FINAL REPORT

MI-35.

SPIRIT HILL SEISMIC SURVEY 0 P.3

ONSHORE

Conducted for

OIL DEVELOPMENT N. L.

100 Collins Street,

Melbourne, Victoria.

- by -

GENERAL GEOPHYSICAL COMPANY (BAHAMAS) LIMITED

113 EAGLE STREET,

BRISBANE, QUEENSLAND.

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Commencement Date - 21 July, 1962.
Termination Date - 7 September, 1962.

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Rec 62/14

GENERAL GEOPHYSICAL COMPANY

I N D E X

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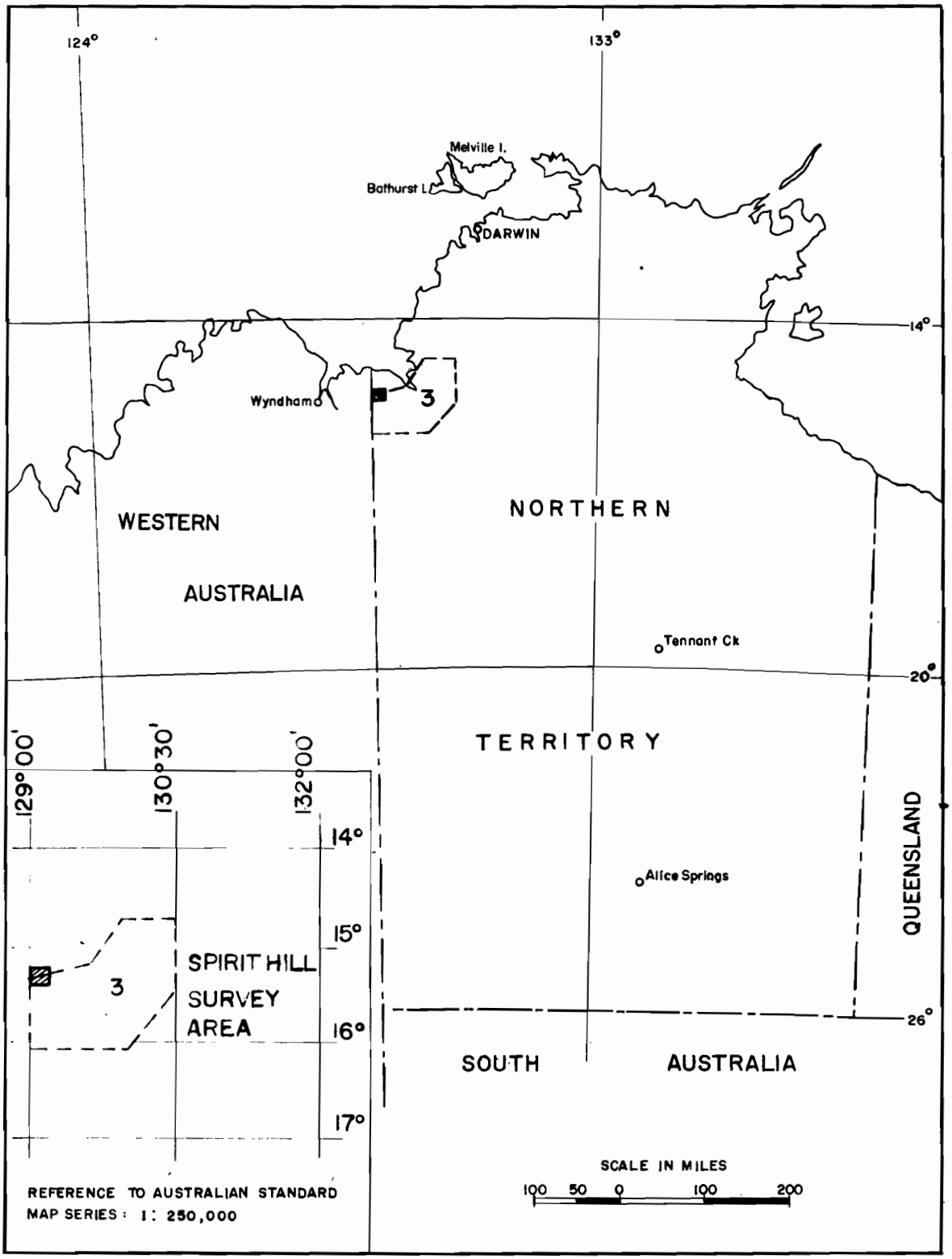


Fig. 1. LOCALITY MAP

LOCATION :

The Spirit Hill Seismic Survey is located in OP-3 situated in the north-western part of the Northern Territory close to the border between the Northern Territory and Western Australia near the head waters of the Keep River. The surveyed area is approximately 40 miles north-east of the Kimberly Research Station.

OBJECTIVE OF SURVEY :

The purpose of this survey was to discover and delineate structure suitable for the accumulation of Oil or Gas and also if possible obtain data on the thickness of the sedimentary section and attitude of the basement. Previous geophysical work had suggested a possible structure in the vicinity of the Spirit Hill Bore and this survey was also to delineate this structure if present.

The programme included one month of field work, however, actual time in the field on this project amounted to 45 days. The initial 8 days in the field was spent in experimental work to try to improve record quality - this experimental work is discussed in the section headed "Special Test Recording Procedures". Due to the experimental work and even though the crew was retained in the area longer than was originally programmed, it was not possible to delineate any structures in the limited time available.

Previous geophysical work done in this area consists of a reconnaissance gravity and seismic reflection traverse by the Bureau of Mines and Mineral Resources in 1956, Gravity Surveys by Westralian Oil Limited in 1955 and 1957, and a seismic reflection survey in the north west corner of OP-3 in the vicinity of the Spirit Hill Area, by Geosurveys on behalf of Oil Development N.L. in 1960.

TOPOGRAPHY, VEGETATION AND CLIMATE :

The topography is generally flat with scrub vegetation, although there are some open grass covered plains. There are some large outcrops of broken sandstone, but most of the surface is soft sand and hard black soil. The Keep River Channel intersects the north-western part of the survey and another deep channel cuts across the eastern portion. Various small stream channels were also frequently crossed. A bulldozer was required to clear the reconnaissance traverses in the survey.

Elevation varies from 94 to 240 feet above sea level, average elevation is approximately 130 feet.

The weather was generally clear and dry. There was no lost time due to the weather.

REGIONAL GEOLOGY :

The area covered by the survey contains a few scattered outcrops of

REGIONAL GEOLOGY (Continued)

generally flat lying sandstones that are correlated with the Upper Carboniferous Border Creek Sandstone, which forms the Weaber Range lying immediately to the west of the surveyed area. The Border Creek Sandstone is presumed to underlie the sand and black soil of the generally flat terrain which occupies the area between these scattered outcrops.

To the south of the area surveyed, in the vicinity of Spirit Hill, the Border Creek Sandstone lies with a distinct angular unconformity on the Lower Carboniferous Point Spring Sandstone, about 260 feet thick, which in turn rests conformably on about 800 feet of Lower Carboniferous Shales known as the Milligans Beds. Some uncertainty still exists as to the correlation of the sequence found below the Milligans Beds in Spirit Hill Well No. 1, which was drilled to 3,003 feet several miles to the south of the area surveyed ; details of the stratigraphy of the region as a whole and the possible interpretations of the subsurface sequence in Spirit Hill Well No. 1 are contained in the completion report for that well. Below the Milligans Beds in Spirit Hill Well No. 1 there is about 1,200 feet of dolomitic sandy limestone followed by about 1,000 feet of white medium grained quartz sandstone ; this apparently conformable sequence below the Milligans Beds probably belongs mostly to the Lower Carboniferous, but it could range down to late Devonian in age.

Geologic mapping in the Spirit Hill area (See Plate) indicated the presence of an anticlinal fold in the outcropping Lower Carboniferous sediments, and subsequent seismic survey showed this fold to be plunging toward the north. A reconnaissance line run from west to east in the northwestern corner of the Permit indicated the possible presence of an anticlinal fold in the vicinity of Sandy Creek, and the object of the present survey was to obtain further information on this possible structure and to conduct further reconnaissance in the area farther south toward Spirit Hill with the object of locating other subsurface structures that would provide suitable drilling targets.

In the area surveyed it would be expected that possibly a few hundred feet of Border Creek Sandstone would be found to overlie a Lower Carboniferous sequence of at least a few thousand feet thick, below which an Upper Devonian section of unknown thickness would be expected. The possibility also exists that Cambro-Ordovician sediments, similar to those found farther to the west along the southern margin of the Carlton Embayment of the Bonaparte Gulf Basin, may be present between the Devonian sequence and the Proterozoic basement, which is exposed on the upthrown side of the Cockatoo fault, to the east and south-east of the area surveyed.

EQUIPMENT :

Vehicles :

1 International R-190, 4 x 4, equipped with a Failing CFD-1 air-water combination rotary drilling unit.
1 International R-190, 6 x 6, equipped with a 1,500 gallon capacity water tank.

EQUIPMENT (Continued)

Vehicles (Continued)

1 International R-160, 4 x 4, Recording Truck
1 International R-190, 2 x 4, equipped with a Mayhew - 1,000, air-water combination rotary drilling unit.
1 Ford, 2 x 4, equipped with a 1,000 gallon capacity water tank.
2 Dodge, 4 x 4, Power Wagons
2 Landrovers, 4 x 4, for Surveying and Party Manager's use.
1 Willys, 4 x 4, Jeep
1 Caterpillar D-6 Bulldozer

Instruments :

1 set of 24 channel "General" JMH reflection amplifiers
1 "General" portable Oscillograph
1 power and control unit for JMH amplifiers
1 "General" Geocord magnetic tape recorder
1 set of portable reflection cables (24 outlets), 145.6 feet between outlets and a maximum usable spread length of 3,500 feet.
576 Hall-Sears 21 C.P.S. reflection geophones.

PERSONNEL :

Party Chief	---	R. J. Tinline
Assistant Party Chief	---	J. S. Fife
Computer	---	S. J. Lang
Party Manager	---	R. Ulmer
Observers	---	F. Prestonbaok and T. Jones
Surveyor	---	J. F. Keating
Driller-Mechanic	---	George McKigney

In addition to the key personnel listed herewith, a cook and his offsider and 8 other men were employed in the field operations.

CAMP :

All operations were conducted from a portable camp which was frequently moved to lessen driving time between the living area and the work site. A contract camp and catering service supplied by Seismic Supply (Aust.) Pty. Ltd. was employed and consisted of the following :

6, 15 foot x 15 foot screened canvas tents
5, 10 foot x 10 foot canvas tents
1, Southern Cross diesel generator for electricity
Complete messing and cooking facilities, groceries, and sleeping equipment.

In addition, outside communications were maintained by a radio transceiver operating on the Royal Flying Doctor radio frequencies via Darwin.

SURVEYING :

Horizontal distances were measured using a surveyor's chain and checked by stadia readings. Levelling was carried out using a Zeiss automatic level. Horizontal angles were measured by a theodolite.

Horizontal control was established by ties to Northern-Territories-Western Australia border pegs SS-29 and SS-28. The border pegs were located on the map according to information furnished by the West Australian Surveyor General's Department.

Vertical control was established from elevations of Geosurvey points from their seismic survey in 1960.

Magnetic declination in the area was N3° 30' E of true north.

Permanent markers were located at numerous shot points. The markers consist of star pickets with aluminium tags containing the line number, the shot point number and elevation of the shot points. A record of the location of the permanent markers is included with this report.

DRILLING :

A Failing C.F.D. - 1 air-water combination rotary drilling unit was used during the course of the survey. Air was normally used as the drilling medium, however, water and drilling muds were used to drill a few difficult holes.

Drilling was mostly in soft sand and sandstone, but clay and hard sandstone were encountered in some holes. Drilling was fairly good over most of the area, although circulation of the drilling medium was frequently lost due to cavities in the sandstone. It was necessary to load the holes immediately after they were drilled as they would not normally stay open due to the loose sand caving in the holes at the shallow levels.

Bottom hole core samples were taken at each shot point and have been submitted to the Bureau of Mineral Resources.

RECORDING :

All shooting was done using split spread continuous profiling. Shot Points were normally spaced 1740 feet apart with station intervals spaced 145 feet apart. A 1000 foot shot point spacing and an 85 foot station spacing was used at the beginning of the survey to get better energy response on traces farthest from the Shot Point.

Multiple geophones were used. Normally 12 geophones per trace laid parallel to the recording line, 6 on each side of the station flag spaced 15 feet apart were used. At the beginning of the survey where 1,000 feet shot point spacing was used geophones were positioned 10 feet apart.

RECORDING (Continued)

A filter setting of 1-25-75 was normally used to record the shot and a setting of 2-35-75 was used when palying back the magnetic tape. These filter settings appeared to give the best results, however, other filter settings were used in an attempt to improve record appearance, but with little success.

Records were normally recorded in 2 way slow AGC and "played back" in 2 way fast AGC. The recorded shot was not mixed. "Playback" records were mixed 20% bilaterally.

Normally a 3 hole pattern was used in this area, the pattern consisted of a 40 foot hole at the shot point and 30 foot holes at geophone stations 12 and 13. A single 80 foot hole was shot wherever record quality appeared to be fair.

Oscillator tests were run frequently to check head alignment and the 100 C.P.S. test records were made at intervals to check timing accuracy. Group shots and parallel shots were made to check alignment and polarity.

SPECIAL TEST RECORDING PROCEDURES :

Before production shooting was started and whenever time permitted tests were conducted in various localities in the survey in an effort to improve record quality.

A 10 shot hole pattern with holes spaced 15 feet apart parallel with the profile line, a 4 shot hole pattern with holes spaced 15 feet apart parallel with the profile line and 20 and 24 shot hole diamond shaped pattern with 15 foot spacing were shot. Also, single holes ranging to 120 feet in depth were shot.

Tests were also conducted using 6 and 12 seismometers per trace, spaced 15 feet apart and parallel to the profile line and 24 seismometers per trace set out in a flat X pattern at approximately 30° to the profile line and spaced 15 feet apart.

Twelve seismometers per trace gave better results than six seismometers per trace, but other test procedures showed no improvement in record results.

COMPUTATION PROCEDURE :

Refraction break time-distance plots were constructed at each shot point, giving the velocities of the weathered layers. Velocity intercepts were then used to compute the depth of the weathered layers, using the standard 1 and 2 layer refraction methods. The velocities V1 and V2 were observed from the time-distance plots, the near surface velocity Vo, which is fairly constant, was observed from the uphole velocity survey. Each seismogram was further corrected to a Sea Level elevation and weathering datum plane using 9,000 feet per second as the correcting velocity.

COMPUTATION PROCEDURE (Continued)

The $\triangle T$ curve was constructed using the velocity function Va = 10, 140, + .11 S that had been employed by Geosurveys in 1960. The $\triangle T$ curve constructed using this information did not appear to remove sufficient $\triangle T$ for the shallower reflections. This function is thought to be unreliable. An extended profile was shot in the adjoining Carlton Basin Area and a velocity function computed from it of Va = 9,560 + .32 S. This function was used in computing the depth to the subsurface phantom horizon.

Migration of dip was not made as dip did not appear to be great enough to warrant such procedure.

RESULTS :

The results of the survey are presented in the form of a contour map of the proposed Paleozoic reflection, an elevation map of the area and plotted cross sections. Also submitted are corrected 3" record sections and corrected 3" variable area record sections.

Record quality varies from fair to unusable with the majority of records being of a very poor quality. The best record quality was in the northwest portion of the surveyed area with the quality deteriorating as the survey continued south and east.

Record quality is thought to depend mainly on the soft sand overburden masking energy return, however, records shot over black soil showed no improvement over those shot over soft sand. Also, the poor record results may be attributed in part to the fact that this area is a flood plain and the surface varies considerably due to the presence of a multitude of old drainage channels.

The 3 hole pattern normally employed, appeared to give better results where record quality was poor but showed no improvement over a single 80 foot hole where record quality was fair. Shot depths did not appear to be critical where record quality was fair, but were critical where record quality was poor.

The data used in the construction of the subsurface contour map is considered to be poor but generally reliable. Record quality precludes continuous correlation, and a phantom horizon has been employed over much of the area. Continuous correlation was attempted but was not considered reliable.

The phantom horizon mapped is believed to be of Upper Devonian or Lower Carboniferous in age. This phantom horizon indicates a seismic high at the north end of line ND trending south-south-east towards the high indicated on line EC. A syncline trending south-south-west at the north end of line NB appears to saddle across the southward trending high at the junction of the EA and ND lines. A small fault is postulated at shot point 32 line EC, but could not be well defined. Regional dip appears to be to the northwest.

CONCLUSION :

The velocity function of Va = 10, 140 + .11 $\bar{s}$ as used to compute the Δ T curve for removal of moveout, although considered to be unreliable, is not a serious error as centre times of reflections are not affected and end traces tie reasonably. The function produces an "Umbrella" effect of the traces. Dip segments of shallower reflections however, are seriously affected, consequently dip of the shallow reflections was based mainly on the dip of deeper reflections where removal of step out is not critical and the dip was considered reliable.

The velocity function of Va = 9,560 + .32 $\bar{s}$ as used to compute the depth values of the subsurface horizon is considered reliable in the adjoining Carlton Basin Area and is considered as being the best usable function in the Spirit Hill Area, according to velocity information available. However, a change in lateral velocity between the location of the extended profile and the Spirit Hill area could appreciably change the average velocity.

There appears to be a problem of multiple reflections in this area as well as a problem of poor energy return. Changes in the shothole depths and single and pattern shot holes did not appear to change the multiple reflection bands. Pattern holes appear to help energy return where record quality was poor. Several diffractions are apparent notably on the east and west ends of the line EC. With more extensive shooting the origins of the diffractions could possibly be determined.

The results of this survey are considered generally reliable as to attitude of the sedimentary section near the horizon mapped, however, no data could be obtained as to depth or attitude of the basement. There are some indications of reefing, notably secondary phasing between the reflection mapped and the phase below it, however, poor record quality precluded an outline of this proposed reefing.

The results of the survey indicate several interesting features which will require additional seismic to delineate any possible drilling targets.

The most interesting feature appears to be the seismic ridge trending south-south-east from the north end of line ND and the possible continuation of this high ridge south on line EC.

This ridge is possibly due to the draping of sediments over a basement high or due to thickening within the sedimentary section. Also, it may be the result of the draping of sediments over a reef formation, however this is thought unlikely as the relief does not appear great enough for this possibility. The premise that the high ridge was formed as a result of the draping of the sediments over a basement high is thought the most probable reason for its formation.

If more control is anticipated, it is recommended that shooting be

CONCLUSION (Continued)

concentrated south of this survey. Also, refraction profiling should be considered in any additional work as record quality in reflection profiling has proven to be inferior.

Respectfully submitted,

GENERAL GEOPHYSICAL COMPANY
(BAHAMAS) LIMITED

R. J. Tinline

(Ronald J. TINLINE)
Party Chief

BRISBANE
11th March, 1963.

STATISTICAL DATA

Commencement Date	-	21 July, 1962
Termination Date	-	7 September, 1962
Total Number of Working Days	-	49
Miles of Traverse completed	-	43.06
Total Number of Shot Points	-	150
Total Number of Shots	-	223
Total Number of Holes Drilled	-	448
Total Footage of Holes Drilled	-	22,675'
Average Hole Depth	-	50.6'
Total Drilling Hours (2 Drills)	-	562.5
Rate of Penetration	-	40.3 ft./hr.
Total Amount of Explosive Used	-	14,750 lbs.
Average Charge Size	-	66.1 lbs.
Total Number of Caps Used	-	658
Rock Bits Used	-	7
Replacement Bits Used	-	54 (Skidmore Crooks)
Drilling Mud Used	-	6 sacks
Total Number Recording & Shooting Hours	-	392.5 Hours
Total Travel Time Recording & Shooting Crews		48 Hours
Total Travel Time Drill Crews	-	66 Hours
Total Travel Time Survey Crew	-	105 Hours
Total Lost Time - Recording Equipment	-	19.5 Hours
Time Spent on Move	-	40 Hours

PERMANENT MARKER LOCATIONS

(Star pickets, aluminium tag with shot point number, line number and elevation stamped thereon).

Line EA

S.P.	0
"	10
"	16
"	23-2
"	28-2

Line EC

S.P.	29
"	34
"	39
"	44
"	49

Line ND

S.P.	0
"	5
"	10

Line NE

S.P.	5
"	10
"	15

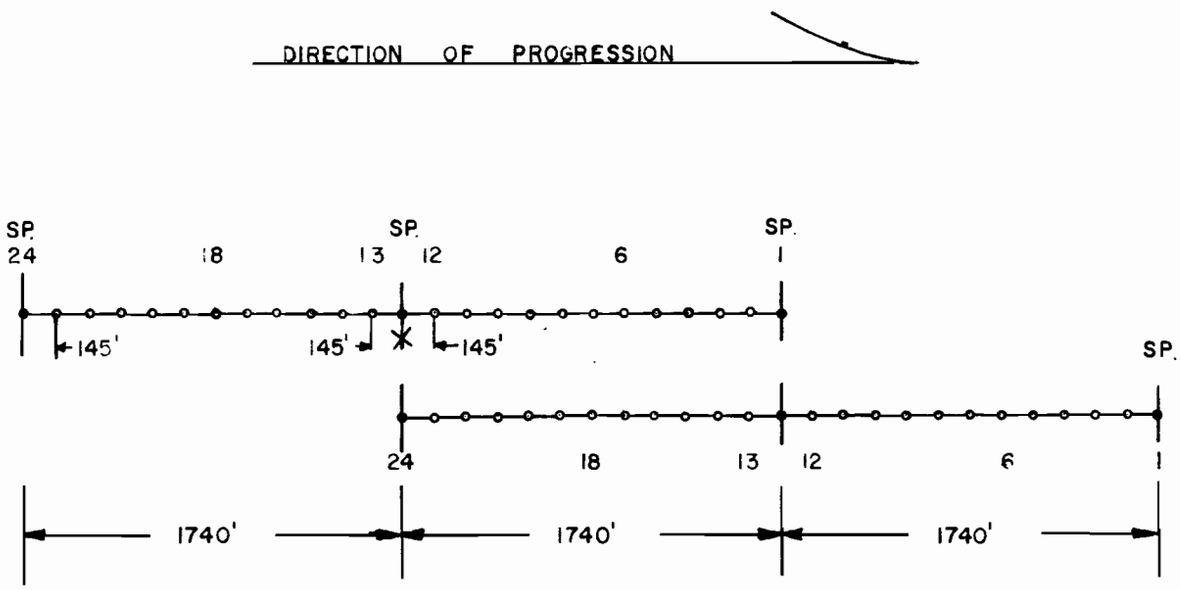
Line NB

S.P.	0
"	10
"	15
"	20
"	25
"	29

Line NF

S.P.	0
"	5
"	10

TYPICAL REFLECTION SPREAD LAYOUT



TYPICAL GEOPHONE LAYOUT

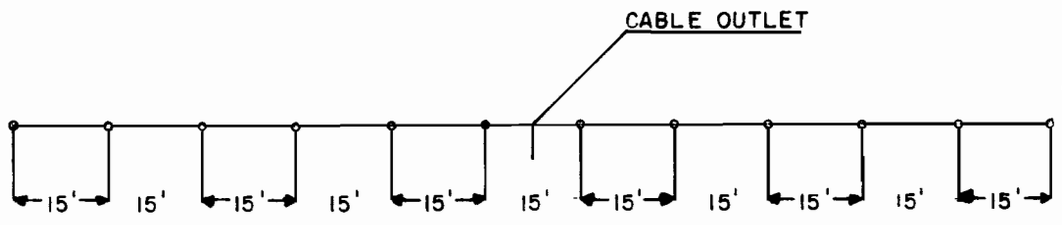
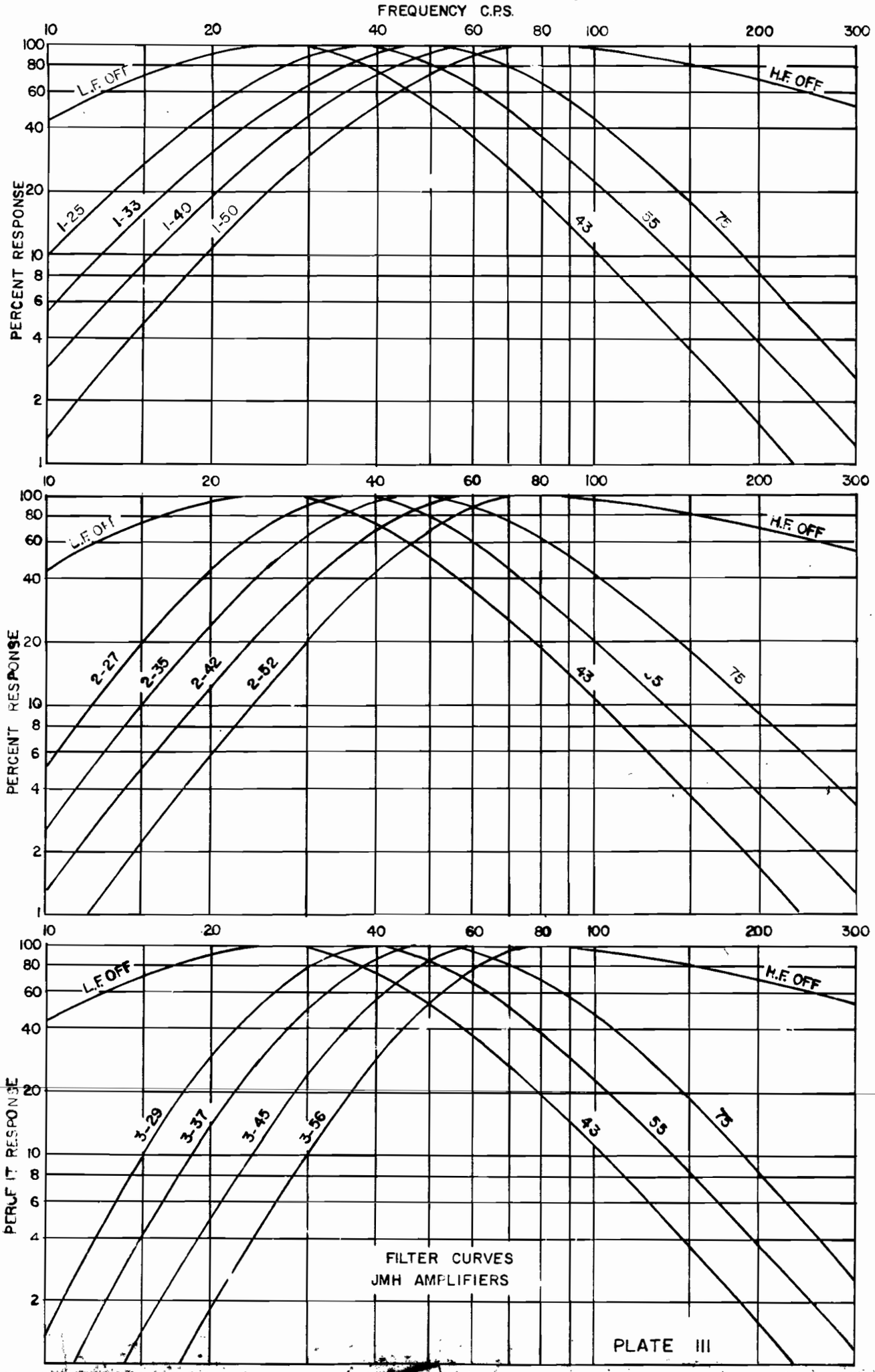


PLATE 1

GENERAL GEOPHYSICAL COMPANY.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10
20
40
60
80
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200
300
PERCENT RESPONSE
100
80
60
40
20
10
8
6
4
2
1
L.F. OFF
H.F. OFF
1-25
1-33
1-40
1-50
43
55
75
2-27
2-35
2-42
2-52
3-29
3-37
3-45
3-56
FILTER CURVES
JMH AMPLIFIERS
PLATE III