To: Harold Lefevre, R. ~~Lodgewood~~ See pocket to ~~~~ ~~#HE~~

MS 623SS File; Williams

HMGT.

File.

WM DOCKET CONTROL CENTER

'86 FEB 18 P3:09

WELL REPORT.

DEVELOPMENT ASSOCIATES, INC.

BASALT EXPLORER NO. 1

Sec. 10, T. 21, R. 31 E.W.M.

Lincoln County, Washington

8603250455 860218
PDR WASTE
WM-10 PDR

1717.

WM Record File 101

WM Project 10
Docket No.
PDR ✓
LPDR ✓

Distribution:
H Lefevre
R Johnson
(Return to WM, 623-SS)

From Cook to Lefevre

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pocket 10)

Rec'd 2/18/86 with Well Rpt: Lincoln Cty, Wash. 101

(1717)

Well Report

BASALT EXPLORER NUMBER 1

N/2 NE/4 NW/4 NW/4 SW/4 SECTION 10

TOWNSHIP 21 NORTH, RANGE 31 EAST

LINCOLN COUNTY, WASHINGTON

James F. Williams

Development Associates, Inc.

602 Spokane and Eastern Building

Spokane, Washington

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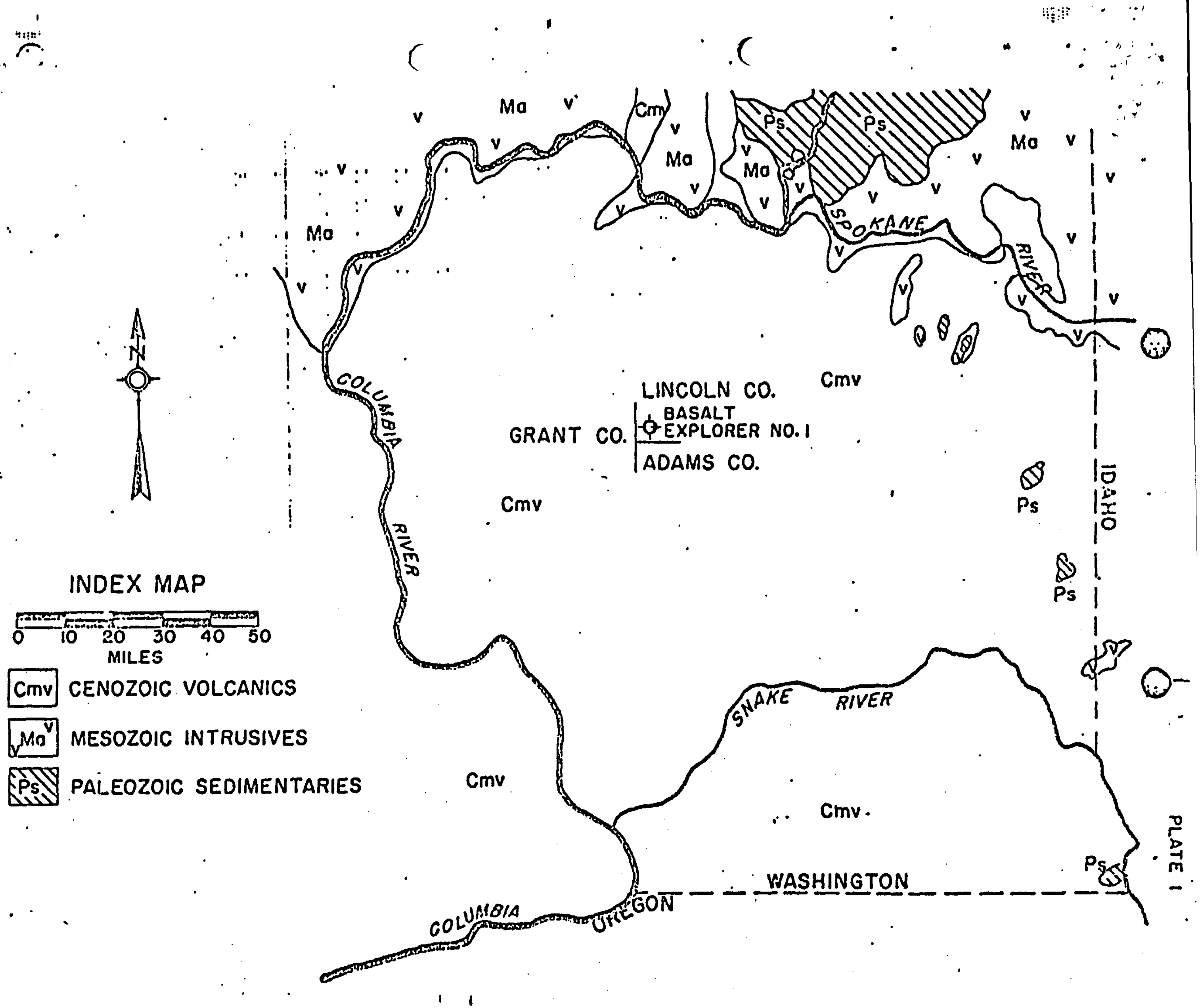

INDEX MAP
0 10 20 30 40 50
MILES
Cmv CENOZOIC VOLCANICS
Ma MESOZOIC INTRUSIVES
Ps PALEOZOIC SEDIMENTARIES
N
COLUMBIA RIVER
SPOKANE RIVER
SNAKE RIVER
COLUMBIA
LINCOLN CO.
BASALT EXPLORER NO. 1
GRANT CO.
ADAMS CO.
IDAHO
WASHINGTON
OREGON
Cmv
Ma
Cm
Ps

PLATE 1

INTRODUCTION

Geographic Location

The Development Associates Basalt Explorer No. 1 is a wildcat well drilled in the autumn of 1960 in Section 10, Township 21 North, Range 31 East of the Wilamette Meridian, in Lincoln County, Washington. The exact location of the wellsite is described as beginning at the northwest corner of Section 10, thence south a distance of 2662.63 feet along the west line of the section, thence South 82° 51' East a distance of 477 feet. The well is nearly centered in the North Half of the Northeast Quarter of the Northwest Quarter of the Northwest Quarter of the Southwest Quarter of Section 10, (N/2 NE/ NW/ NW/ SW/ Sec. 10). The town of Odessa is 11 miles to the east and the town of Marlin is six miles to the northwest.

Geologic Location

The Basalt Explorer well is in the channeled scabland portion of the Columbia Plateau Province and is approximately 50 miles south of the north rim of this saucer-like basin and 75 miles north of the basin's center. The surface is generally covered by wind deposited silt which may be very thin to several feet thick, but much of it is covered by nothing except rough rock and a very thin silty to clayey soil weathered from the underlying lava rocks, generally referred to as the Columbia River Basalt. Topographically the area gently rolls except where cut by box-like canyons or coulees. Hence the name, channeled scabland. The wellsite is in a scabland area which supports mainly a scanty sagebrush cover. Precipitation is light and the basin is semi-arid since it is in the rain shadow created by the Cascade Mountains on the west. Most of the drainage is internal, especially in the sagebrush areas where moisture can readily enter the joints or fractures which are characteristic of basalt. Consequently, the density of established surface drainage channels is comparatively low, even for an arid area. There are many irregularly shaped closed depressions which support only sagebrush since the soil is so leached. Some of the depressions are filled with small lakes at least part of the year.

Purpose

The Basalt Explorer well was drilled to prospect for gas or oil, or locate strata suitable for underground gas storage. No production was obtained and no strata were found which would be economically usable for gas storage, but the information resulting from the drilling will add to the geologic knowledge of an area covering most of eastern Washington. The purpose of this report is to make the results of the well available to anyone interested in geologic exploration of the Columbia Basin.

Drilling Program and Methods

The Basalt Explorer well was spudded August 12, 1960 and released December 14, 1960 to be completed as a water well. The drilling contractor was Nichols-M.K. of Boise,Idaho. The contractor used a Robbins rotary drill, briefly described later. A 17 1/2 inch surface hole was drilled to 96 feet using air to remove drill cuttings. Casing of 9-5/8" size was set at that depth with 4 1/2 cubic yards of concrete. From 96 feet to 1938 feet a 7 7/8 inch hole was drilled with air and foam equipment contracted from Wells Completion, Inc. of Denver, Colorado. From 1938 feet the 7 7/8 inch hole was continued to the total depth of 4682.5 feet, using circulating mud to remove cuttings.

Two 3 1/2 inch cores were cut, one in shale at 4499 feet and one in intrusive rock at 4667 feet (see Sample Descriptions). The total depth of 4682.5 feet was reached October 14, 1960, or 64 days after spudding, an average of 73 feet per day. After the total depth was reached, two Halliburton drill stem tests were attempted (see TESTS). A Schlumberger electric log was made next, and depths were selected from it for the side wall core samples (see Sample Descriptions). A Geolograph was installed at 584 feet and used to the total depth. Operations at the wellsite were ended October 30, 1960.

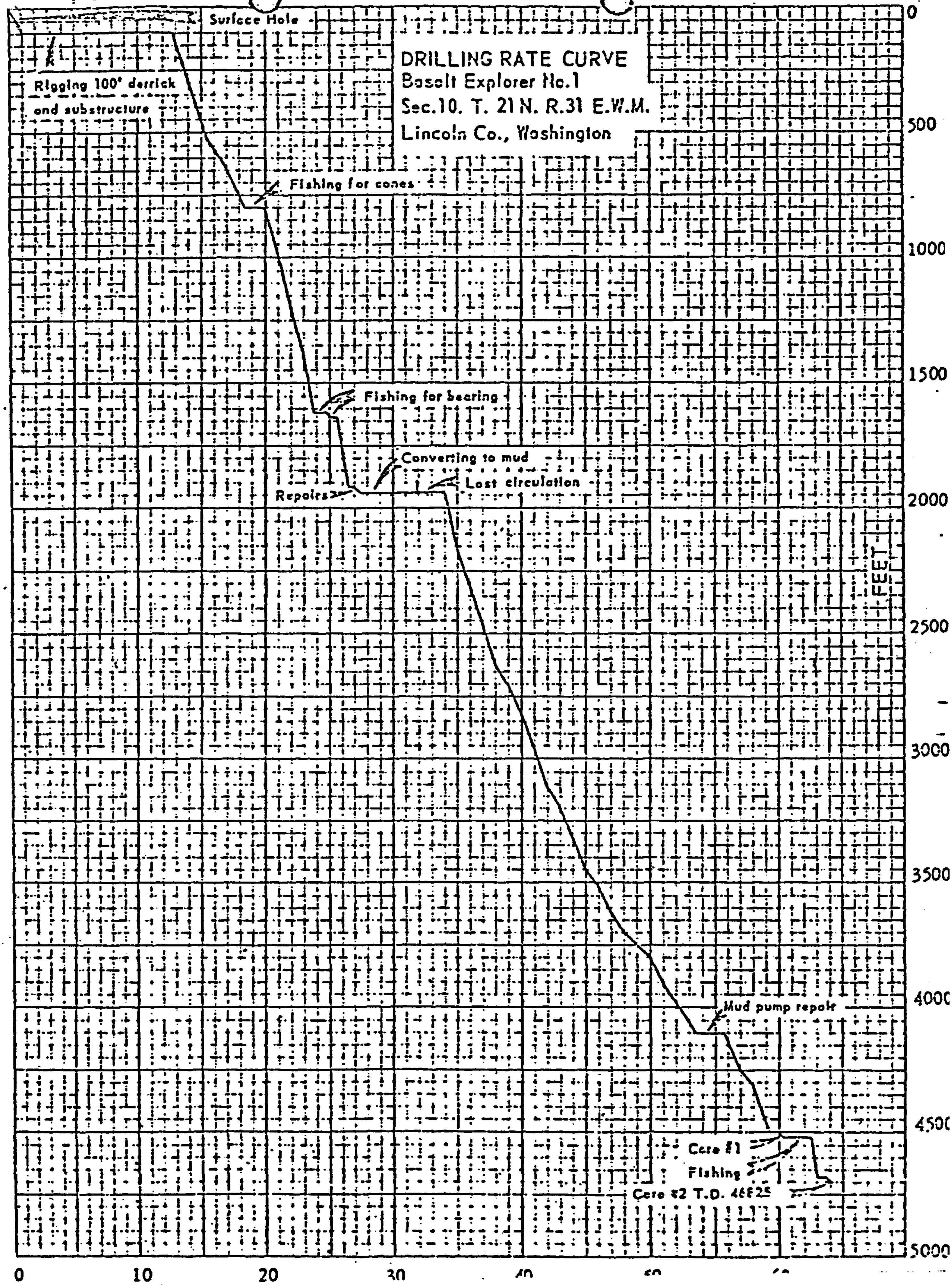
Drilling the Explorer well provided an opportunity to test new equipment and techniques for drilling in the Columbia River basalts. A Robbins rotary drill which was specifically designed for drilling large diameter relatively shallow holes in hard rock was used. The kelly joint and rotary table of the Robbins drill are mounted in a mast on the front of a D-9 Caterpillar tractor. A swivel-traveling block combination is in the same mast in front of the kelly and is raised and lowered by a sprocket wheel and chain assembly. The mast members serve as tracks for the swivel combination which moves up and down the kelly. The kelly transmits the rotary motion to the drill string but is by-passed by the drilling mud which is fed directly into the drill string from the swivel. The sprocket assembly enables most of the weight of the caterpillar to be applied to the drill bit. The mast holds one 30 foot length of pipe of the drill string which it supports. A 100 foot derrick was used to rack the drill pipe. The caterpillar was moved into the 100 foot derrick for drilling and out of it to allow drill bits to be changed. Hoisting power was supplied by a winch and conventional traveling block. An air compressor is mounted at the rear of the caterpillar and shallow holes are drilled with air. This compressor was used only while drilling the surface pipe conductor hole of the Basalt Explorer well.

The Robbins drill can apply weight on the drill bit from the start, whereas, with a conventional rotary drill, bit loading results only from the weight of the tools. This advantage is gradually lost as the drill stem becomes heavy enough to supply the needed weight.

Drilling with air as a circulating medium was tried from the surface to a depth of 1938 feet where the equipment could no longer satisfactorily overcome the hydrostatic head. A foaming agent was added continuously, starting at about 300 feet. Two 850 cubic feet per minute air compressors and one booster delivering air at the standpipe at 1000 pounds per square inch were used during the air drilling phase of the well from 96 feet to 1938 feet.

Air drilling had the advantages that it could be determined almost immediately what type of formation the bit was drilling, lost circulation was not very evident, and samples and formations seem to have been relatively uncontaminated. After converting to a mud system, the up-hole mud velocity was found to be about one and one-half minutes per 100 feet, which delayed the rock samples up to an hour or more. As determined from the side wall cores (see Sample Descriptions), some soft sedimentary type deposits interbedded in the basalt section were not detected in the rotary drill samples. It was inferred that other such deposits were not noted because they were dissipated by both the drilling mud and air.

Water base bentonitic mud was used throughout the hole below 1938 feet. Circulation could not be established until sawdust was added to the drilling mud and about one and one-half days were lost trying to establish circulation. During air drilling the hole was drained of fluids, and permeable zones where circulation might have been lost were not identified. For that reason, the depth of the zone, or zones, where mud circulation was lost, is not known. They are probably above 900 feet in the well, in the Wenas Basalt (see STRATIGRAPHY) which is more porous than the basalt below 900 feet.


DRILLING RATE CURVE
Basalt Explorer No.1
Sec.10. T. 21 N. R.31 E.W.M.
Lincoln Co., Washington
Surface Hole
Rigging 100' derrick
and substructure
Fishing for cones
Fishing for bearing
Converting to mud
Repairs
Lost circulation
Mud pump repair
Core #1
Fishing
Core #2 T.D. 4682
FEET
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
0
10
20
30

Below 1938 feet there was very little non-drilling time due to poor circulation. The zones of lost circulation were never completely sealed, however, and mud had to be mixed and sawdust added during every tour to total depth.

Bit pressures of 40 to 50 thousand pounds and rotating speeds of 40 to 50 revolutions per minute were maintained during both the air and mud drilling phases. A rotary speed of about 60 revolutions per minute was tried early in the air drilling phase and seemed to lessen bit life. A hole deviation of 4° was measured at 3618 feet. No symptoms of serious deflection were noted.

During the air drilling phase 1842 feet were drilled in 181.5 hours, an average of 10 feet per hour. During the mud drilling phase 2729 feet were drilled in 409 hours, an average of 6.7 feet per hour. Drilling time and footage for the surface hole and during coring are not included in these comparisons. The drilling time is the actual hours drilled and does not include time used in making pipe connections, changing bits or repair time. The drilling rate with air was 152% of the rate for mud drilling, and the average cost per foot with air was 81.3% of the average mud drilling cost. Factors used in the cost comparison are those items which were restricted to the individual drilling method, i.e. air compressors, mud pump, etc. Special and overhead costs, which were relatively constant to both methods, were not included. Since drilling costs increase with depth, the inclusion of fixed charges would show air drilling to be even more efficient in this case.

Recent Exploration

The closest recent attempt to drill through the Columbia River Basalt was by Standard Oil of California in Benton County, Washington in 1958. The Standard well, the Rattlesnake Hills Unit No. 1, is 10 miles west of the depleted Rattlesnake Hills gas field and approximately 75 miles southwest of the Basalt Explorer well. Standard's well was drilled to a total depth of 10,660 feet, five times as deep as the field wells in the same area, and over twice as deep as the Explorer well, without passing through the Columbia River Basalt.

STRATIGRAPHY

The lava flows drilled by the Basalt Explorer well are divisible into two units which appear to be correlative with the Columbia River Basalt. An upper porphyritic unit and a lower and thicker aphanitic unit may correspond to the Wenas Basalt and the Yakima Basalt respectively, the recognized two members of the Miocene Columbia River Basalt formation.

Below the basalt flows the Explorer well penetrated through a previously unknown sedimentary section. This and the lava flows are described below. The sediments have been tentatively named the Irby Shale and the Odessa Sand, after nearby towns. A distinctive red zone in the Yakima Basalt has also been given a tentative name, the Marlin marker, since it would be a good reference plane if it is extensive horizontally.

The Wenas Basalt

The basalt flows of the upper 910 feet drilled in the Explorer well are very porphyritic with much secondary mineralization and a high frequency of rust and red colored weathered zones. They are distinguished from the subjacent aphanitic basalt flows on the basis of these criteria and may correlate with the Wenas Basalt member of the Columbia River Basalt formation.

It is probable that there were greater time lapses between the individual flows of the Wenas than there were between the Yakima flows. The Wenas formation represents the last stages in the crustal adjustments which extruded the Columbia River Basalt, and which seem to have become intermittent before ceasing.

During the interflow times aerated surface waters should have had easy access to the shrinkage fractures which are characteristic of basalt. The water facilitated the deterioration and recombination of basaltic minerals in the upper parts of succeeding flows forming the red zones and secondary minerals.

Another distinguishing, and also curious, feature of the Wenas Basalt in the Explorer well is the presence of zones of a highly concentrated magnetic mineral identified as magnetite. The entire Wenas was found to be unusually rich in disseminated magnetite when compared with the Yakima Basalt, and beginning at the depth of about 150 feet thin zones comprised almost exclusively of that mineral were present. Magnetite is almost always a basic accessory mineral in basalt but something approaching magmatic differentation or segregation had to take place to concentrate it and make it a primary constituent. Differences in cooling rates could possibly account for the magnetite but it could easily be theorized that a change in the composition of the parent magma of the Columbia River basalts took place before the extrusion of the Wenas Basalt, differentiating it from the Yakima Basalt.

Water bearing zones were found to be numerous in the basalts and seemed to be especially so in the Wenas. The first such zone was encountered at about 70 feet and was barely detectable. Succeeding flows were free flowing and plentiful but apparently not under much pressure. Only once did enough head build up for water to flow to the surface, and then it was only for a few seconds with no jetting action. The flow could have been caused by a surging action in several of the low pressure water zones as a result of their equilibrium having been disturbed.

Permeability seems to be provided by the complex and extensive joint systems in basalt or by broken and weathered interflow zones. A limited amount of permeability was observed in samples with interconnected vesicles which were presumably from the upper parts of flows. The observed vesicular permeability could not account for the amount of water found in the Explorer well but the jointing seen in surface exposures could. The rate of water ejection by the air drilling equipment often increased abruptly after the rate had been constant for many feet. The water volume leveled off each time at the increased rate. The increases in water volume were especially noticeable during the air drilling phase and each increase was cumulative on down to 1938 feet in the Yakima Basalt where air drilling was discontinued due to the difficulty of ejecting water which would fill the hole to within approximately 100 feet of the surface during drilling interruptions.

The Yakima Basalt

Underlying the Wenas Basalt in the Explorer well there is about 3550 feet of aphanitic and generally featureless basalt flows which are here correlated with the Yakima Basalt. The Yakima is the lower and older unit in the twofold division of the Columbia River Basalt. There is some doubt about the lower boundary which is explained later. The upper boundary was placed at 910 feet where the basalt became very uniform in dark gray color and very fine texture with few secondary minerals and much less magnetite than was found in the Wenas Basalt. These criteria were not immediately recognized as constituting the Yakima, so it was some time before a definite identification was made. It is now believed that immediate identification can be made with the above characteristics and upon the first appearance of blue-green colored amorphous amygdules and inclusions which average about one-twentieth inch across. The blue-green mineral appeared frequently and characteristically in the Yakima , generally as a secondary lining in gas vesicles. It sometimes occurred as a second stage in secondary mineralization, being underlain by a layer of olive-green amorphous mineral in vesicles. Both the blue-green and the olive-green minerals are somewhat reniform or botryoidal and have a dull wax-like appearance. The distinction between the two divisions of the Columbia River basalts at 910 feet may or may not be genetic. The important factor is that there is a division which may be consistently identified and used to give structural data.

The Yakima Basalt as found in Basalt Explorer is remarkable in its lack of variety. Over 3100 feet of rock has scarcely any distinguishing features. It is probable that the mass of Yakima Basalt was extruded in a relatively short geological time. The flows were probably rather thin, perhaps on the order of 50 feet thick, and must have come one upon the other so rapidly that preceding flows may not have been completely cool. There was little time for weathering processes to take effect as there was later with the Wenas flows, and it might be said that the times required for extrusion of the two could have been nearly the same though the Yakima is nearly four times as thick as the Wenas.

At 3100 feet to 3140 feet in the Yakima there was a bright red zone of weathered basalt which was distinct from anything previously seen in the well, especially in the Yakima. In a generally featureless sequence such as was found, this zone could serve as an excellent marker and it is proposed that it be called the Marlin marker. There had been other limited occurrences of rusty colored weathered basalts but none as unique as the Marlin marker which could easily be used as a datum for subsurface structure maps if it is extensive enough.

The exact lower limit of the Columbia River Basalt in the Explorer well could not be determined within a margin of about 100 feet. It is between the depths of 4350 feet and 4470 feet. By rotary drill sample interpretation the basalt was drilled through at about 4470 feet with a 300 foot interval above that depth of interbedded basalt and sedimentary rock. The electric log appears to show the bottom of the basalt at a depth of about 4350 feet.

Sedimentary Deposits

The first conclusively non-basaltic rocks indicated in the drill samples were at the depth of 4170 feet as discussed below. By drill samples the first pre-basalt sediments were found below 4465 feet. After reaching total depth nine side wall cores were cut, several of which recovered sedimentary rocks. The following discussion is in the order of the sediments relative position in the well and not in the order in which they were first noted.

The drill cuttings sample from 4170 feet to 4175 feet contained a trace of pale green diatomite, the siliceous shells of microscopic algae. The trace was so small that this information is not very valuable in itself. The five foot sample was, however, followed by an interval down to 4200 feet in which the samples contained a high percentage of light brown mudballs from a very soft shale. The shale is slightly calcareous and, when wet, has a greenish tint indicating it probably contains some diatom shells.

Five side wall cores were recovered from between the depths of 4400 feet and 4525.5 feet. Two were micaceous shale or siltstone which were somewhat plastic, like modeling clay, and had indistinct bedding planes. Three were fine to coarse white subangular quartz grains in a plastic clay-like light gray matrix which was not definitely identified. The unidentified matrix in the latter three cores and the one at 940 feet are probably glassy volcanic ejecta which has been devitrified and is in the process of being altered to a clay.

Angular and subangular grains similar to the quartz grains in the last three side wall cores were often encountered below 1930 feet where they first appeared. Doubtlessly some of them were quartz grains washed out of deposits similar to those in the cores, but most of them were probably olivine. The grains in general looked like milky or colorless quartz but were not quite hard enough to be quartz. When grains were found with green flecks of color it was decided that the quartz-like grains were an unusual type of olivine.

Other semi-indurated sedimentary beds similar to the cores described above were probably penetrated by the hole but because they are so thin and soft were dissipated in the drilling mud or pulverized in the air drilling and consequently they were not detected in the drill cuttings.

By drill sample interpretation the final break through the basalt flows was at about 4465 feet. An unconsolidated sand was encountered which persisted to 4499 feet. The sand consisted of quartzose poorly sorted grains up to coarse size. Most of the grains have a somewhat rounded shape which is indicative of its sedimentary origin. Fracture surfaces which appear unworn are abundant and there are some sharply angular grains. Cementing material appears completely lacking which would tend to greatly increase porosity and permeability. An average description would be that of an unconsolidated quartzose sand of subangular coarse to fine grains.

An attempt was made to obtain a 3 1/2 inch vertical core of the sand starting at 4499 feet. Apparently that was the exact bottom of the sand since the cored material consisted entirely of 14 feet of red shale.

Irby Shale

The shale cored from 4499 feet to 4513 feet is a rust or red color, has poorly developed bedding planes which occasionally are parallel but generally are hackly, and contains zones with up to about 10% sand grains similar to those described above. One two-inch specimen contains parallel layers up to one-sixtieth inch thick of greenish bentonite. The bentonite's chief attendant meaning is in its being bedded which shows that the red shale is a true though poor shale and not a paleosol as was thought by one authority.

After coring the 14 feet from 4499 feet to 4513 feet, drilling was resumed and by sample determination the bottom of the red shale was at about 4575 feet, or a total thickness of about 75 feet. An X-ray spectrographic analysis of specimens of the shale core showed them to be approximately one-half clay of the montmorillonite group and one-half clay of the kaolinite group in a single specimen. These are clay minerals which are, respectively, hydrous and anhydrous aluminum silicate hydroxides. Montmorillonite supposedly characterizes lagoonal and alkaline environments, and kaolinite a fresh water environment. Little research has been done in this respect and the information is not to be relied upon, especially since it is contradictory in this case. Little can be determined in this direction except that about 75 feet of approximately 90% plus clay particles were deposited in quiet water which was probably fresh. The red color does not denote an abnormally high content of iron but rather that the iron present is in ferric compounds such as hematite and not in ferrous compounds. Montmorillonite is the chief ingredient in bentonite, the main uses of which are due to its ability to absorb water and swell to eight times its own volume. Another type of bentonite absorbs water and slakes without swelling much. This is the way the red shale from Basalt Explorer reacts. Moderate swelling because of the montmorillonite content plus the presence of thicker and probably more absorbent bentonite layers below the cored interval, at about 4565 feet, prevented electric logging the lower part of the well.

Residual clays such as were found in the red shale are near the final decomposition products of crystalline rock. When they are transported and deposited as shale the average proportion is one-third clay and two-thirds silt (Pettijohn, 1957, p. 343). Certain minerals form in place after deposition. Chlorite is such an authigenic, or secondary, mineral. A variety of chlorite, prochlorite, was identified from the red shale.

Several samples of the shale core were examined for microfossil content to determine the geologic time of its deposition. No fossils were found which strengthens the probability that the shale is of continental rather than marine origin. Montmorillonite is likely to be rare in Paleozoic sediments and common in post Paleozoic fine grained rocks (Pettijohn, 1957, p. 137). The red shale could be Mesozoic in age but may be considerably younger and was probably deposited during the Tertiary, just prior to the extrusion of the Columbia River Basalt.

Odessa Sand

Immediately beneath the Irby shale, and a continuation of the previously unknown sedimentary interval, is some 90 plus feet of unconsolidated sand which has been tentatively named the Odessa sand. The upper contact with the Irby shale is between the depths of 4570 feet and 4580 feet and the lower contact with intrusive rock is probably at the depth 4667 feet. The physical description of the sand is very similar to the sand above the Irby shale and is generally described as fair to poorly sorted quartzose subangular grains up to one millimeter in diameter. Most of the grains have a rounded outline, but most have fresh conchoidal fracture surfaces, and none appear well worn or frosted. A few of the grains are very angular. All of them are either colorless or milky. The sand above the Irby shale is probably part of the Odessa sand as shown in the diagram on PLATE 3..

The Odessa sand contains considerable feldspar, but grain size, color and shape are so nearly like the quartz grains that a visual estimate of the feldspar content could not be given. If the Odessa sand had 25% or more feldspar content it might be called arkose. The petrogenesis of the Odessa sand is not clear but it is not thought to be arkose since it is too well sorted and mature.

The Odessa sand and the overlying sediments follow the pattern of sediments deposited by a transgressing and regressing sea (see PLATE 3). The sand was probably the product of a transgressing basin-size sea of fresh water.

According to the ideal transgressing pattern there should be a gradation upward from very coarse or conglomeratic to very fine grains in the Odessa sand. The Odessa sand follows the ideal pattern only to a limited extent. It does not include grains over one millimeter in diameter and is poorly sorted below that size. However, in general aspect, the sand seems to grade upward from medium grain, to coarse plus medium grain, to medium grain, to coarse plus medium grain. Many variations are possible from the ideal, or theoretical, pattern from temporary fluctuations of sea level.

Following the deposition of the Odessa sand in shallow water the depth increased and the Irby shale was deposited in relatively deep quiet water. During the deposition of the Irby shale there were occasional undersea currents, probably concurrent with flooding on the adjacent land, which left zones in the shale containing sand grains. The sand above the Irby shale indicates that regression of the sea followed next. The succeeding time interval may have been characterized by broad shallow lakes which received fine grain clastic material and volcanic dust at times. The sporadic extrusion of the Columbia River Basalt, with which the sediments seem interbedded, began during this time. Before the basalt extrusion became dominant it

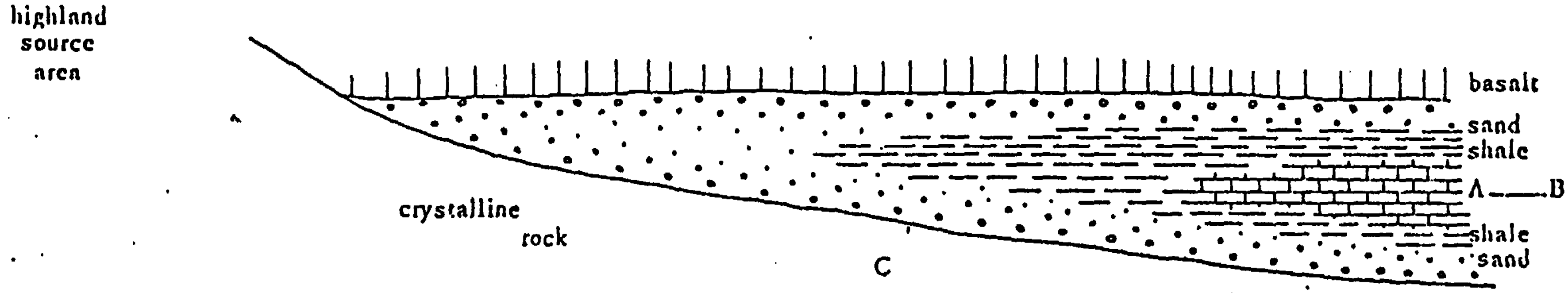


PLATE 3 Diagramatic idealized cross section showing probable history of the principal sediments found in Basalt Explorer. As diagramed, the sediments below line A-B were deposited by a sea rising toward the left, those above line A-B to the basalt by a receeding sea. The location of Basalt Explorer would be in the vicinity of C. No vertical or horizontal scale used.

PLATE 3

seems to have ceased for a short time. During this time there was probably a large lake in the basin in which was deposited the diatomaceous slightly calcareous shale found between 4170 feet and 4200 feet in the Explorer well. After this the extrusion of the Columbia River Basalt became dominant. There were probably a few short quiescent times, especially during Wenas time, when sedimentary processes could take effect but sample evidence is lacking.

Felsic Crystalline Rock

Crystalline rock was encountered at 4667 feet in the Explorer well. The crystalline rock is a quartz porphyry felsic or acid rock in contrast to the Columbia River Basalt and was probably intruded. No intermediate or metamorphic rocks were indicated between the Odessa sand and the crystalline rock. We can be reasonably sure the intrusion pre-dates the overlying sediments, and that it probably dates from the Mesozoic Era or the Tertiary Period in conformity with most crystalline rocks in eastern Washington.

The crystalline rock was cored from 4667 feet to 4682.5 feet, the final depth of the Explorer well. Thin sections have been made from the core and it has been identified as a microgranite or a porphyritic quartz monzonite. This indicates that the core is from what could be a limited sill or dike, and the sedimentary section may be more extensive than has been proven. Crystalline rocks to the north of the wellsite, generally north of the Columbia River, are coarse textured granitic types (Culver, 1936, pp. 36, 46) and other batholithic types which might be termed a basement complex. Rock in this area which perhaps most nearly resembles that beneath the Odessa sand is a latite porphyry, the extrusive equivalent of monzonite, in the Republic area.

A temperature of 138° F. was measured at about 4550 feet when the electric log was made. The average geothermal gradient is about 1° increase over the mean annual temperature for every 50 feet of depth. At Odessa, Washington, the mean annual temperature is 49°, and 138° would be an increase of 1° for every 51 feet. Since increases in the geothermal gradient have been attributed to the proximity of intrusive masses, among other things, (Uren, 1953, p. 13), this may be evidence that the intrusive rock is a limited sill or dike.

Sample Descriptions

Samples of drill cuttings were taken at five or ten foot intervals from below the surface casing to total depth. During the air drilling phase, the flow line was tapped and part of the returning foam was diverted into a baffle box to settle the cuttings from which samples were collected. During the mud drilling phase the flow line was emptied into a wooden settling trough which was emptied periodically and sample cuttings removed. All samples were examined under a ten power microscope.

The following descriptions are for drill samples from near the base of the basalt to the total depth and for the side wall core samples. A complete set of samples is available for inspection and a written description and lithologic log are available upon request.

Surface to 100 feet not sampled--surface casing.

100-4130	Sample descriptions available upon request.
4130-4160	Basalt, medium to dark gray, very fine crystalline to dense, with a trace of calcite, amber, translucent, showing cleavage faces.
4160-4165	No samples returned.
4165-4170	Basalt as above with a trace of white calcite.
4170-4175	As above with a trace of diatomite, pale green.
4175-4200	Basalt, dark grey, dense, very fine crystalline, with mudballs which indicate possible dark grey shale or mudstone interbeds.

4200-4270 Basalt, as above.

4270-4340 Basalt, as above to medium gray.

4340-4360 Basalt, as above, with dark to medium grey shale interbeds.

4360-4370 Shale, as above.

4370-4410 Basalt, dark gray, dense, with 30% glass and/or quartz grains, angular, unconsolidated, with a trace of basalt, brown, very fine crystalline, dull luster, and a thin possible shale, dark gray.

4410-4430 Basalt, as above, with no shale indications.

4430-4465 Basalt, dark to medium gray, very fine crystalline to dense with a trace of basalt, medium brown and rust and up to 10% unconsolidated coarse subangular sand grains.

4465-4495 Sand grains, coarse subangular unconsolidated.

4495-4499 Sand grains, white, coarse, unconsolidated, with a trace of rust shale.

(Core No. 1 4499-4513)

<u>Irby Shale</u> (4499-4575)

4499-4513 Shale, rust, very clayey, with trace of subangular quartz grains, hackley to parallel bedding, occasionally mottled green and with a few 1/60" green bentonite parallel interbeds.

4513-4565 Shale, as above, with traces of shale, medium brown, with pink and pale green cuttings which are probably bentonite.

4565-4575 As above with an increase of pale green bentonite plus 15% basalt, dark grey, dense; and coarse subangular quartz grains.

<u>Odessa Sand</u> (4575-4667)

4575-4600 Sand, coarse to medium grain, subangular, quartzose, unconsolidated, fair sorting, with a trace of calcite.

4600-4640 As above, grades to medium grain.

4640-4650 As above, coarse to medium grain.

4650-4660 As above, medium grain.

4660-4667 As above plus possible feldspar.

(Core No. 2 4667-4682.5)

4667-4682.5 Crystalline rock, medium gray, visible biotite less than 5%, occasionally rust colored, texture occasionally near aphanitic, moderate amount of vertical fractures.

4682.5 Total depth.

Side Wall Cores

664 Basalt, dark gray, very vesicular, some interconnection of vesicles, with large (probably several inches) very weathered pale green serpentine inclusions, and one rust colored weathered portion which is very pasty and measures one-half inch, core was water wet.

693 Basalt, rust, very weathered, soft, water wet.

940 Magnetite, dull black, very sharply angular, sub-metallic luster, grains to one-quarter inch, in a medium gray very soft fine grained matrix.

985 Basalt, dark gray, very dense, with 35% large vesicles lined with serpentine, one-fifth of core recovered.

1040 No recovery, core bullet shattered.

4400 Shale or siltstone, medium brown, micaceous, grains too small to identify, light brown to white indistinct cross beds.

4420 Shale, medium brown, micaceous, with 10% fine white quartz grains, very soft, bedding indistinct.

4491 Diatomite? Tuff? Light gray, with 85% very fine to coarse, white, subangular quartz grains.

4501 As above.

4525.5 As above.

TESTS

The Odessa sand had a slight yellow fluorescence when viewed under ultra-violet light. Fluorescent cuttings are ordinarily separated and treated with a solvent which intensifies the fluorescence if oil is contained in the pore spaces. The Odessa sand could not be treated this way since it is unconsolidated and individual grains had been washed in the drilling mud. The liquid from wet samples of the Odessa sand was placed under the ultraviolet light and found to have a slightly yellow fluorescent film. Soft paper would absorb some of the material from wet samples and leave fluorescent spots. The fluorescence is not thought to be contamination since previous samples had been tested the same way without obtaining the same results, and no unusual contaminating source could be found.

The Halliburton drill stem tests were attempted because of the fluorescence to get formation fluid samples and indications of the porosity and permeability of the Odessa sand. Neither test was completely successful. On the first test the packer was set in shale and failed to seat, allowing drilling fluid to drop past it and enter the dry drill pipe. On the second attempt the test was normal until the tool openings plugged with sawdust, even though they had been reamed out in anticipation of that happening. In 35 minutes 480 feet of drilling fluid entered the drill pipe. Had all of the drilling fluid below the packer been able to enter the pipe there would have been 800 feet of it and then whatever was pushing it could have entered the pipe. Pressure gauges failed to record the static formation pressure before the tool was opened. Though the tool was probably getting progressively more plugged during the 35 minutes it was open, pressure of fluid entering the pipe may have been increasing as indicated by a rise from 236 psi to 238 psi. Static pressure of the formation measured after the tool was closed increased in increments averaging 32 psi at 6.4 minute intervals from 205 psi to 527 psi. We can be reasonably certain then that the Odessa sand is permeable to some extent but no sample of its content was obtained.

An electrical survey was made of the bore hole in an attempt to get more information on the possible oil show in the Odessa sand. Because the Irby shale swelled and closed the hole each time the drill pipe was removed, the electric log sonde could not get below 4559 feet, about 15 feet above the top of the Odessa sand. An increase in bentonite was noted in the drill samples between 4565 feet and 4575 feet. Since no difficulty was experienced with the drill pipe, the swelling zone is probably not more than two or three feet thick. The electric log could not accomplish its main purpose of surveying the Odessa sand but it may prove valuable in correlation work.

Copies of the drill stem test reports and the electric log are available to anyone interested.

DRILLING BIT PERFORMANCE AND DATA CHART

Development Associates Basalt Explorer No. 1

Sec. 10, T. 21 N, R. 31 E., Lincoln County, Wash.

Type Bit	No. Used	Cost per Bit	Total Cost plus 10%	Footage Total	Footage Max.	Footage Min.	Footage Ave.	Hours Actually Drilling	Actual Hours + 5 Hours per Bit Change	Foot-hours per Dollar	Bit cost per foot per hour	Bit cost per foot
W7R	6	3-$229.32 3-$210.85	$1,452.57	372	111	14	62	57:00	87:00	22.28	$0.0449	$3.90
RG2JS	3	1-$1257.98 2-$1144.57	$3,901.83	1112	328	394	371	92:30	107:30	30.64	$0.0326	$3.50
RG1J	13	$1031.64	$14,744.15	2514	319	70	193	390:15	455:15	77.61	$0.0129	$5.06

Note:

A total of 27 drill bits was used. Five bits were of other types used only once each, or bits which failed for various reasons and were not included in the above statistics.

$$\text{Bit cost per foot per hour} = \frac{\text{Bit costs}}{\text{Hours} \times \text{footage}}$$

$$\text{Foot-hours per dollar} = \frac{\text{Hours} \times \text{footage}}{\text{Bit costs}}$$

PLATE 4

DRILLING BIT RECORD

Basalt Explorer No. 1, Sec. 10, T. 21 N, R. 31 E, Lincoln County, Washington

Bit No.	Type	Depth Out	Feet	CONDITION: Cones Frozen	Cones Loose	Cones Good	Appearance
1*	W7R (T)*	96	96				
2	RG2JS(B)*	486	390			3	Good
3	W7R (T)	557	71	Cut up to make fishing tool			
4	W7R (T)	584	27			3	Good
5	W7R (T)	695	111		3		Good
6	VCB (B)	798	103	Reclaimed by manufacturer for failure check			
7	W7R (T)	900	102		3		Fair
8	RG2JS(B)	1228	328			3	Good
9	RG2JS(B)	1622	394		3		Bearings missing
10	W7R (T)	1636	14		3		Good
11	RG7XJ(B)	1919	283	Reclaimed by manufacturer for failure check			
12	YPBW(T)	1938	19	Reclaimed by manufacturer for failure check			
13	RG1J(B)	2257	319		1	2	Good
14	RG1J(B)	2530	273	1	2		Bearing missing in 1 cone
15	RG1J(B)	2657	127		3		Poor
16	RG1J(B)	2922	265		3		Poor
17	RG1J(B)	3127	205	1	2		Cones half worn off
18	RG1J(B)	3321	194	2		1	Fair
19	RG1J(B)	3510	189	1		2	Fair
20	RG1J(B)	3706	196	1	2		Fair
21	RG1J(B)	3776	70	Reclaimed by manufacturer for failure check			
22	RG1J(B)	3950	174	1		2	Fair
23	W7R (T)	3997	47			3	Good
24	RG1J(B)	4097	100			3	Good
25	RG1J(B)	4284	187	2	1		Fair
26	RG1J(B)	4499	215			3	Very good
27	OSCJ(T)	4667	168	Cones bald; bearings seem good			

... 17 1/2"; all others were 7 7/8".

PLATE

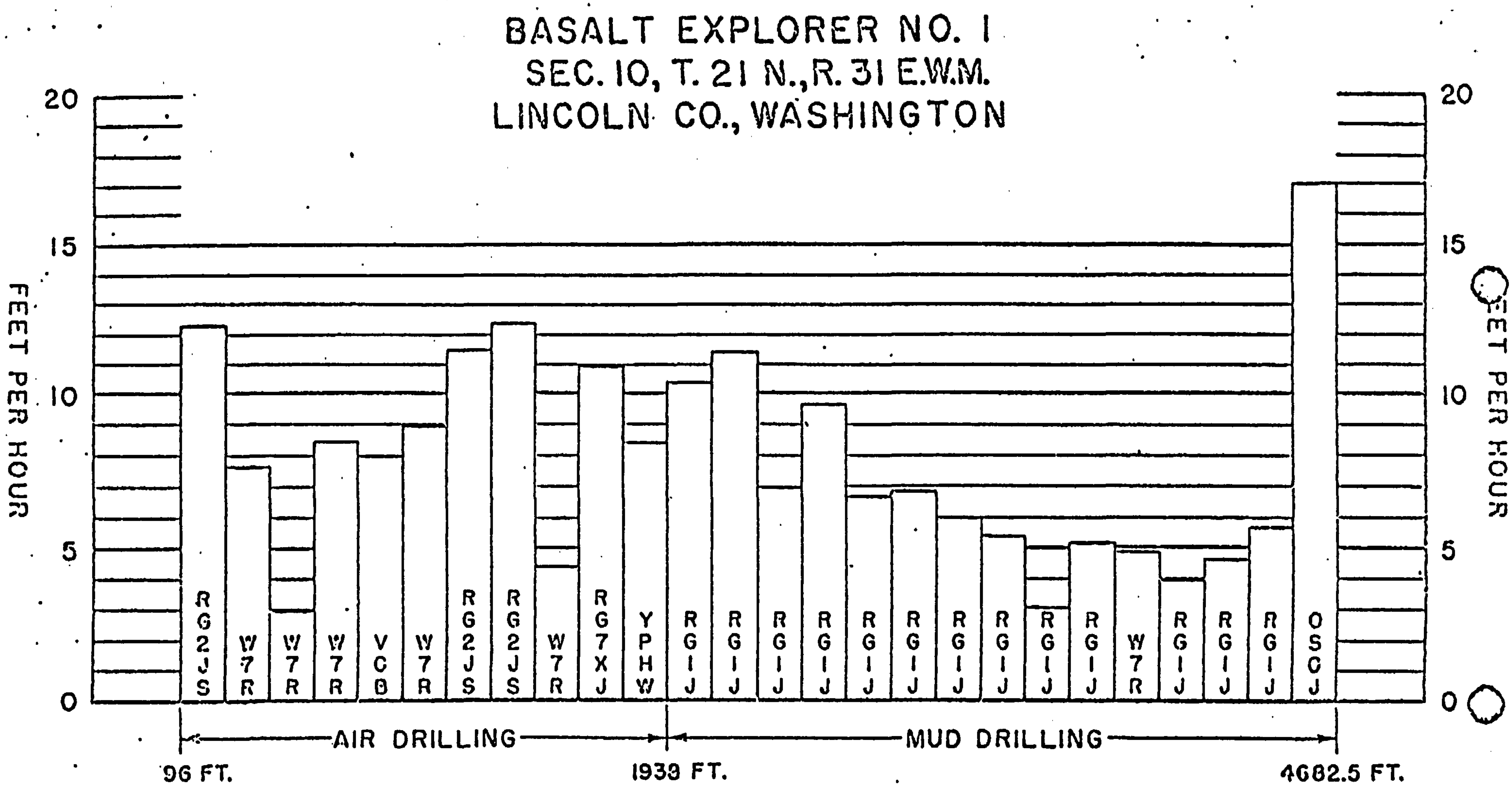


PLATE 5: DRILL BIT FOOTAGE PER HOUR

TOOTH TYPE BITS: W7R, YPHW, OSCJ

INSERT TYPE BITS: RG2JS, VCB, RG7XJ, RGIJ

PLATE 5

147

SCHLUMBERGER WELL SURVEYING CORPORATION
HOUSTON, TEXAS

SCHLUMBERGER

Electrical Log

COUNTY	LINCOLN
FIELD or	WILDCAT
LOCATION	10 - 21N - 31E
WELL	BASALT EXPLORER NO. 1
COMPANY	DEVELOPMENT ASSOCIATES

COMPANY DEVELOPMENT ASSOCIATES

WELL BASALT EXPLORER NO. 1

FIELD WILDCAT

LOCATION 10 - 21N - 31E

COUNTY LINCOLN

STATE WASHINGTON

Other Surveys: ES (ONLY)

Location of Well

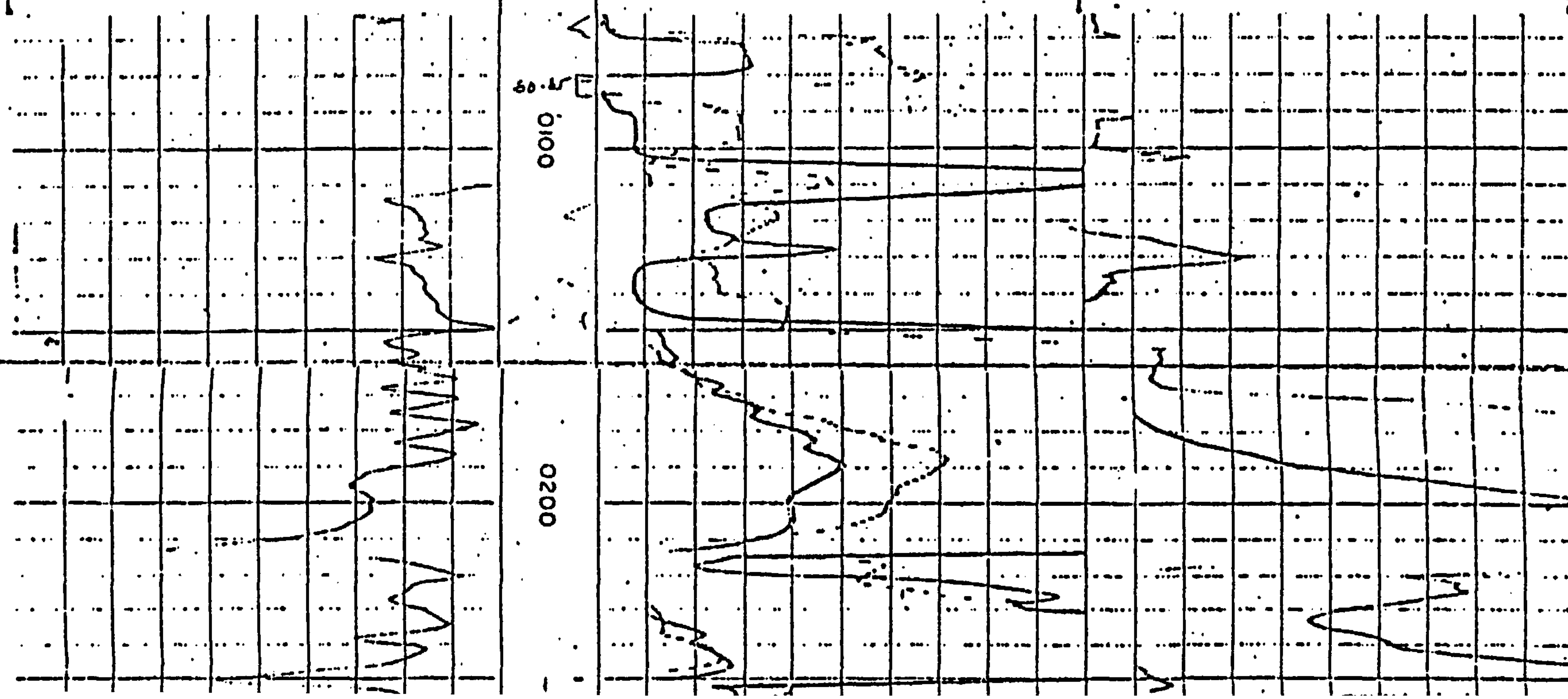
Elevation: D.F.: 5 ?C
K.B.:
or G.L.:

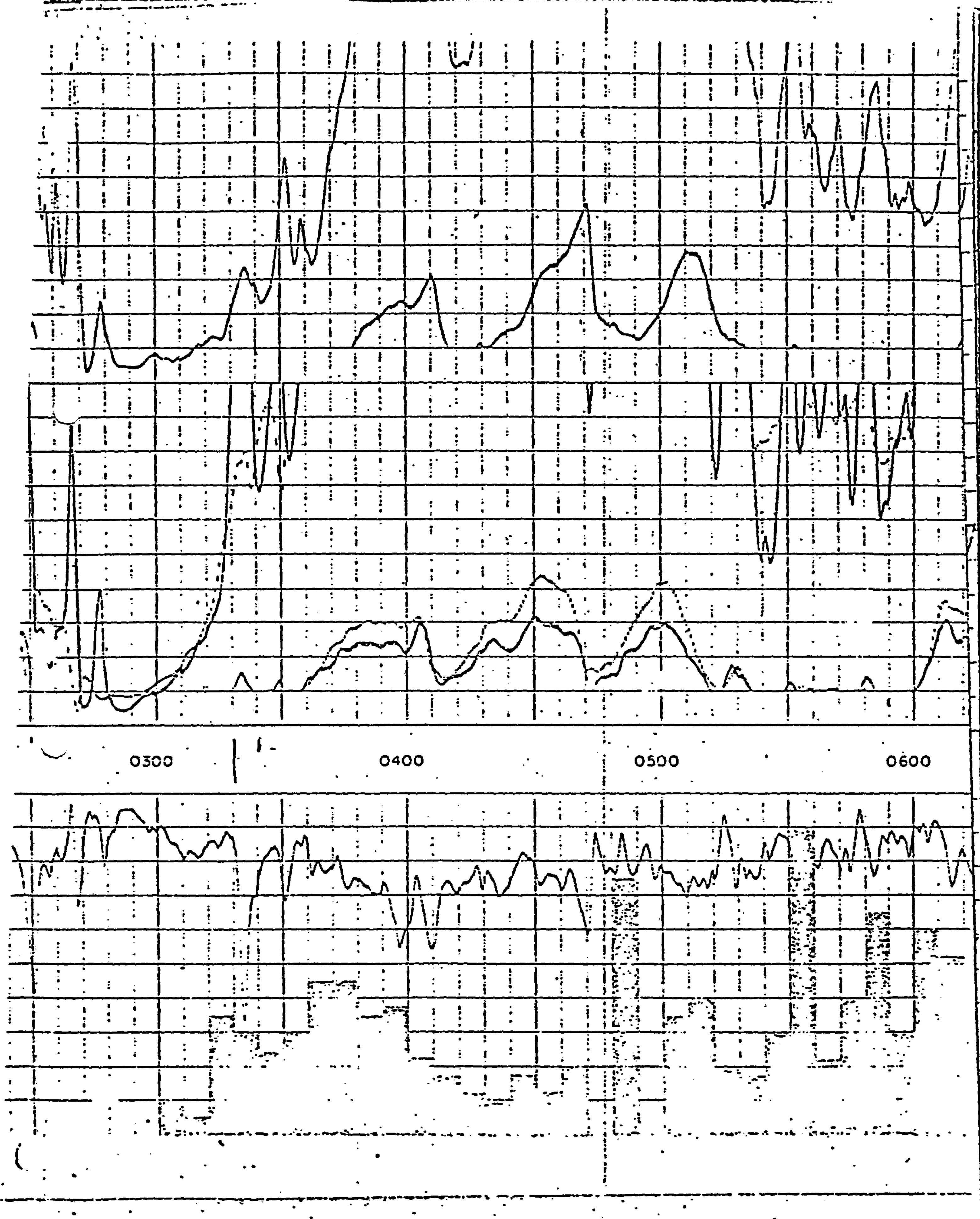
FILING No.

RUN No.	ONE				
Date	10-25-60				
First Reading	4557				
Last Reading	90				
Feet Measured	4467				
Csg. Schlum.	90				
Csg. Driller	96				
Depth Reached	4559				
Bottom Driller	4632				
Depth Datum	TOP ROP				
Mud Nat.	CLAY				
Dens. Visc.	- 45				
Mud Resist.	12 @ 62 F	@ F	@ F	@ F	@ F
" Res. BHT	5.3 @ 138 F	@ F	@ F	@ F	@ F
Rmf	3.9 @ 138 F	@ F	@ F	@ F	@ F
Rmc	5.2 @ 138 F	@ F	@ F	@ F	@ F
" pH	7.5 @ 62 F	@ F	@ F	@ F	@ F
" Wtr. Loss	- CC 30 min.	CC 30 min.	CC 30 min.	CC 30 min.	CC 30 min.
Bit Size	7 7/8"				
Spcgs.—AM	16"				
A M	64"				
AO	18'8"				
Opr. Rig Time	3 HOURS				
Truck No.	2507 530				
Recorded By	CREACY				
Witness	WILLIAMS				

REMARKS

SPONTANEOUS·POTENTIAL millivolts	DEPTHS	RESISTIVITY ohms. m²/m	RESISTIVITY ohms. m²/m
10 ↔ 20 MINUTES		0 AM=1.6" 500	0 AO=18'8" 500
		0 5000	0 5000
		0 AM=64" 500	
		0 5000	

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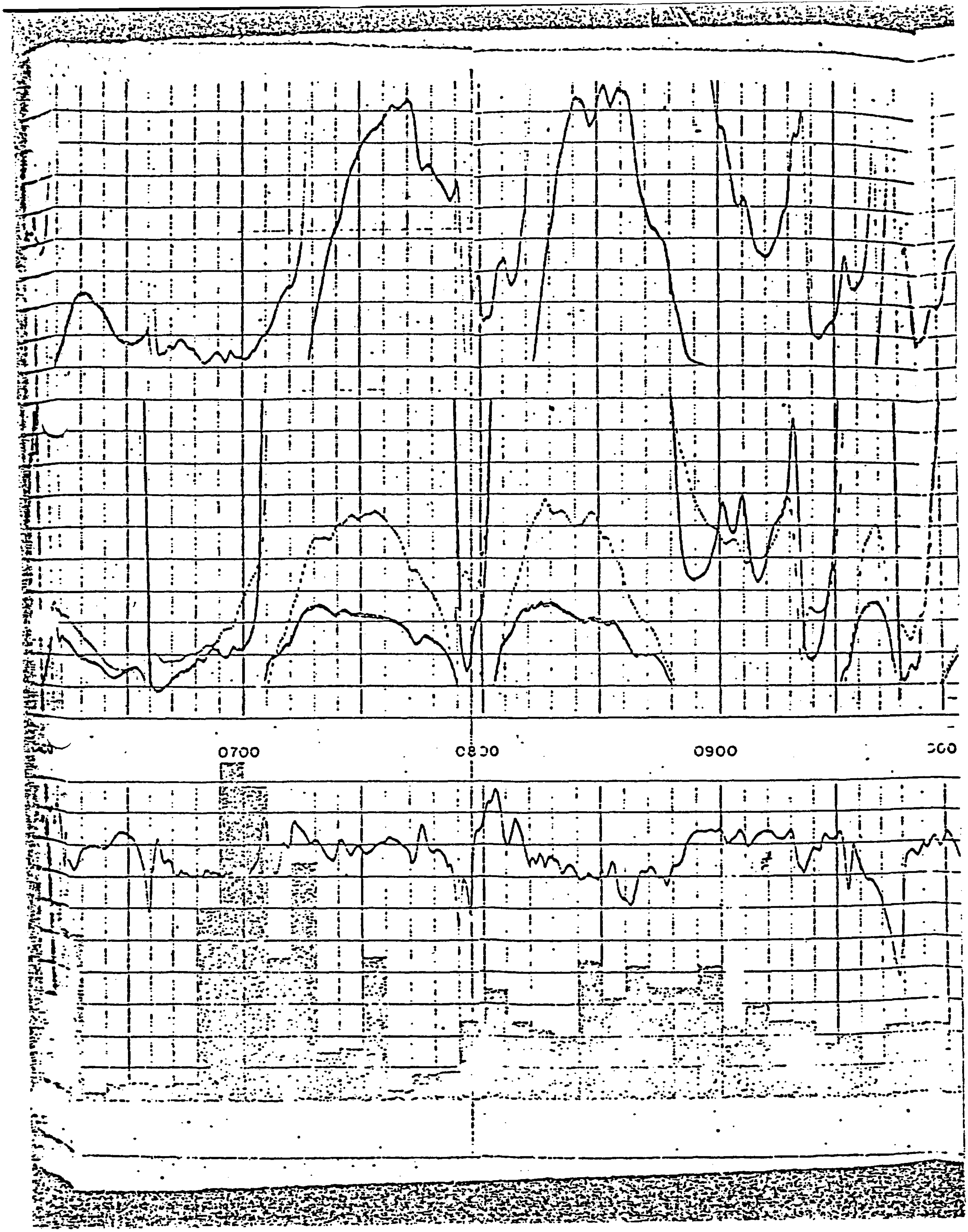
0400
0500
0600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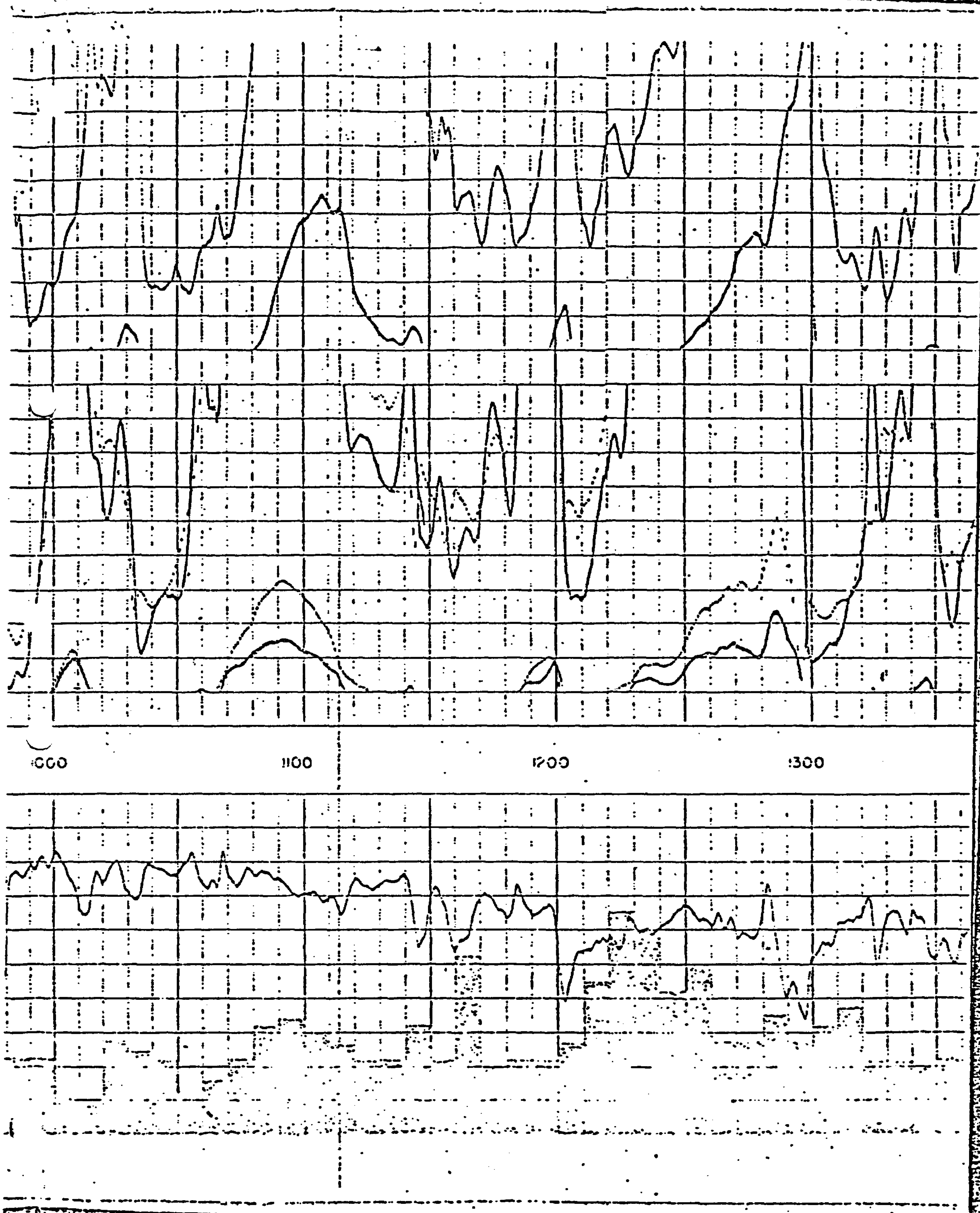
0800
0900



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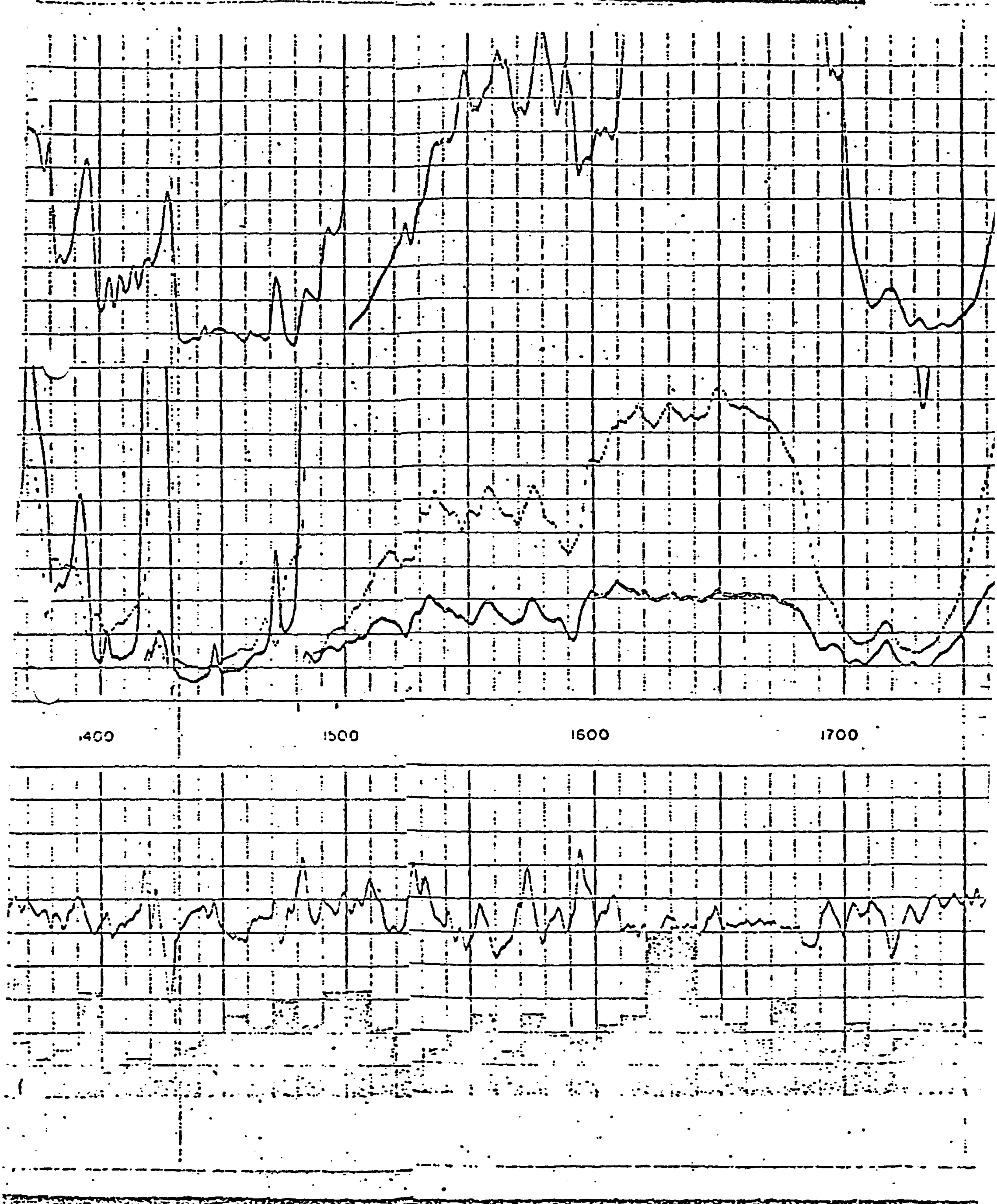
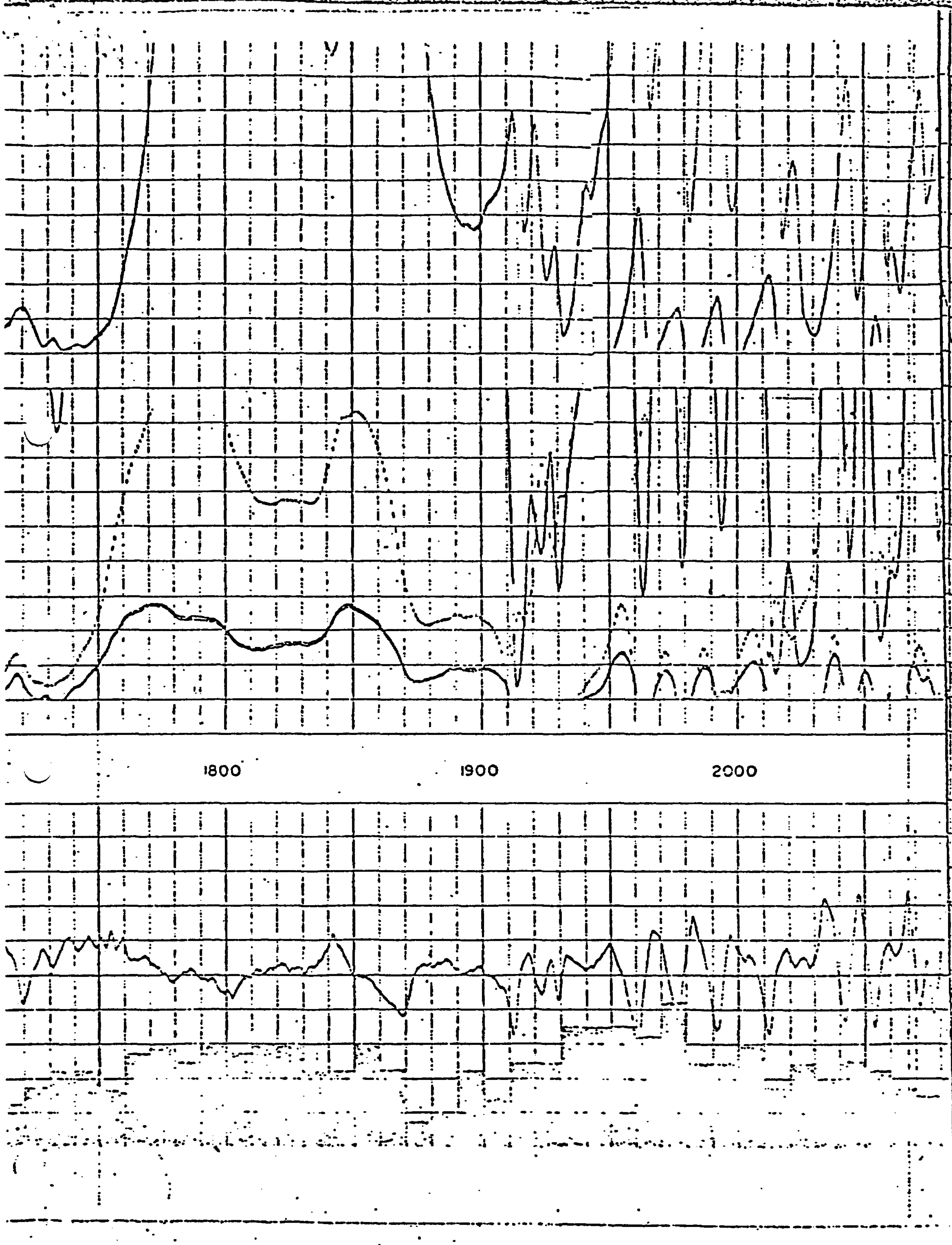
1100
1200
1300


1400
1500
1600
1700



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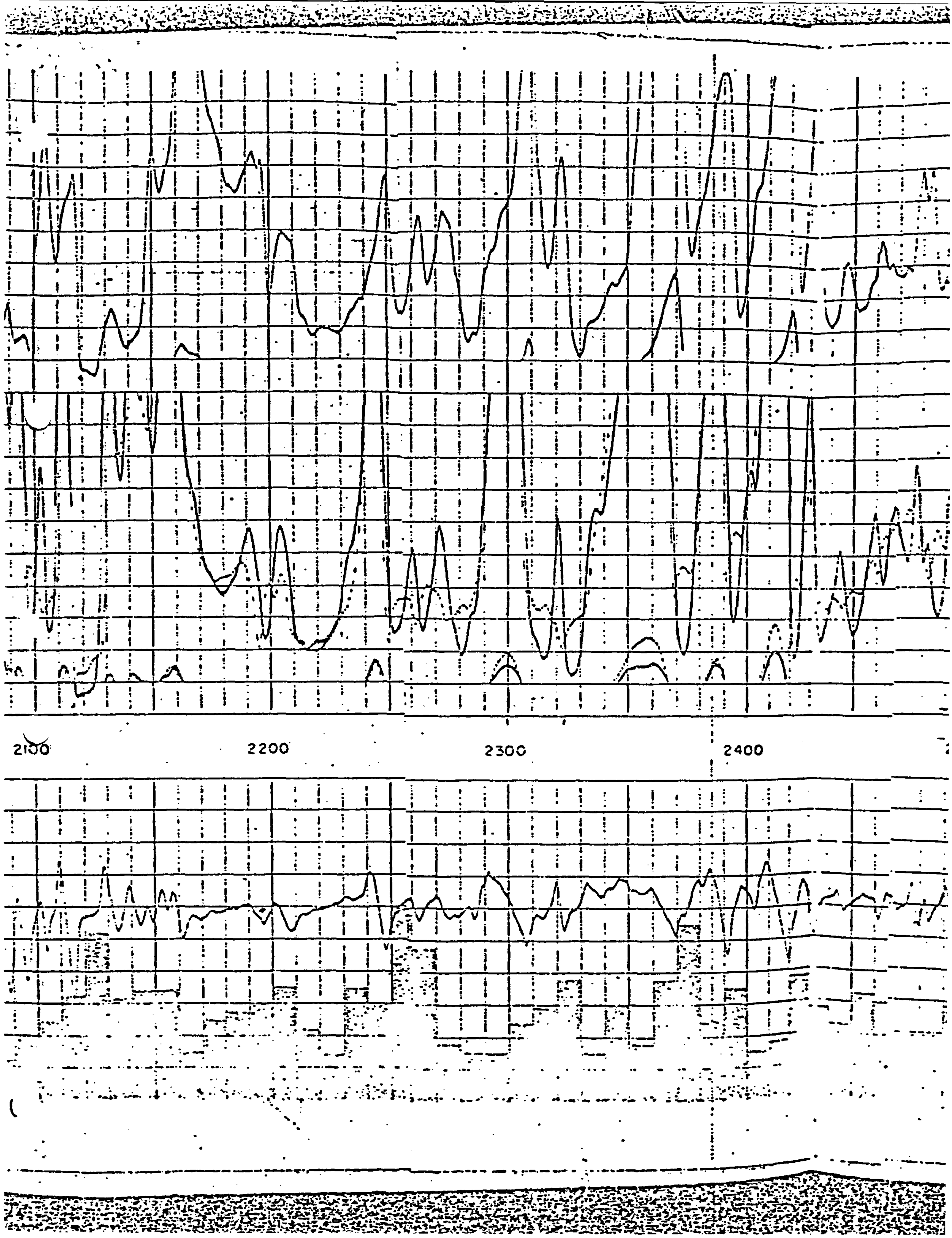
1900
2000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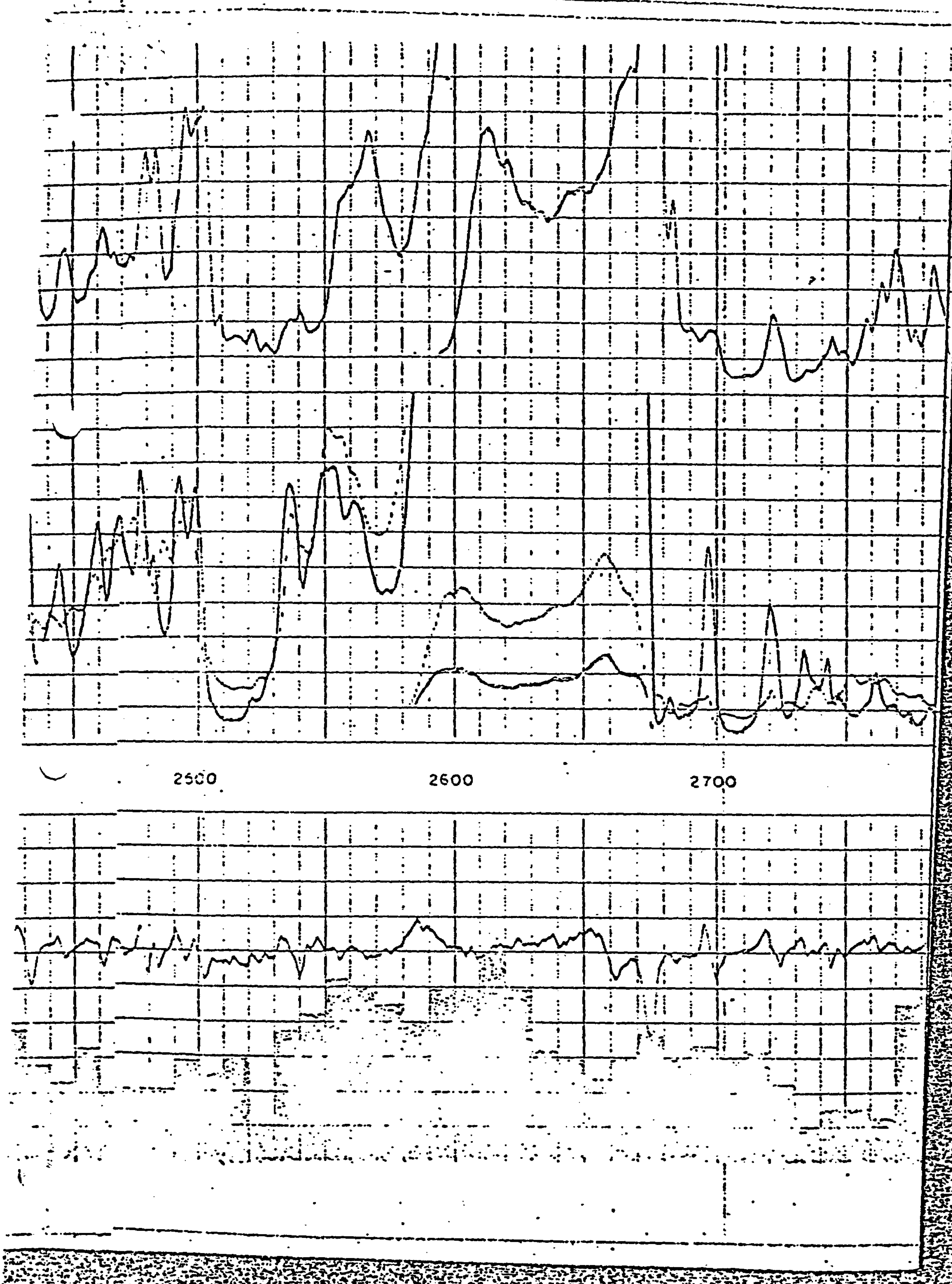
2300
2400



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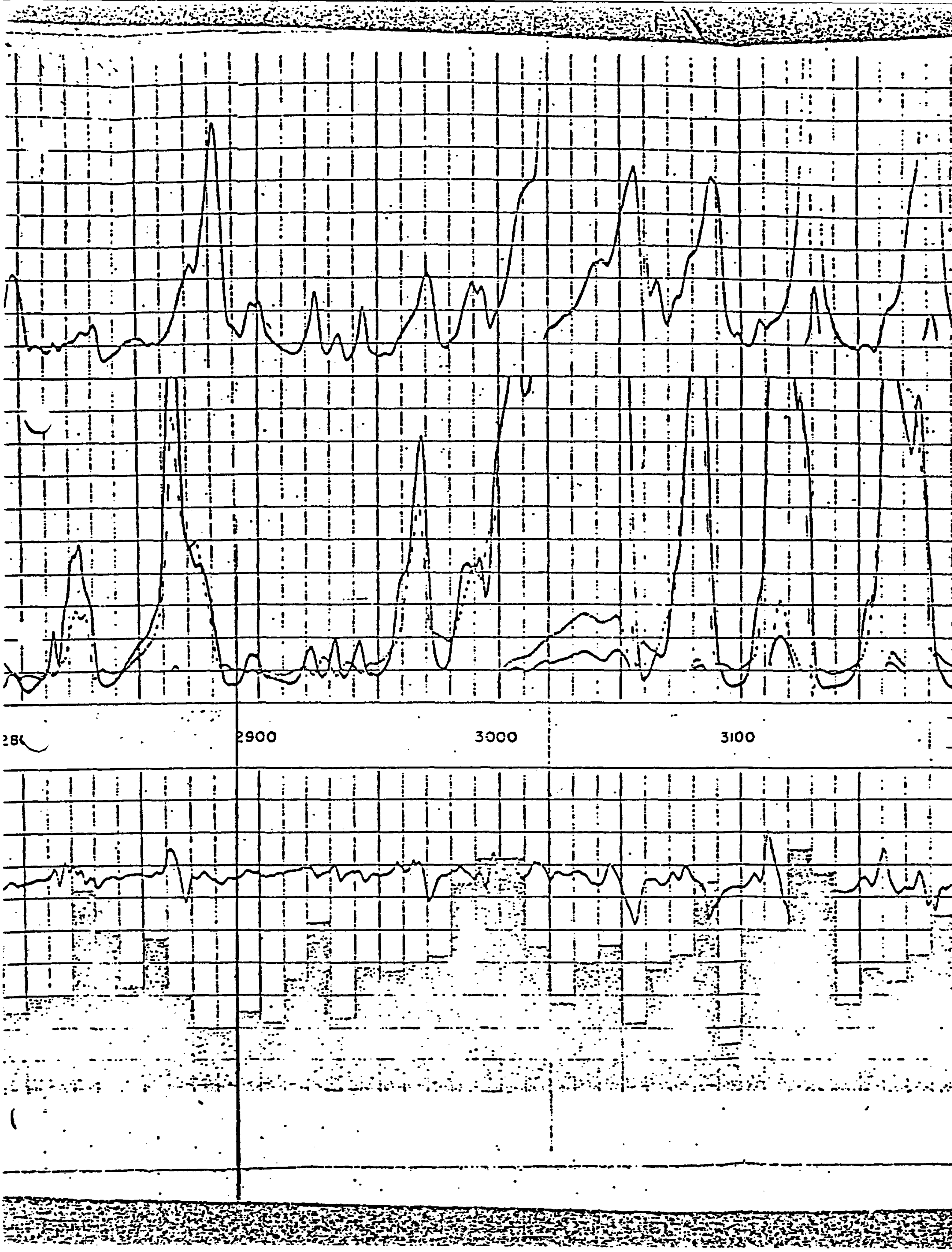
2600
2700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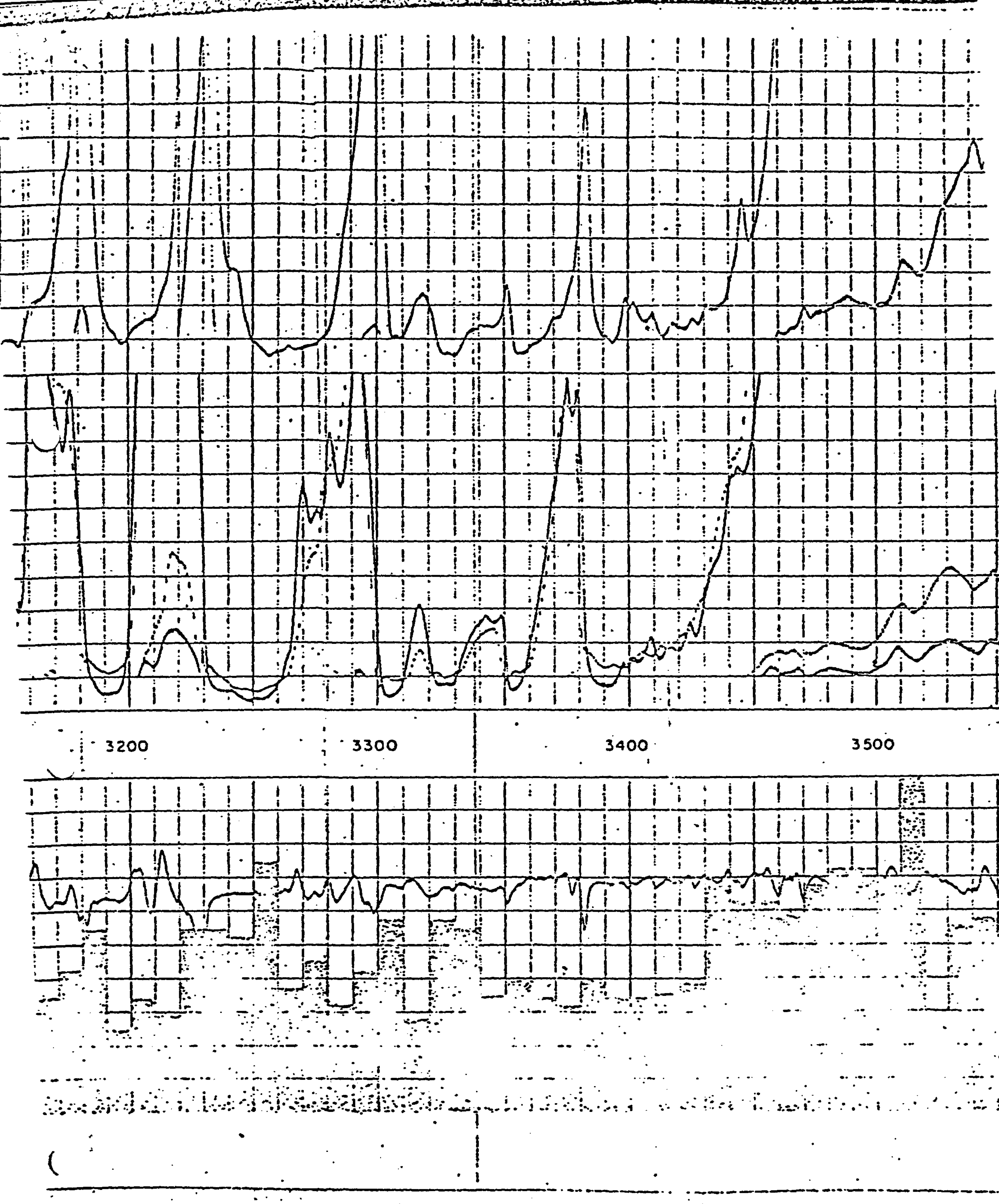
3000
3100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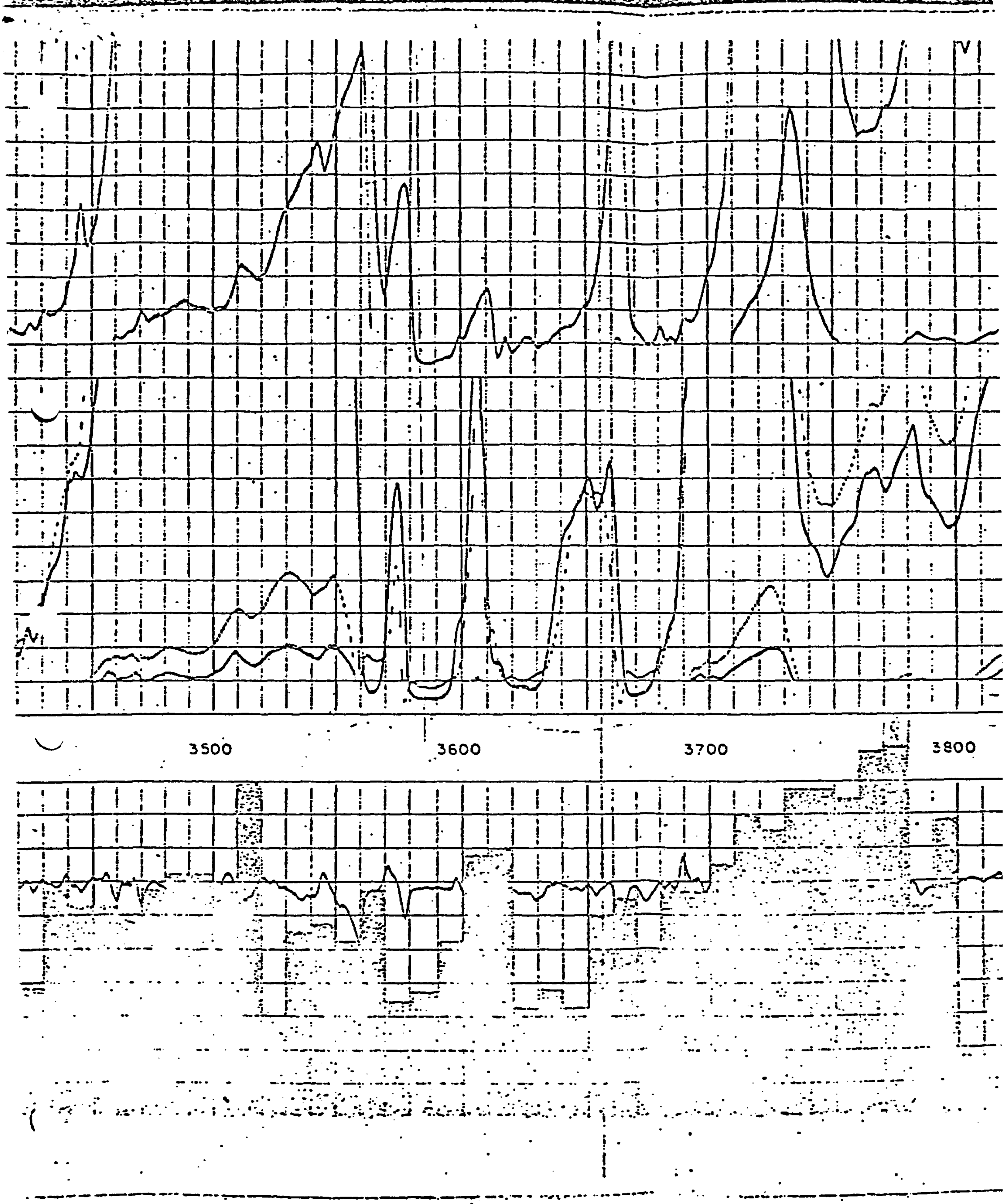
3300
3400
3500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3600
3700
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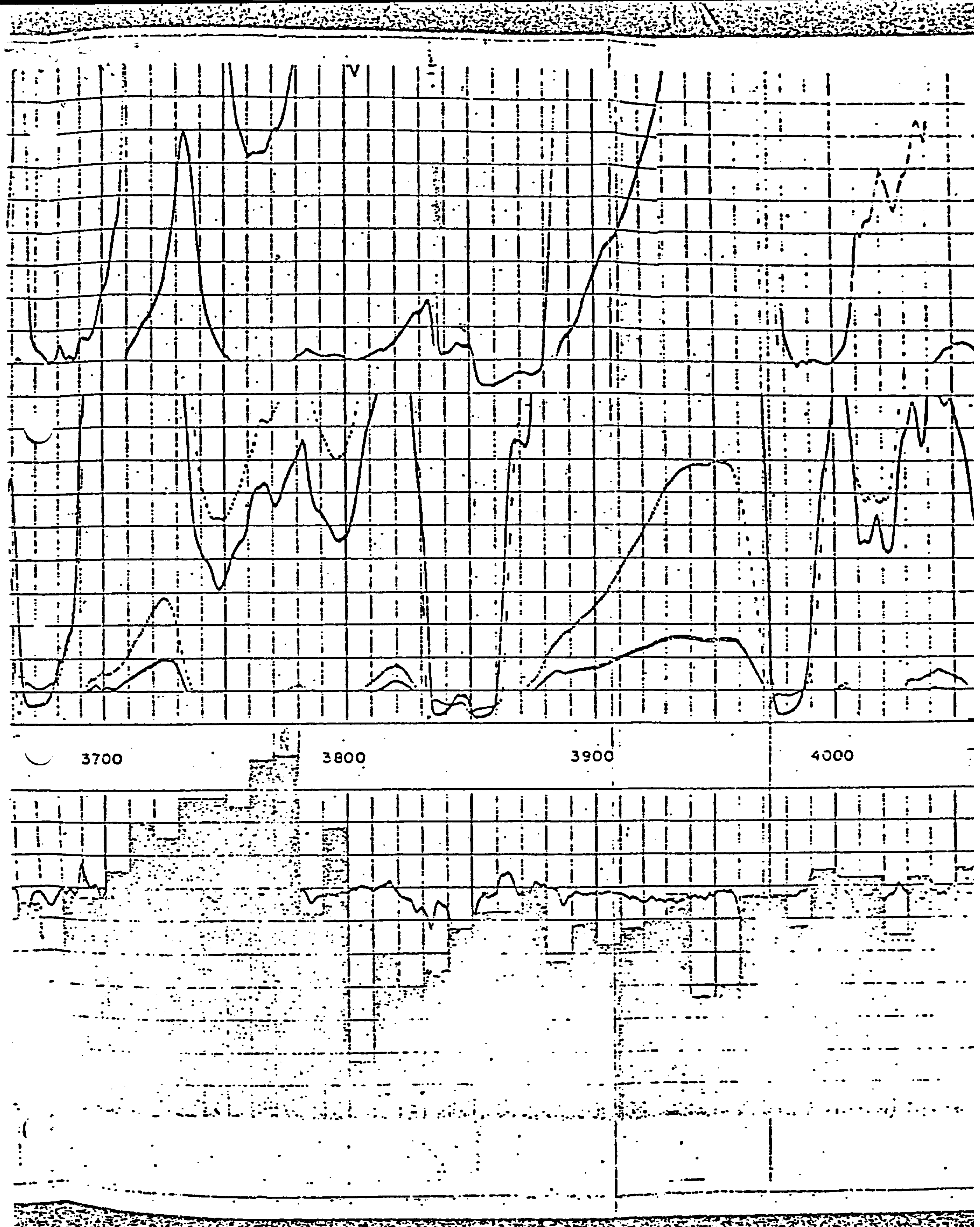

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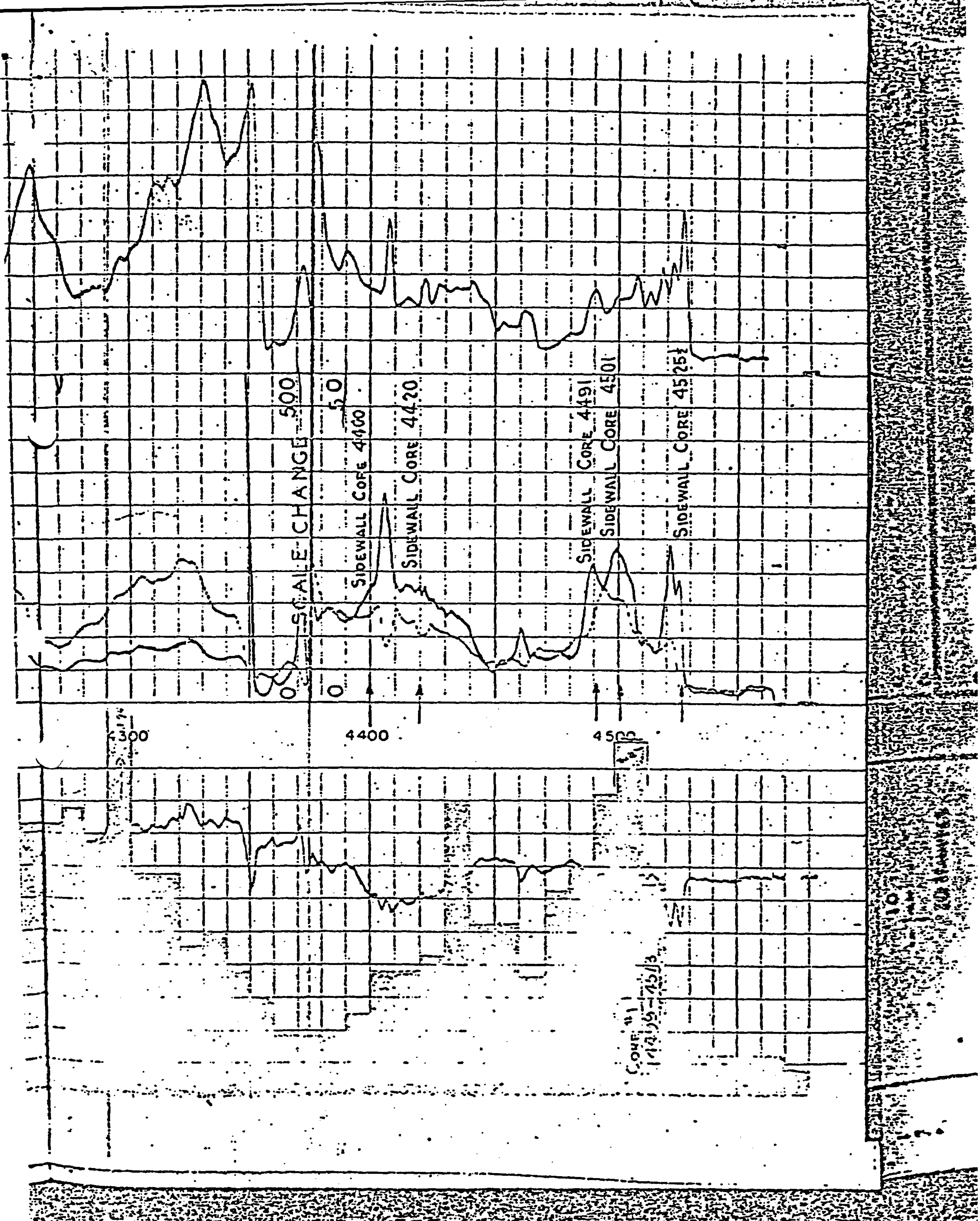
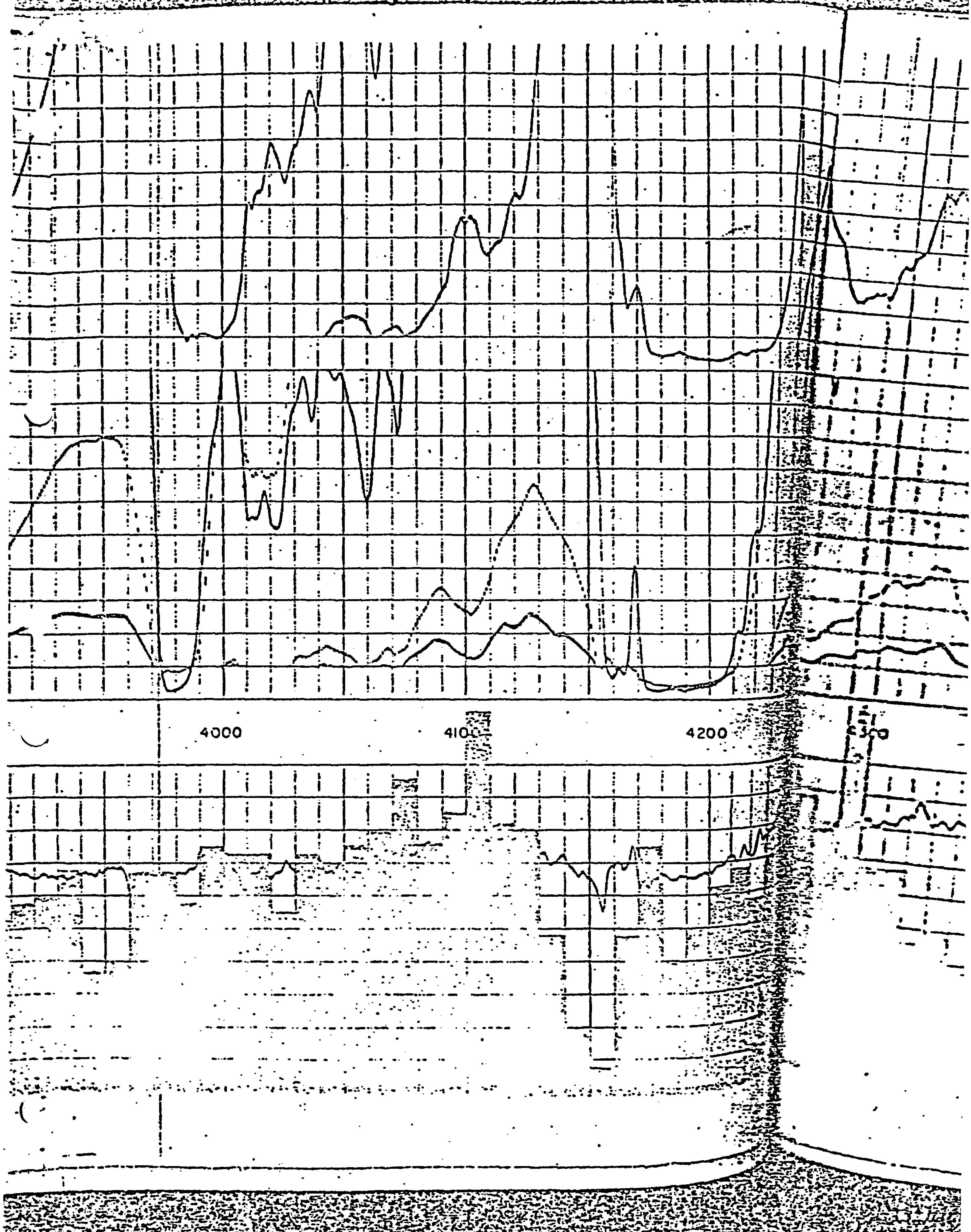
3800
3900
4000


SCALE CHANGE
500
50
0
0
SIDEWALL CORE 4400
SIDEWALL CORE 4420
SIDEWALL CORE 4491
SIDEWALL CORE 4501
SIDEWALL CORE 4525½
4300
4400
4500
CORE #1
4496–4513



4000
4100
4200

10 – |<->| + 20 MINUTES		0 AM 16" 50 0 500 0 AM 64" 50 0 500	0 AO 18'8" 50 0 500
SPONTANEOUS-POTENTIAL millivolts		RESISTIVITY ohms. m^2/m	RESISTIVITY ohms. m^2/m

COMPANY DEVELOPMENT ASSOCIATES

WELL BASALT EXPLORER NO. 1

FIELD WILDCAT STATE WASHINGTON

Rm 12 @ 62 °F
Rmf 3.9 @ 138 °F
Rmc 5.3 @ 138 °F
BHT 138 °F

SWSC FR 4557
SWSC TD 4555
DRLR TD 4602
Elev:
KB
DF
GL