceous hornfelsed slates. Sandstones are quartzitic. Tightly folded. Rare greisen veinlets	4.40	477.32
	Dark grey slightly hornfelsed micaceous slates with thin sandstone layers, dipping at 20°	1.72	479.04

Classification	Description	Thickness m	Depth m
	Pale grey sandstones with up to 25% of grey and brown intercalated slate. Sub-horizontal folding. Few quartz veins	2.16	481.20
	Dark brownish grey slates and occasional paler sandstones dipping at 20°. Tight folding	1.73	482.93
	Pale grey, rather quartzitic sandstones. Some horizons up to 0.66 m. Thin interbedded micaceous slates, dark grey to brownish grey. Rare quartz veining. Slate up to 20% of whole	17.73	500.66
	Grey, silty, spotted micaceous and hornfelsed slates. Still preserve slaty cleavage dipping at 10°	1.02	501.68
	Hornfelsed sandstones and slates, the former pale grey and quartzitic, the latter darker grey or brown. About 60% of lithology is sandstone. Gentle dip. Thin greisen at 511.48 m	11.91	513.59
Greisen Vein	Greiseny aplitic vein dipping at 75-80°	0.58	514.17
Portscatho Series	Mainly pale grey quartzitic sandstones with lustrous silvery or dark grey micaceous and hornfelsed slates interbedded. Variable sandstone:slate ratio but at least 50% sandstone. Some thin greisen veinlets and locally abundant quartz veins	13.24	527.41
Portscatho Series?	Dark grey, spotted or hornfelsed silty slates with streaky, phacoidal texture. Foliation dips at 10-20° and major cleavage at 0-10°. Well folded. Zones rich in quartz veins. Rare sandstones	29.54	556.95
Portscatho Series	Predominantly grey quartzitic sandstones with dark grey, greenish or brownish hornfelsed micaceous slates. Highly disturbed strata with many flat folds. Rare greisen veinlets	12.04	568.99
Quartz Vein	Massive milky white quartz dipping at 20°, not quite parallel to bedding in the sediments. Cut by steep greisen veinlet	1.42	570.41
Portscatho Series	Pale grey sandstones, with darker lustrous slates interbedded. Sandstones comprise at least 70% of sediments	7.67	578.08

Classification	Description	Thickness m	Depth m
	Interbedded slates and sandstones. Slates are micaceous and occasionally chiastolitic. Abundant quartz veining. Down to 580.00 m slate predominates, thereafter sandstones represent at least 60% of the lithology	5.94	584.02
Aplite-pegmatite Vein	Vein of aplitic granite with irregular patches of quartz and an upper margin of pegmatite. Whole is chloritised. Dips at 50-55°	0.38	584.40
Portscatho Series	Pale grey sandstones with interleaves of darker grey hornfelsed slate. Dip 20°	2.70	587.10
Greenstone	Dips at 15°, almost parallel to bedding in slates. Tough, compact, fairly fine grained greenish grey igneous rock. Cut by quartz and pyrite veinlets with traces of chalcopyrite	7.29	594.39
Portscatho Series	Banded sandstones and brown biotitic hornfelsed slate	0.40	594.79
Aplite-pegmatite Vein	Dips at about 40°. Upper part is pegmatitic and lower is aplitic	0.46	595.25
Portscatho Series	Very tough, foliated, adinolised slate	0.08	595.33
Greenstone	Fine grained, tough green and brown rock. Extremely dense. Near horizontal	0.68	596.01
Portscatho Series	Intensely biotitic, hornfelsed slates interbedded with pale biotitic sandstones	0.18	596.19
Greenstone	Horizontal body. Dark green, very tough, compact, fine grained rock	0.99	597.18
Portscatho Series	Pale grey sandstones interbedded with brown biotitic hornfelsed slates	0.41	597.59
Greenstone	Compact, tough, greenish fine grained rock, in part biotitised. Apparently horizontal though contacts difficult to define	0.38	597.97
Portscatho Series	Succession predominantly of pale grey, tough, quartzitic turbidite sandstones with thinner greenish, brownish or dark grey hornfelsed micaceous slates. Much folding and shearing of original bedding which dips at 20°. Rather rare quartz veining. Two thin greisen veins	47.70	645.67
Quartz Vein	Massive quartz, milky white, dipping at 70°. A little chlorite but no ores	0.91	646.58

Classification	Description	Thickness m	Depth m
Portscatho Series	Mainly dark grey quartzitic hornfelsed sandstones with thin bands of green, dark grey and brown hornfelsed micaceous slates. Intensely sheared, consisting in parts of superimposed fold hinges with intervening limbs stretched out. Rare thin greisen veinlets	18.93	665.51

End of borehole 665.51 metres

2. Bosworgy Borehole

Location Bosworgy Farm, Townshend, Fraddam, Cornwall
 Collar situated at G R SW 5806 3367,
 1420 m at $303\frac{1}{2}^{\circ}$ (T) from Townshend crossroads.
 1" Geol. Sheet NS 351/8

Driller Drilling and Prospecting International Ltd

Date January - February 1973

Surveys Vertical, maximum deviation 2° . Collar height approx. 83.8 m above O. D.

Sizes	0-2.90 m	H size
	2.90 - 149.18 m	HQ size
	149.18 - 214.15 m	NQ size

Classification	Description	Thickness m	Depth m
Overburden	No recovery	1.37	1.37
	Clay with abundant rock fragments	0.92	2.29
Mylor Series	Slates, ferruginous, in matrix of clayey decomposition products	0.61	2.90
	Weathered grey and brown slates, rather ferruginous. Horizontal cleavage. Well broken	8.28	11.18
	Partly hematitic greenish grey slates with alternating spotted and unspotted layers. Major cleavage varies from 10° to 35° . Several low angle quartz veins	12.19	23.37
	Well spotted and chiastolitic grey slates with some distinctly hornfelsed layers. Rarely ferruginous. Some quartz veining	8.00	31.37
Vein Zone	White massive quartz at top and bottom separated by argillised broken slate. Little grey copper ore. Dip $60-70^{\circ}$	0.81	32.18

Classification	Description	Thickness m	Depth m
Mylor Series	Light to medium grey, somewhat hornfelsed, micaceous spotted slates. Locally altered. Major cleavage dips 0-20°. Some quartz veining	6.15	38.33
Vein Zone	Broken white vein quartz with slate inclusions. Patches of chlorite	0.99	39.32
Mylor Series	Brown, purple and light grey slates with alternations of spotted and unspotted layers. Some quartz veining	6.40	45.72
Vein Zone	White quartz vein in wall rock of siliceous, chloritised and hematised slates. Dips at 65°. No ore minerals	1.83	47.55
Mylor Series	Variably altered, argillised, intensely spotted slates, usually grey in colour but with occasional thin, unspotted purplish bands dipping at 20°, almost parallel to cleavage. Some quartz veining	4.67	52.22
	Similar lithology but not argillised except around some joints. Some greenish, chlorite slate bands occur	8.54	60.76
Vein Zone	White vein quartz with hematitic walls. A little chlorite but no ores	0.40	61.16
Mylor Series	Medium to greenish grey micaceous spotted slates cleaved at 10-20°. Little quartz. Become highly argillised below 60.90 m	9.53	70.69
Vein Zone	Massive white vein quartz with bands of soft hematite. Dips at 40°	0.76	71.45
Mylor Series	Purplish and greenish grey slates, universally spotted and micaceous, often argillised. Cleavage dips at 0-20°. Some quartz veins and rare greisen veins. Locally hornfelsed to the stage of losing thermal spots	42.14	113.59
Vein Zone	Wide zone comprising chloritised and hematitic slates and massive white vein quartz. No ore minerals	4.32	117.91
Greisen	Greisen vein dipping at 75°. Traces of arsenopyrite but no cassiterite	0.99	118.90
Mylor Series	Alternations of grey and purplish brown hornfelsed and spotted micaceous slates, usually somewhat argillised. Some low angle quartz veins. Cleavage at 10°. Rare greisen veinlets with traces of pyrite	19.10	138.00

Classification	Description	Thickness m	Depth m
Greisen	Intensely hematized greisen veinlet with patches of chlorite and quartz. A little pyrite. Dip 80°	0.40	138.40
Mylor Series	Grey and purplish brown slates, spotted or hornfelsed with cleavage dipping at 10°. Some folding apparent. Cut by small greisen veinlets	5.31	143.71
Aplitic	Sugary quartz and feldspar with abundant white mica and scattered tourmaline. Traces of arsenopyrite. Dip about 80°	1.30	145.01
Mylor Series	Argillised hornfelsed and spotted slates in alternating greenish and grey purplish brown layers. Cleavage at 10° dip, banding about 20°. Some quartz veins	7.03	152.04
Granite Vein	Rotted granitic vein, medium grained. Dips at 60°	0.97	153.01
Mylor Series	Alternating greenish grey and brownish purple slates, heavily spotted to distinctly hornfelsed. Frequent quartz veining	4.80	157.81
Granite Vein	Upper contact dips at 65°. Uppermost 0.6 m is white quartz. Granite is medium to fine grained and equigranular. Partly kaolinised and partly ferruginous at the top. Some pegmatitic feldspars around 159.4 m, 160.2 m, and 160.9 m. Lower contact dips at 75 -80°	10.84	168.65
Mylor Series	Hornfelsed greenish grey micaceous slates with occasional purplish bands. Remnant cleavage dips at 10°, steepening near the granite contact. No flinty hornfels developed. Several quartz veins	2.11	170.76
Granite	Contact almost horizontal. Upper 0.06 m very micaceous then coarsely pegmatitic for 1 m. In this zone there is development of coarse biotite and a little arsenopyrite and cassiterite. The main granite is medium grained and equigranular with scattered specks of chalcopyrite and free cassiterite. Has a somewhat greiseny appearance, becoming fresher in depth. Chalcopyrite persists to about 187 m and cassiterite a little further. Below 192 m tourmaline is common as an accessory and feldspars become larger and more conspicuous, tending towards a finely megacrystic stage	43.39	214.15

End of borehole 214.15 metres



ELECTRIC LOG

COMPANY	IGS			
BOREHOLE	FRADDAM			
STATE	CORNWALL			
COUNTRY	ENGLAND			
Permanent Datum	ROD			
	; Elev. - Ft.			
Log measured from	ROD			
	Ft. above P.D.			
Drilling measured from	ROD			
	Ft. above P.D.			
Run No.	Depth Scale	1	20'-1"	(After 2nd pass)
Date	1973-7-12			
First Reading	122'ft	200'ft		
Last Reading	200'ft	122'ft		
Interval Measured	62'ft	78'ft		
Casing BPB	218'ft	174'ft		
Casing Driller	N/A	N/A		
Depth Reached	702'ft			
Bottom Driller	703'ft			
Mud Nature	Water			
S.G.	1.01			
Bit Size 1	to	to	to	
2	to	to	to	
Casing Size	11 1/2"			
Operating Time	1 hour			
Truck No.	10			
Recorded By	J. M. S.			
Witness	J. M. S.			

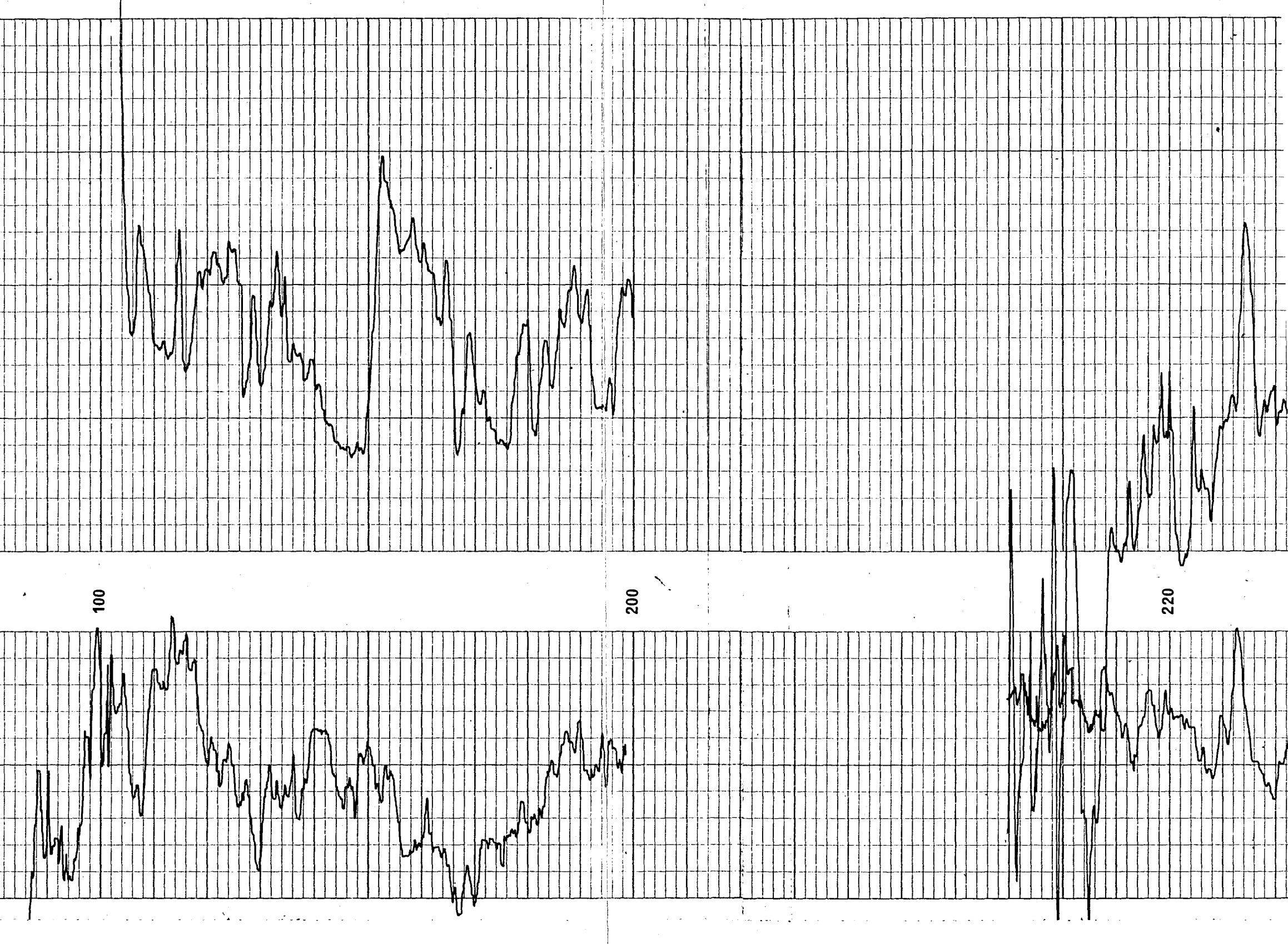
HOLE DATA		TOOL DATA		PANEL DATA	
Customer TGS		Sonde	SPD	Source type	Ratemeter -----
Contractor		Normaliser	-----	Source strength	-----
Date Logged 1973-7-12		Logging speed	40		
Date Drilled 1973-7-12		Time constant	---		
Borehole professional		Spacing	----		
COMMENTS					

Cyclic noise on trac. This was caused by close proximity of overhead cables.

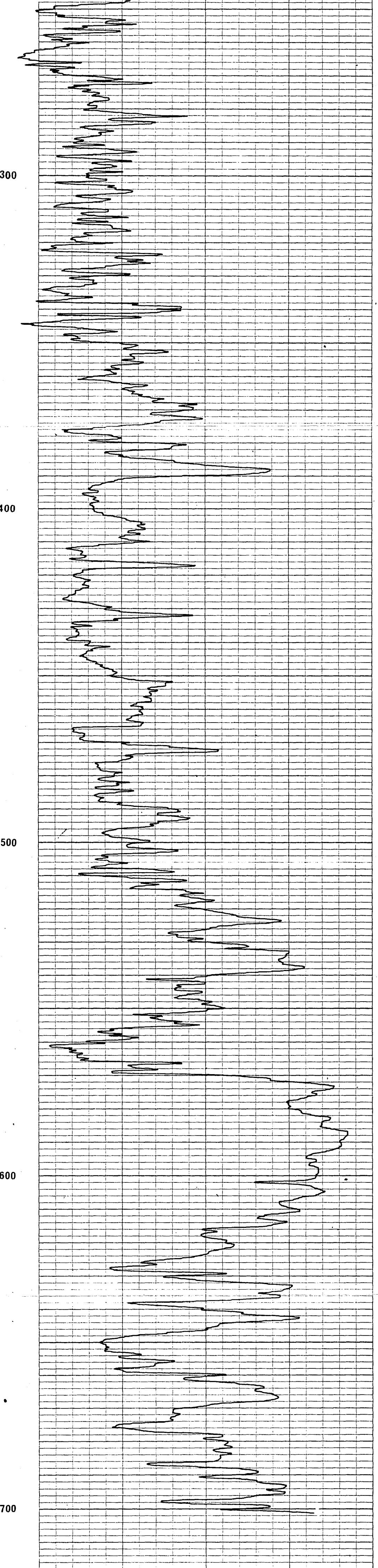
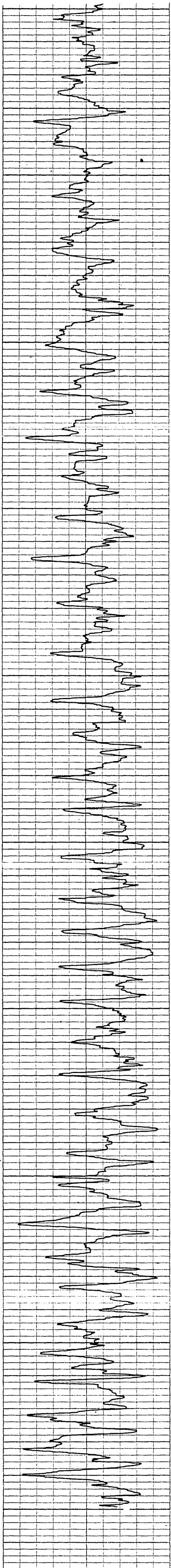
CALIBRATION AND SCALES

Track 1	Depth (Scale)	Track 2	Depth (Scale)	Track 3	Depth (Scale)
120'	200'	120'	200'	120'	200'
200'	120'	200'	120'	200'	120'

MY 22649



1 SL 753



WPLMR/7S/1
Electric
Log



LS DENSITY LOG

COMPANY **IGS**
BOREHOLE **FRADDAM**
STATE **CORNWALL** COUNTRY **ENGLAND**

Permanent Datum GROUND ; Elev. - Ft.
Log measured from GROUND Ft. above P.D.
Drilling measured from GROUND Ft. above P.D.

Run No. Depth Scale 1 20'-1" (AFTER CASING)

Date 9-FEB-73

First Reading 701ft 200ft

Last Reading 14ft

Interval Measured 701ft 10ft

Casing B.P.B. 218ft N/A

Casing Driller V.A.

Depth Reached 702ft

Bottom Driller 702ft

Mud Nature WATER.

S.G. Viscosity N/A

Bit Size 1 N/A to to to

2 to to to

Casing Size N/A

Operating Time 14 HRS

Truck No. 10

Recorded By T.C. BERRY

Witness K.E. BEER

fold here

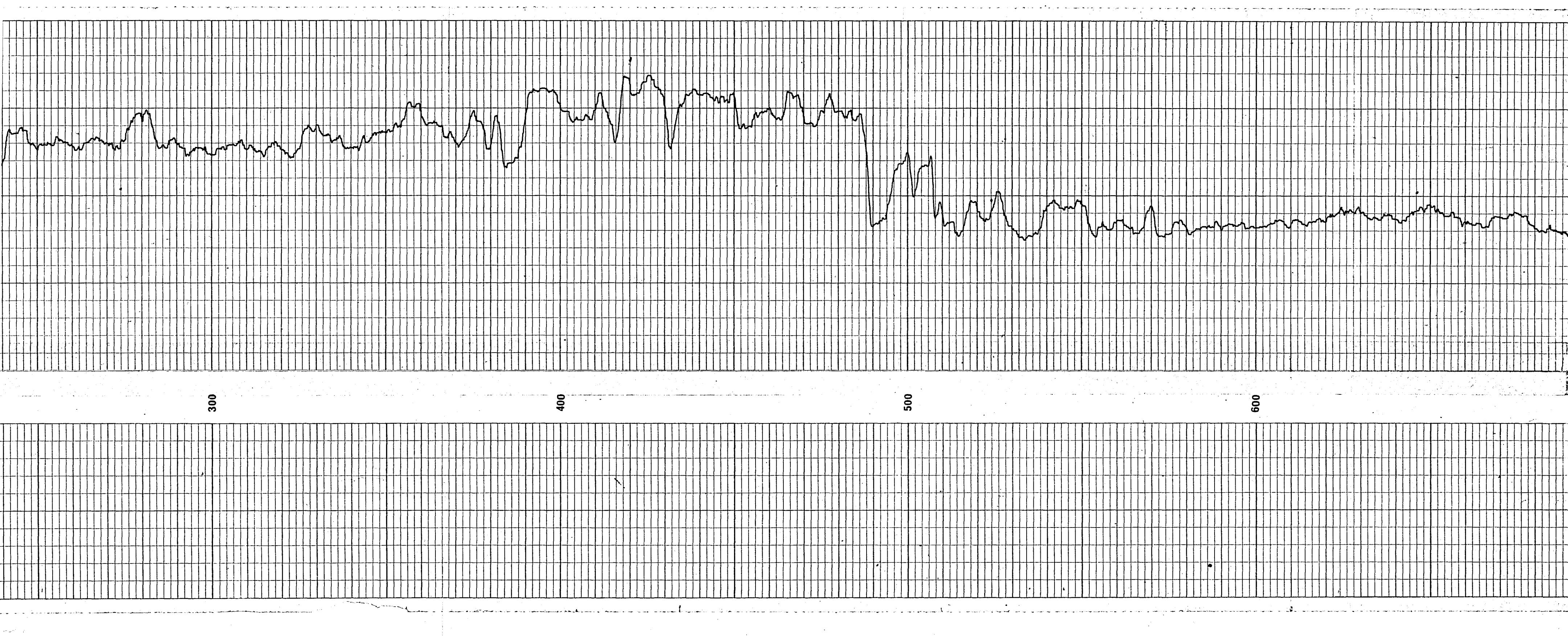
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Customer	T.G.S	Sonde	Source type	Cs137	Ratemeter 1			
Contractor	-----	Normaliser	Source strength	10E110	DTS/C 2			
	-----	-----	-----	-----	-----			
Date Logged	9-FEB-73	Logging speed	30					
Date Drilled	8-FEB-73	Time constant	2					
Borehole	FRADDAM	Spacing	LSD					
COMMENTS								

CALIBRATION AND SCALES

Track 1	Depth (Scale)	Track 2	Track 3
	20'-1"	3500 750 0	14'-11' 111'-200' 0'-701'

STANDARD DENSITY UNITS.





WC/MR/7S/1
LS
density
Log



GAMMA RAY, NEUTRON LOG

COMPANY **IGS**
BOREHOLE **FRADDAM**
STATE **CORNWALL** COUNTRY **ENGLAND**

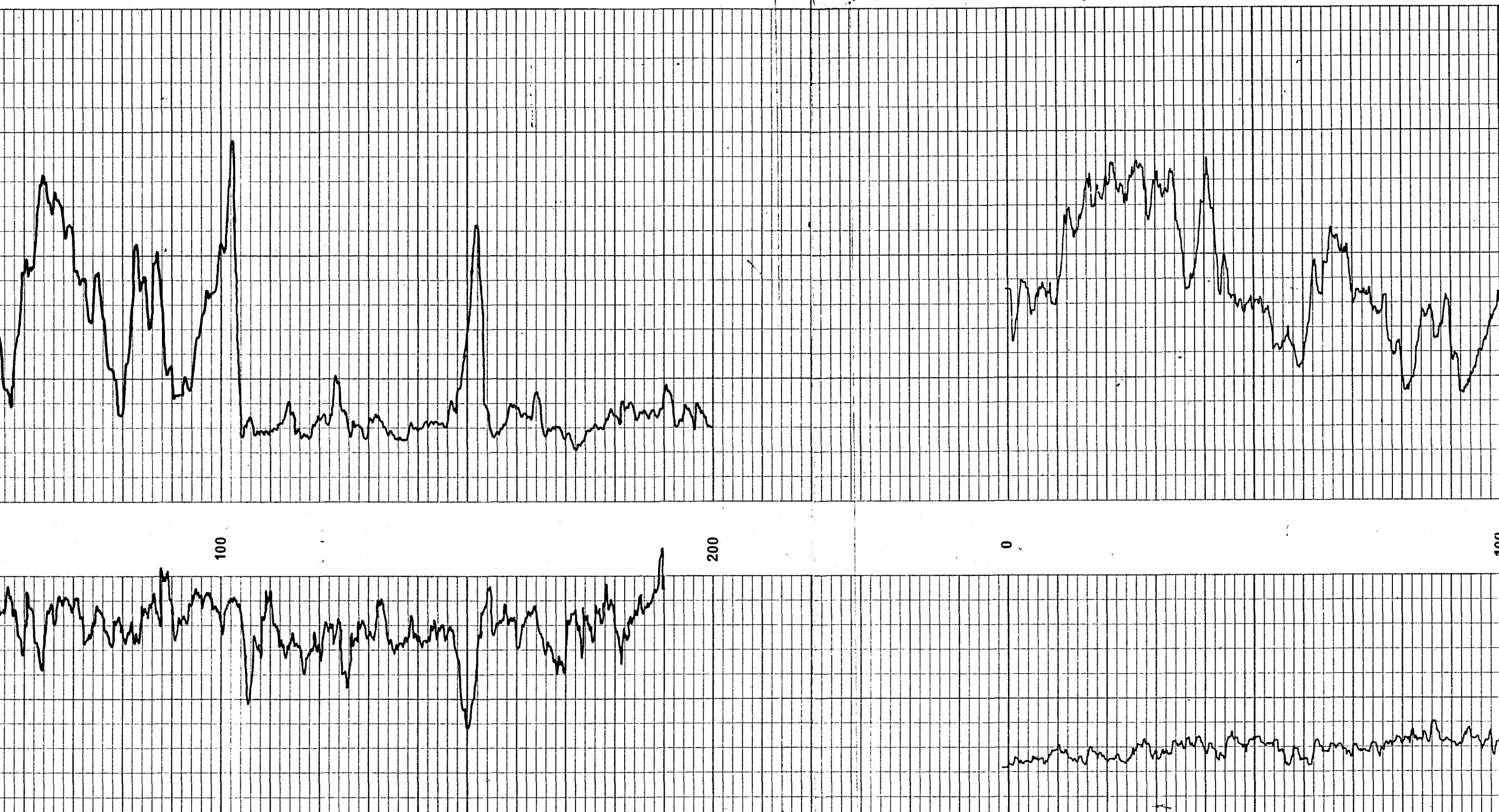
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Log measured from GROUND Ft. above P.D.
Drilling measured from GROUND Ft. above P.D.

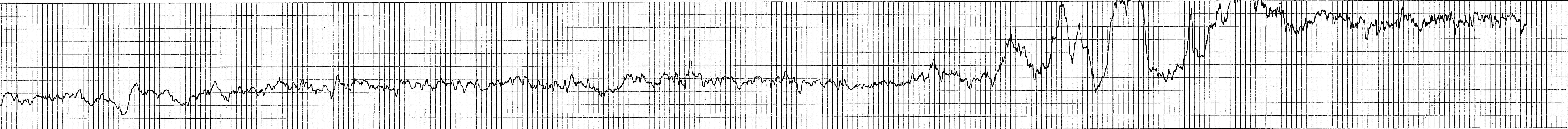
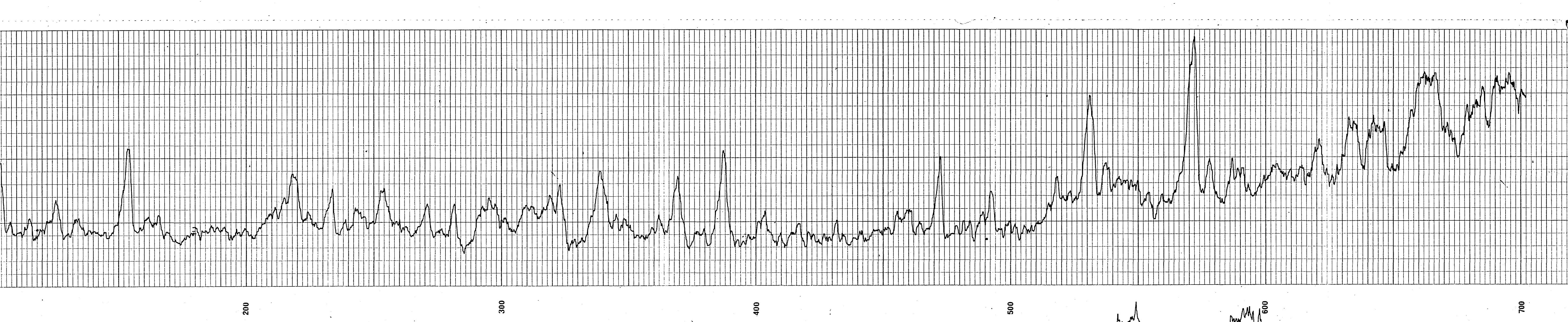
Run No.	Depth Scale	1	20ft-1" (AFTER CASTING)	
Date		9-1MB-73		
First Reading	702ft	200ft		
Last Reading	G.L.	G.L.		
Interval Measured	702ft	200ft		
Casing BPB	218ft	N/APP		
Casing Driller	N.A.	N/APP		
Depth Reached	702ft			
Bottom Driller	702ft			
Mud Nature	WATER			
S.G. Viscosity	N.A.			
Bit Size 1	N.A. to	to	to	
2	to	to	to	
Casing Size	N.A.			
Operating Time	14hrs			
Truck No.	10			

Recorded By **T.C. BERRY**
Witness **K.E. FEEER**

HOLE DATA		TOOL DATA		PANEL DATA	
Customer	S	Normaliser	0.75 0.75	Source type	AmBe
Contractor		Logging speed	70 70	Source strength	10A1
Date Logged	9-1MB-73	Time constant	2	Ratemeter 1	D'SC 2
Date Drilled	8-1MB-73	Spacing	-		
Borehole	FRADDAM				
COMMENTS					

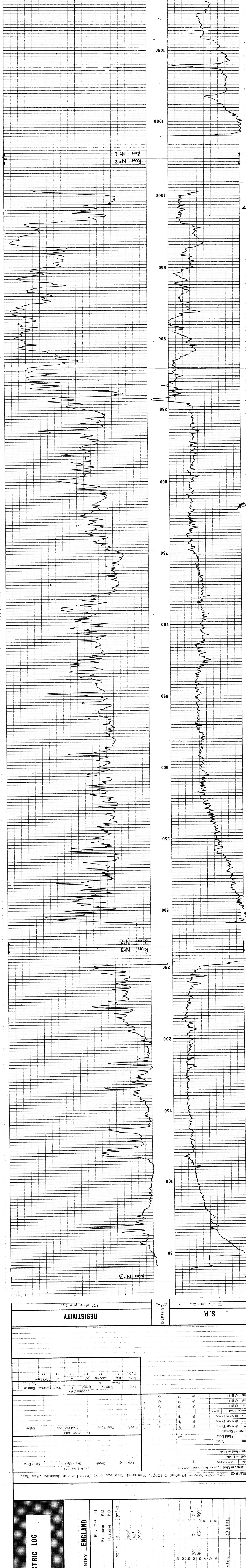
CALIBRATION AND SCALES

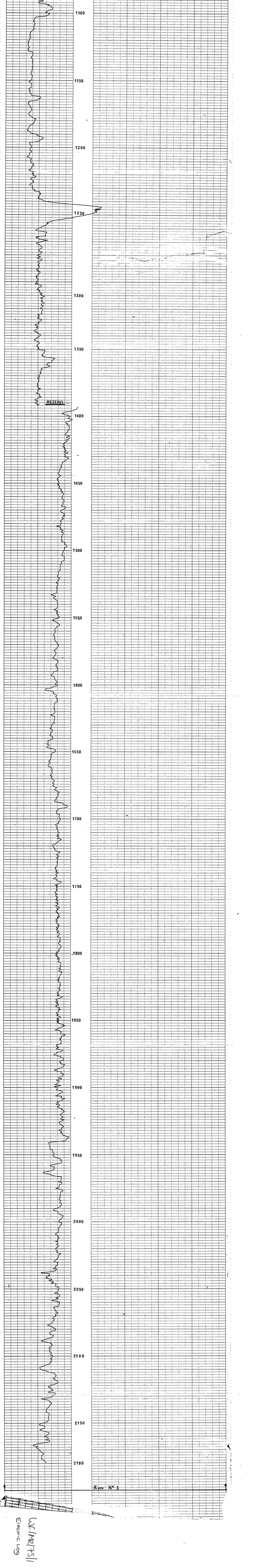


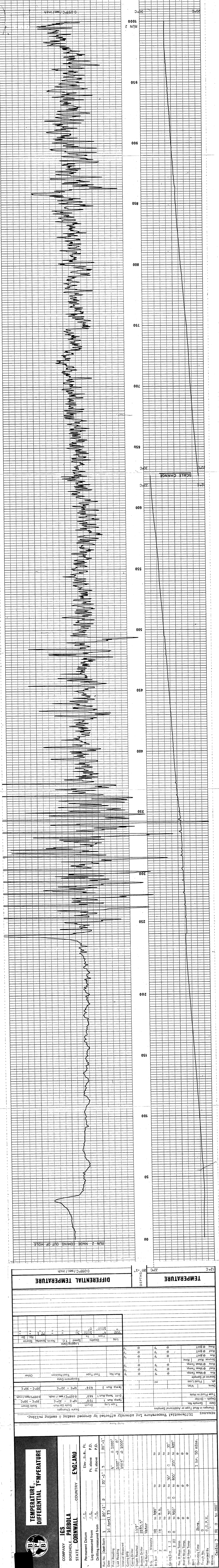


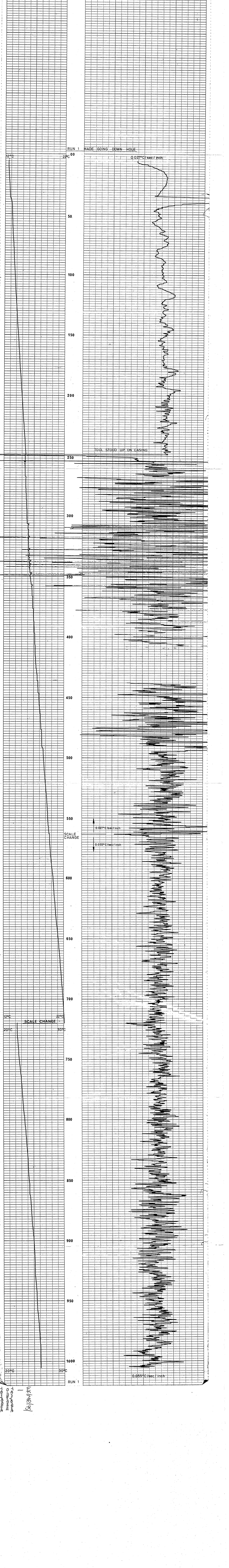
WF/MR/75/1
Gamma Ray
Neutron Log

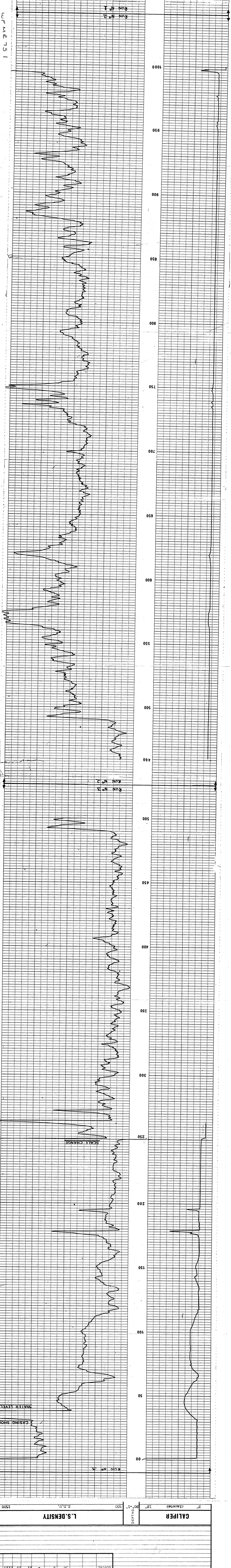
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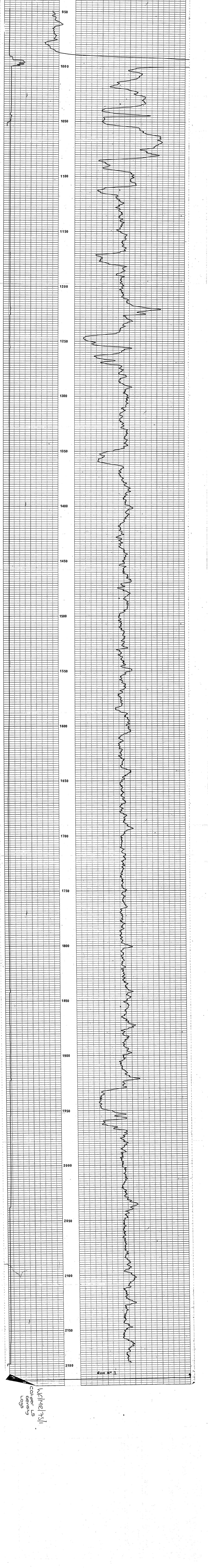












GAMMA, NEUTRON LOGS

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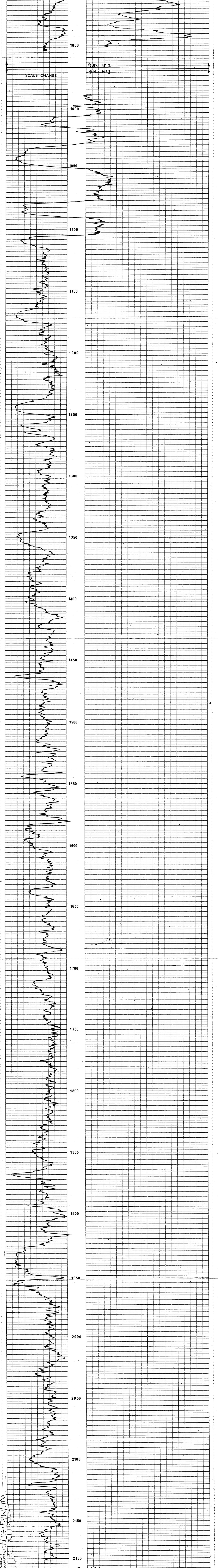
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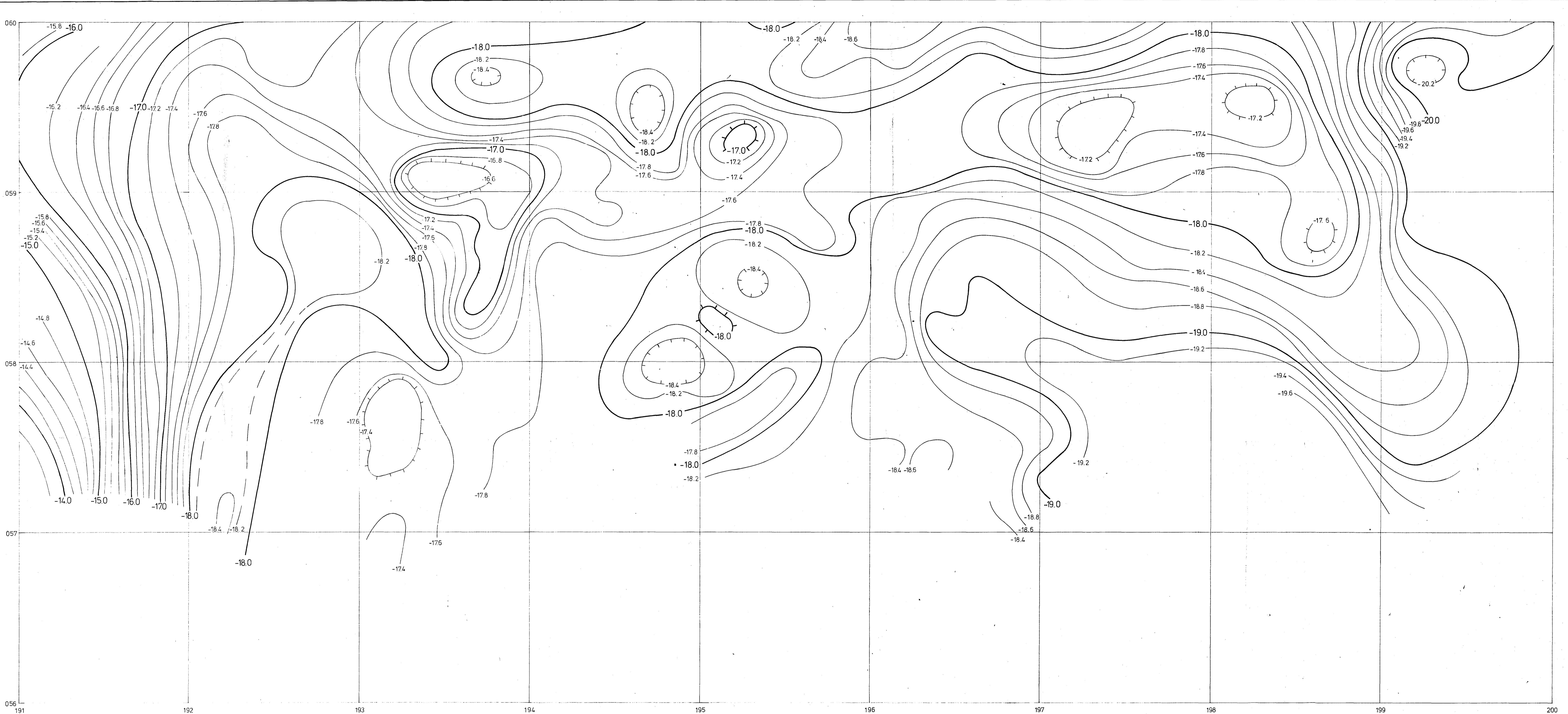
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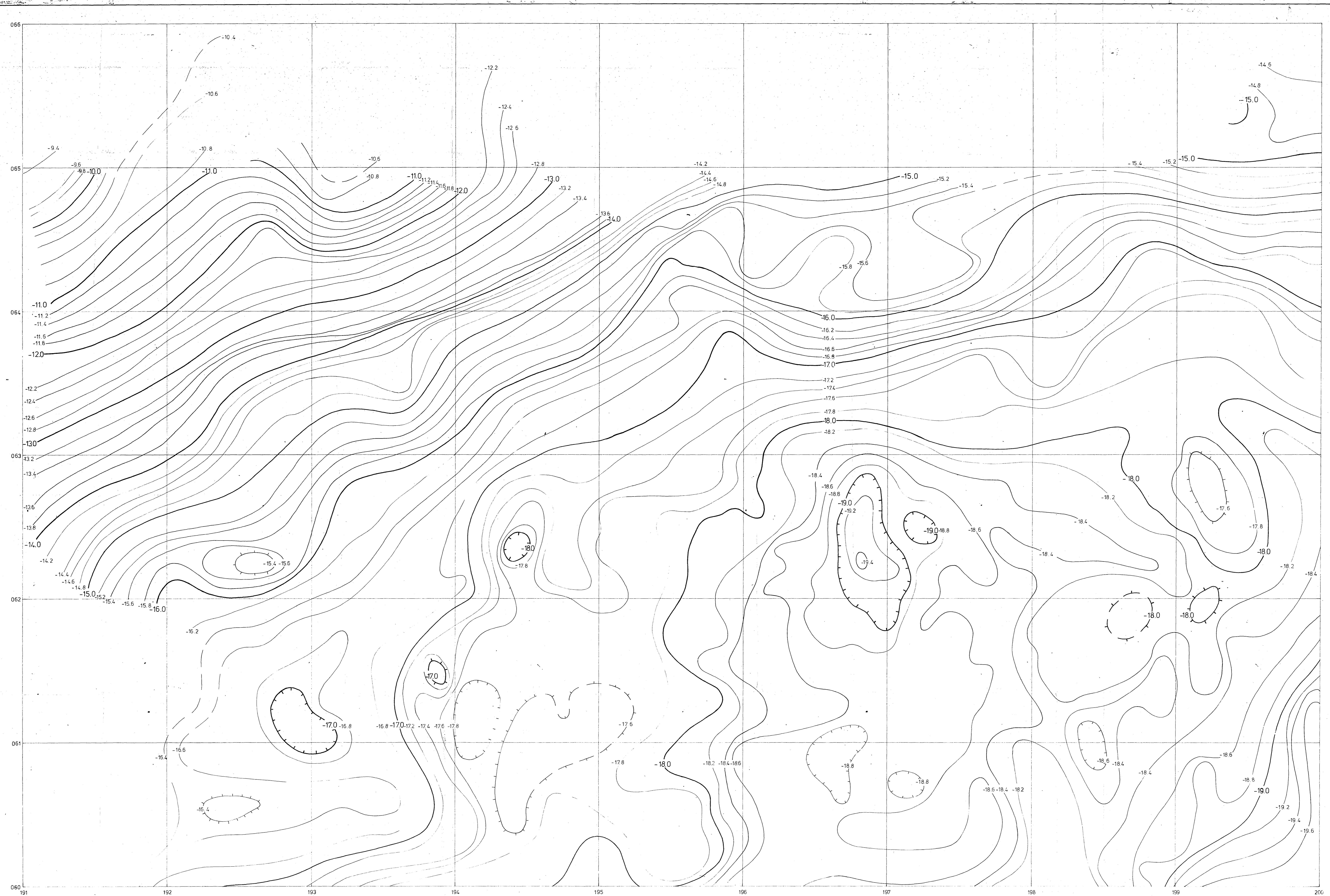


SOUTH WEST ENGLAND
COMPLETE BOUGUER ANOMALIES

ST. AUSTELL AREA : S.W. 95
(SHEET 1 OF 3)

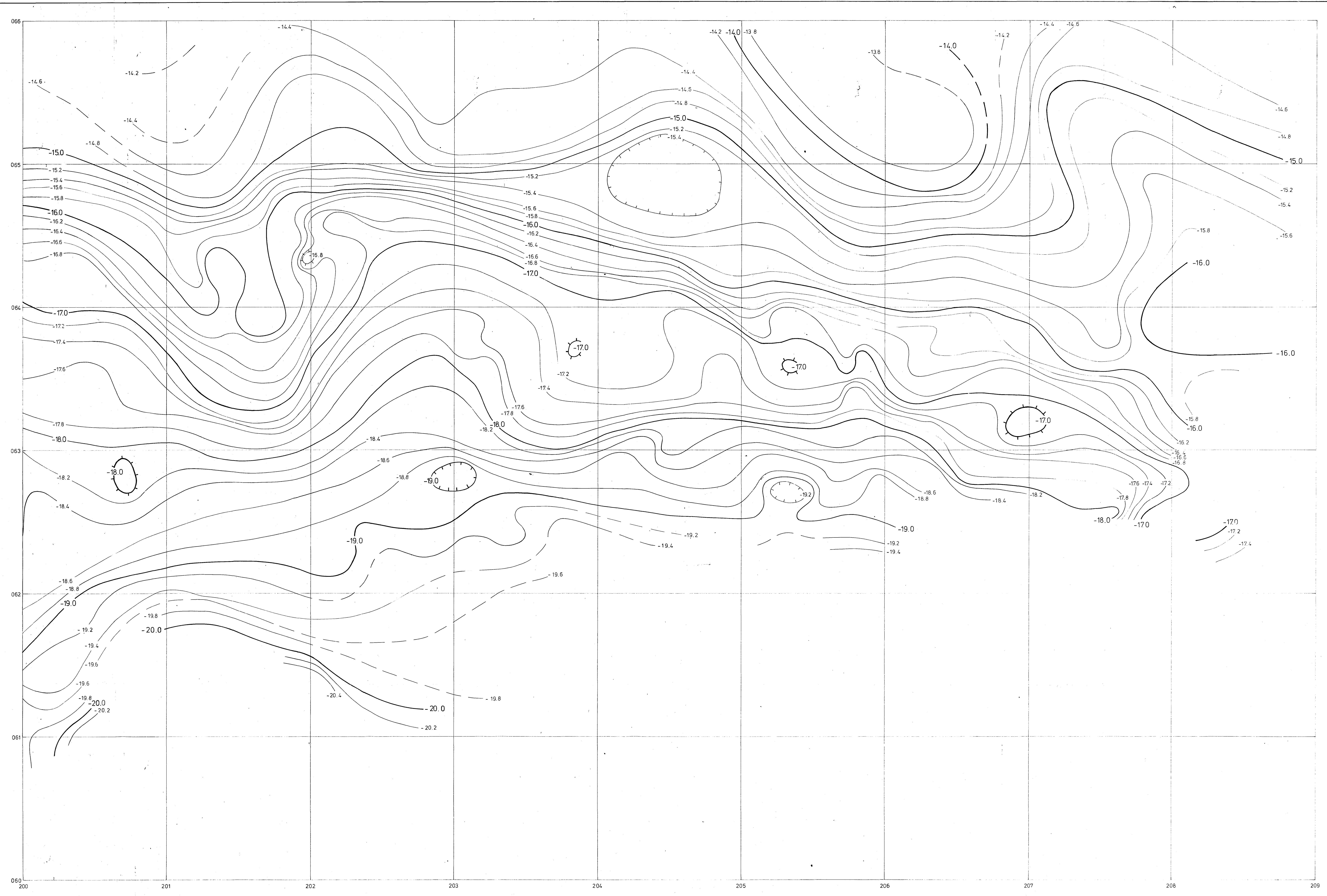
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Gravity datum : IGSN 71 INTERNATIONAL
GRAVITY FORMULA 1967
Scale : 1:10560 CONTOUR INTERVAL 0.2 MILLIGAL
PREPARED UNDER CONTRACT TO THE
DEPARTMENT OF TRADE AND INDUSTRY

WC/MR/75/1



SOUTH WEST ENGLAND
COMPLETE BOUGUER ANOMALIES
ST. AUSTELL AREA : S.W. 96
(SHEET 2 OF 3)
Density : 2.70
Gravity datum : IGSN 71 INTERNATIONAL
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DEPARTMENT OF TRADE AND INDUSTRY

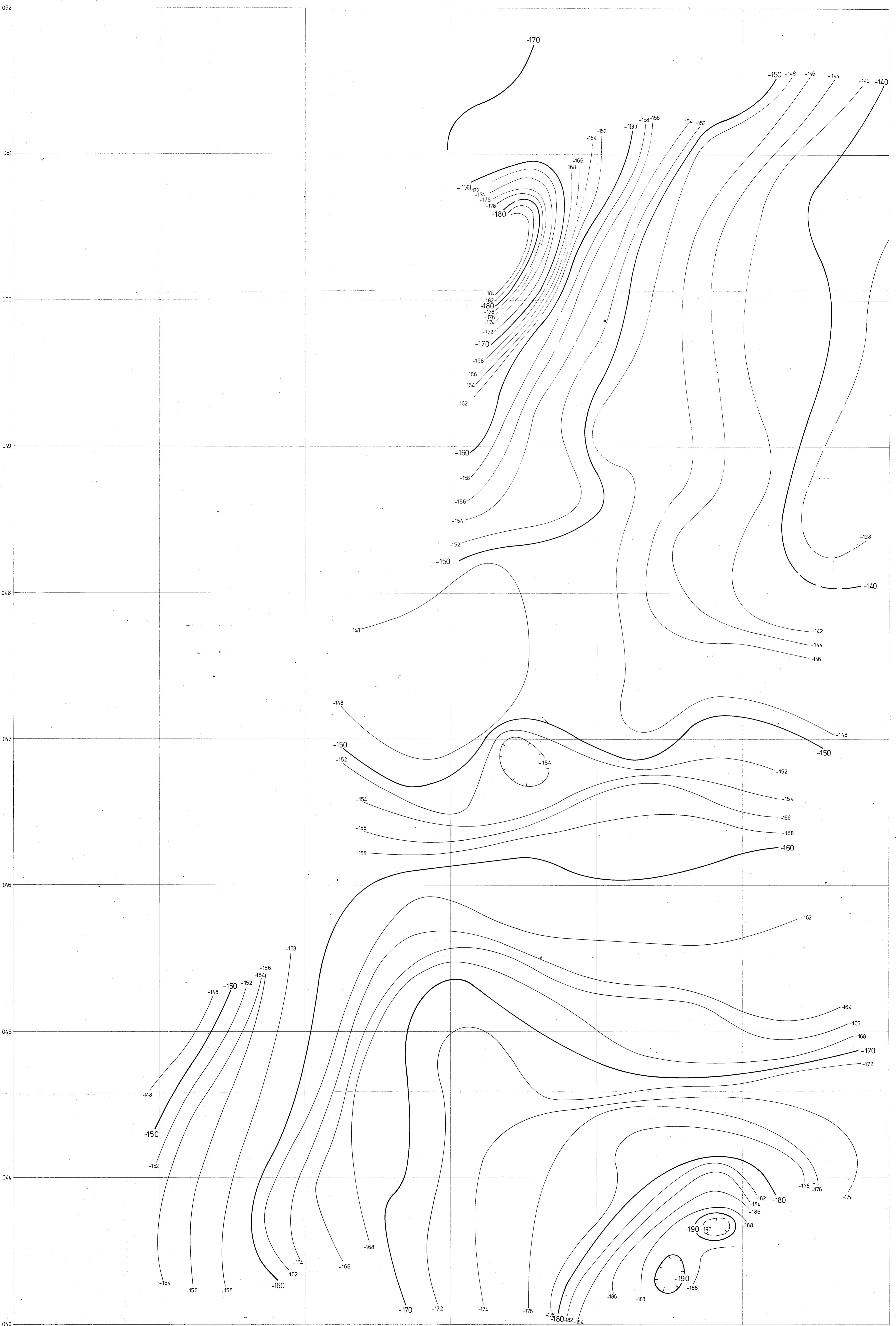
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SOUTH WEST ENGLAND
COMPLETE BOUGUER ANOMALIES
ST. AUSTELL AREA : SX 06
(SHEET 3 OF 3)

Density : 2.70
Gravity datum : IGSN 71 INTERNATIONAL
GRAVITY FORMULA 1967
Scale : 1:10560 CONTOUR INTERVAL 0.2 MILLIGAL
PREPARED UNDER CONTRACT TO THE
DEPARTMENT OF TRADE AND INDUSTRY

DF/MR/75/1



SOUTH WEST ENGLAND
COMPLETE BOUGUER ANOMALIES

ST. AGNES AREA SW64,74,75
(SHEET 1 OF 1)

Density : 2.70

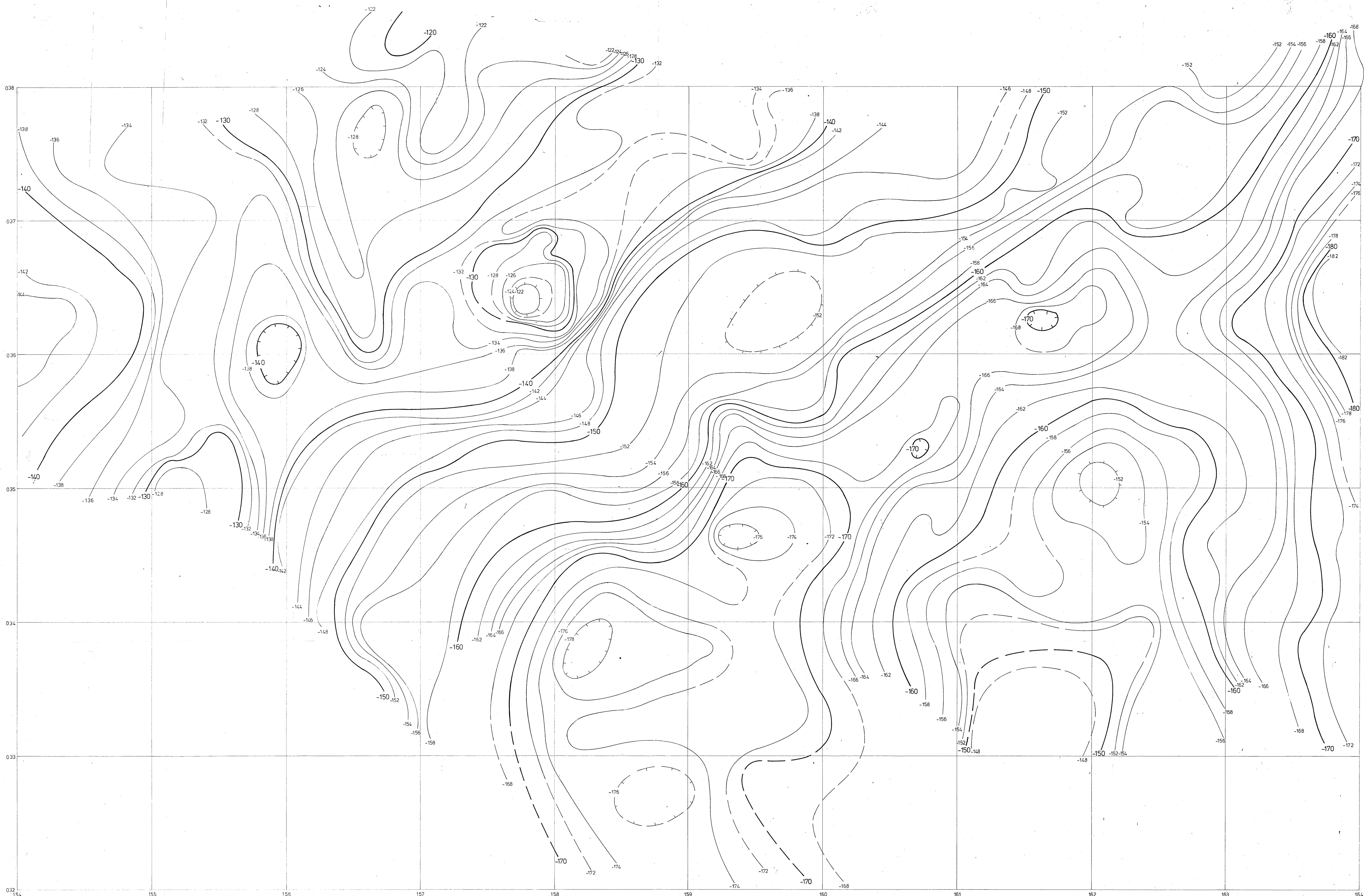
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Scale : 1 : 10560 CONTOURS IN g.u. AT INTERVALS OF 2g.u.

PREPARED UNDER CONTRACT TO THE

DEPARTMENT OF TRADE AND INDUSTRY

W.C./M.R/75/1



SOUTH WEST ENGLAND COMPLETE BOUGUER ANOMALIES

HAYLE - LEEDSTOWN AREA : SW53,63

(SHEET 1 OF 1)

Gravity datum : I.G.S.N. 71 INTERNATIONAL

Gravity datum : IGSN 71 INTERNATIONAL
GRAVITY FORMULA 1967
Scale : 1 : 10560 CONTOURS IN g.u. AT INTERVALS
OF 2 g.u.

PREPARED UNDER CONTRACT TO THE
DEPARTMENT OF TRADE AND INDUSTRY